Volume XII, 2018

Symmetry

An annual publication of Central Department of Physics, TU

Dedicated to John Bardeen, who discovered transistor & Superconductivity

Message from Leon Cooper

70 years of John Bardeen's Contribution

Meta-Materials

Quantum Decoherence

Physics of Hitting Sixes in Cricket

Parking Spots in Space

ICTP Director's Visit to CDP

NASA Scientist Dr. Michael S. Kirk

Lifetime Sketch: Prof. Dr. Kedar lal Shrestha

Editorial Board Members

Past Issue (Symmetry Vol. XI): Comments

Thanks for the detail information on E. Fermi's contribution to material science. I read this physics magazine from a shared link from facebook. We don't have physics magazine here Vietnam. It would be wonderful if we can have access to its hardcopy in our library.

Do Van Tien, Hue, Vietnam

27 Feb 2018

I congratulate physics students of Tribhuvan University, who worked hard to publish physics magazine. I am really impressed to read activities of department, publications and most importantly a list of students joining various USA Universities in the last year. I assume the quality of physics education and research is excellent there. I wonder I could visit your department someday.

Mamadou Lamine, Senegal

8 May 2018

Third Batch of the Semester System (2016-18)


Group A


Group B

Dedicated to

John Bardeen

Born: 23 May, 1908, Madison, Wisconsin, USA
Died: 30 January, 1991, Boston, Massachusetts, USA

Volume XII, 2018
Symmetry
An annual Publication of CDP, TU

Publisher
©Central Department of Physics,
Tribhuvan University
Kirtipur, Kathmandu, 01-4331054
Email: aryalbinil@gmail.com
Website: www.tucdp.edu.np

Print
TU Press, TU, Kirtipur

Indivisual Price: Rs. 500/-
Institutional Price: Rs. 2000/-

Editorial

The field of scientific research and physics, in particular, has contributed a lot in shaping our modern society. The paradigm from Aristotle's philosophical beginning to the current technological innovations has its root in the immense research done in the physics and other sciences- the intensity of which became more apparent after the two Great World Wars. This year was marked with the Nobel prize in physics for the ground-breaking invention in the field of Lasers. Moreover, Donna Strickland was declared to be the third woman (i.e ¼ the share of Nobel prize in physics) to achieve such highest honor for devising a method of generating high-intensity, ultra-short optical pulses. This year also witnessed a computer scientist Katie Bouman who helped through her algorithm in deciphering a huge telescopic data (i.e. about 5 Petabytes) observed through the collaborative efforts of several astronomers which helped to obtain the first-ever image of a black hole. Sometimes the people questions on the billions of dollars spent in such research regarding their significances. The discovery of spectrum outside the visible was once questioned similarly but when the real application of such discovery was applied to several sectors like medicine, telecommunication, etc it not only improved the human lives but also helped in globalization. One thing is thus for a certain that science thrives after the rigorous research which later would have direct relevance for human benefits, of course, the matter of use is on the human hand itself. John Bardeen is one of the pioneers who through his invention of a transistor, a device that triggered a revolution in electronics and radically changed the face of technology which further earned him a first Nobel prize in Physics. To date, he is the only one to achieve two such honors, the next honors being in the theoretical regime of superconductors. Physicists, particularly after the Post-war era, have been dedicated to contributing the society, however, the original way of thinking leading to research and innovation are always intact. The Central Department of Physics despite the dearth of high research facilities has been able to produce hundreds of graduates publishing high-quality research in several reputed Journals. Due to the several political and economic instability, the government is unable to provide the necessary platform for the physicists, however, the students graduated from the CDP with their outstanding performances in the worldwide: United States, Europe, and South Korea being the major destination for Ph.D. has made the department and in fact the country itself to be a matter of pride. Proper research facilities and the appropriate national budget allocation in these research areas by the Government of Nepal apart from the collaborative work that department currently does is mandatory to utilize and promote the science and technology throughout the country. Symmetry is the annual magazine published by the CDP and to our delight the 12th volume this year shows the aptitude of scholars and graduates toward the physics. This magazine is concerned about the basic theories and advancement in the field of physics along with the CDP activities. This edition is dedicated to John Bardeen with the prime focus on his contribution particularly for his 2nd Nobel prize in Physics i.e. BCS theory. This edition is honored with a biography and interview of our Prof. Dr. Kedar Lal Shrestha, HoD of CDP (1985-2001). Moreover, the visit of ICTP director, Fernando Quevedo this year has added glory to our department. His inspirational speech highly motivates the physics aspirants from the developing countries like Nepal and we have been able to present his ideas in this volume for promoting Physics. This volume also contains the interview of Subodh Raghunath Shenoy, an Indian condensed matter physicist and a former professor at the Tata Institute of Fundamental Research who taught us a formal course on superconductivity. Also, the CDP students were lucky enough this year to attend the lecture series of Dr. Michael Clark, a NASA scientist.

The publication of the 12th volume of Symmetry has been possible due to the tireless effort from Prof. Dr. Binil Aryal, HoD of CDP, and the cooperation from all the members of Symmetry Publishing Committee. We are similarly thankful to all faculty members for their encouragement and valuable suggestions. We also thank all students, staffs for their help and all the writers who provided their valuable articles to enrichen our magazine.

- *Editorial Board*

Contents

Message from Nobel Laureate **Dr. Leon Cooper** to Symmetry

My Remembrance with John Bardeen

My interaction with superconductivity began when I met John Bardeen in April or May of 1955 at the Institute for Advanced Study in Princeton. John was on the East Coast looking for a postdoc to work with him on superconductivity. He had written to several physicists, among them T. D. Lee and Frank Yang, asking if they knew of some young fellow, skilled in the latest and most fashionable theoretical techniques (at that time, *Feynman Diagrams, renormalization methods, and functional integrals*) who might be diverted from the true religion of high energy physics (as it was then known) and convinced that it would be of interest to work on a problem of some importance in solid-state.

Bardeen, Cooper & Schrieffer

As far as I can recall, it was the first time I had even heard of superconductivity. (Columbia, where I earned my Ph.D. did not, to my memory, offer a course in modern solid-state physics.) Superconductivity is mentioned in the second edition of Zemansky's Heat and Thermodynamics (the text that was assigned for the course in Thermodynamics taught by Henry Boorse that I took in my last semester at Columbia College), but I suspect those pages were not assigned reading. Although John, no doubt, explained something about the problem, it is unlikely that I absorbed very much at the time. John's first suggestion was that I read Schoenberg's book. So, early in September of 1955, I began to consume Schoenberg and other books and articles on the facts and the theoretical attempts to solve the problem of Superconductivity.

We had some real problems. In my calculations of the Meissner effect, I was obtaining a penetration depth a factor of two too small. John and I went over these calculations and could not find anything wrong. We were almost ready to accept that, somehow, this might, in fact, be the case. Thinking through the Meissner effect matrix elements for the thousandth time, I realized that between the initial and final state there existed another path, a path that did not occur in normal metal calculations. In the relevant limit the additional term would be of equal magnitude to the usual term but would possibly di er by a sign. The way we did the calculations then, there were about a half a dozen creations and annihilation operators to be manipulated. It was with some anxiety that I realized I could never, in the course of that concert, determine whether we would get the expected penetration depth or whether the Meissner effect would disappear. The family fortune was on the roulette table: double or nothing.

In a press meet

You will believe that I redid the calculations several times that weekend; by Monday morning there was no longer any doubt. Rushing to the office, possibly somewhat earlier than usual, I recall a vivid image: John in his chair, listening intently and absorbing every word. When I was finished I turned from the blackboard and said, '*You see it comes out right*." John was unusually loquacious that morning. He nodded in agreement and said: *Hmmm*!"

References

[1] Leon N. Cooper, *Remembrance of Superconductivity Past*, World Scientific Review, Volume **9**, (September 2010).

Acknowledgement

We acknowledge Dr. Samana Shrestha, Department of Radiation Oncology at Baylor College of Medicine, University of Rhode Island & Dr. W. Peter Bilderback, Institute for Brain & Neural Systems, Department of Physics, Brown University for their efforts to get contact with Nobel Lauerate Leon N. Cooper (who shared Nobel Prize with John Bardeen and John Robert Schrieffer for the discovery of Superconductivity) for this message.

COVER STORY - 1

John Bardeen: Social Life, Achievement and Overall Contributions

Prakash Timsina
M.Sc. (Physics), Fourth Semester, CDP, TU, Kirtipur

ABSTRACT
This article describes about the introduction of John Bardeen in the field of Physics, covers his social life, achievements and overall contributions in Science and Technology.

John Bardeen, the only person who won the Nobel Prize in Physics twice and among the only four people winning the coveted prize twice was an American Physicist and Electrical Engineers. One of the co-inventors of the transistor who also propose a fundamental theory of Superconductivity well known as 'BCS-theory'. The inventions of transistor on December 13, 1947 at the Bell Laboratory in Murray Hill, New Jersey (which is the research arm of American Telephone and Telegraph (AT&T) in the joint collaboration of William Shockley, John Bardeen, and Walter Brattain led to a revolution in the field of electronics industry and has significant contributions in today's Information and Communication technology. William Shockley played a quite different role in the invention than the other two.

Figure 1: *(a) From left- Brattain, Shockley and Bardeen in Bell Labs. (b) Bardeen accepts the second Nobel Prize in 1972 for his contribution in theoretical background of Superconductivit. [1]*

Shockley had been working on the theory of such a device for more than ten years. While he could work out the theory successfully but after eight years of trying he could not be built a working model. Bardeen and Brattain were called in to handle the engineering and development, while they did in the relatively short time of two years, to the consternation of Shockley. Shockley, as their supervisor, shared in the glory. What Bardeen and Brattain had created was the "point-contact transistor". Shockley subsequently designed a new type of transistor called the "bipolar" transistor which was superior to the point-contact type and replaced it. Bardeen contributions to the Scientific world are of immense significance and he was counted among LIFE Magazine's list of "100 Most Influential Americans of the Century" in 1990. Later in 1957, John Bardeen shared the credit to the Superconducting theory with his Post-Doctoral student Leon Cooper and Doctoral student John Schrieffer on proposing a microscopic explanation (that would later be designation with their surname as BCS) of Superconductor. Superconductivity was not sufficiently explained until 1957, after the discovery of Superconductivity in Mercury in 1911 by the Dutch Physicist Heike Kamerlingh Onnes. This theory explains the superconducting current as a superfluid of Copper pairs, pairs of electrons interacting through the exchange of phonons. [1]

Bardeen shared one-third of the prize with Shockley (1/3) and Brattain (1/3) of the 1956 Nobel Prize in Physics "for their researches on Semiconductors and their discovery of the transistor effect". Again in 1972 Bardeen got the Nobel Prize in second time " for their (Bardeen (1/3), Cooper (1/3), and Schrieffer (1/3)) jointly developed a theory of Superconductivity usually called the BCS-theory". [2]

Social life and Career:

John's brilliance was evident from a very young age. He was so intelligent for his age that his parents decided to have him skip several grades at school. Once, Bardeen misspelled the term 'existance' rather than 'existence' while he sent the postcard from Stokholm to his former student Nick Holonyak. Bardeen claimed that his spelling suffered from his having skipped several grades in primary school. He was a strength of sustaining in a very toughness situation; he was able to manage and continue his study although his mother's death by breast cancer when he was at school. After his graduation from Madison Central High School in 1923, he entered the University of Wisconsin in the fall of the same year. He earned his B.S. in electrical engineering in 1928 and M.S. the next year. In 1930, he moved to Pittsburgh to work for the Gulf-Research Laboratory, the research arm of the Gulf Oil Corporation. He worked there as a geophysicist till 1933. He studied both Mathematics and Physics as a graduate student at Princeton University. In 1935 Bardeen was offered a position as Junior Fellow of the Society of Fellows at Harvard University where he started working with the eminent physicists John

Hasbrouck van Vleck and Percy Williams Bridgman on problems in cohesion and electrical conduction in metals. He received his Ph.D. in Mathematical Physics under the supervision of physicist Eugene Wigner from Princeton in 1936 and continued working at Harvard till 1938. In the same year, he became an assistant professor of Physics at the University of Minnesota and served there till 1941 when he left the job to join the Naval Ordinance Laboratory in Washington D.C. as a civilian Physicist during the world war-II. After 1945, he begins to work at Bell Labs where he was a member of a Solid State Physics Group. Along with his colleagues William Shockley and Walter Brattain he researched how Semiconductors conducts electrons, which eventually led to the development of the transistor in 1947. In 1951, the University of Illinois at Urbana-Champaign offered Bardeen as the position of Professor of Electrical Engineering and of Physics with an annual salary of $10,000 which he accepted after leaving Bell Labs. where he proposed the revolutionary theory of Superconductivity in 1972. Once his friend Nelson Leonard, a chemist, said that Bardeen's "face always lit up" when he spoke about the interplay of science, technology and industry. Charles Gallo, a scientist at 3M, recalled that when Bardeen would speak about high-temperature superconductors at Minnesota Mining and Manufacturing, he "never once mentioned a theoretical, abstract or philosophical motivation. He only stressed the myraid practical applications and the economic viability". His first research student was Nick Holonyak who eventually went to invent the first LED. [1,2]

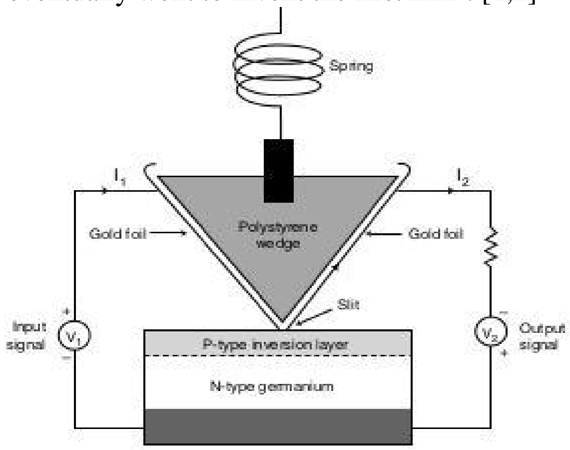


Figure 2: *The first transistor, December 16, 1947.* [1]

Achievement and Major Contributions:

Bardeen is a Fellow of the American Physical Society and member of its council from (1954-1957). He served as a member of the United States President's Science Advisory Committee. He was elected to the National Academy of Sciences in 1954. He gets many honors including the Stuart Ballentine Medal of the Franklin Institute, Philadelphia (1952) and the John Scott Medal of the City of Philadelphia (1955). He received the Fritz London Award for work in low-temperature physics in 1962. [2]

Bardeen played a major role in the development of the transistor along with Walter Brattain and William Shockley. The transistor became the primary building block of various other electronic devices and led to move research and development in the field of electronics and Communication. Before the invention of Transistors, electronic computers use the Vacuum Tubes. Vacuum Tubes are used as the cluster of switches. The basic arrangement of vacuum tubes consists up of a cathode and a plate, separated by a control grid, suspended in a glass vacuum tube. The cathode is heated by a red-hot electric filament, which causes it to emit electrons that are attracted to the plate. The control grid in the middle can control the flow of electrons. By making it negative or positive, we can control the on/off the output of the plate by causing the electrons to the repelled or attracted to the cathode. The vacuum tubes consume much more power as it also losses energy in the form of heat. Its wording efficiency is not as reliable as a switch. After the invention of the transistor's in 1947 (the device which functions as a solid-state electronic switch), replaced the less-suitable vacuum tubes. It is efficient in the various prospects as it has a much smaller size, consumed less power, and faster than the vacuum-tubes.

Figure 3: *A stylized replica of the first transistor invented at Bell Labs on December 23, 1947.*[1]

Although there have been many designs for transistors over the years, the transistors used in modern computers are normally Metal Oxide Semiconductor Field Effect Transistors (MOSFET). Transistor basically is the back-to-back connection (or sandwiched) of the two junction diodes (primarily made up of doped Semiconductors). Based on the arrangement of doped Silicon (Semiconductor) MOSFET's has of two types; NMOS or PMOS. Silicon doped with boron is called P-type (positive) because it lacks electrons, whereas Silicon doped with phosphorus is called N-type (negative) because it has an excess of free electrons. An NMOS transistor is made by using N-type Silicon for the source and drain, with P-type Silicon for the Source and Drain, with P-type Silicon placed in between. The gate is positioned above the P-type Silicon, separating the source and drain and is separated from the P-type Silicon by an insulating layer of Silicon dioxide. Normally, there is no current flow between N-type and P-type silicon, thus preventing electron flow between the source and drain. When a positive voltage is placed on the gate, the gate electrode creates a field that attracts electrons to the P-type Silicon between the source and drain. That, in turn, changes that area to behaves as it were N-type Silicon, creating a path for current to flow and turning the transistor "on". In a similar manner, PMOS works but in the opposite fashion. Almost every technological applications of today's generation are based on the transistors. Scientists have still strived to make it smaller and smaller. The technology materialized with Graphene and Carbon nanotubes, are being explored to produce even smaller transistors, down to the molecular even atomic scales. The modern technological architecture is based on the combination of large no's of transistors on a single device called IC (Integrated Circuits). Thus, without the transistor, today's electronics and technology could not sustain.[3]

Superconductivity was long considered the extraordinary and mysterious of the properties of metals, but the theory of Bardeen, Cooper and Schrieffer-the BCS theory-has explained so much that we now understand the superconducting state, almost as well as we do the normal state. The BCS theory provided a broadly applicable explanation for a problem that many physicists considered unapproachable. Today, the BCS theory is considered one of the hardened and most useful tools for explaining a wide variety of physical phenomena, including those in condensed matter physics and in many seemingly unrelated fields. If we will able to use the superconducting materials as the wire of the transmission line, we wouldn't have to waste any form of energy in transmission from the point where the electricity is generated to the point where is to use. [4]

Conclusion:

John Bardeen served as an advisor till the end of his life and involved in the academic research of Science and Technology. He undoughtly was the great personality of the 20th century who serves the society as in the various prospects of civilization and Science and Technology. He is not only the distinguished physicist of the 20th century but also the good human being who changed the world by discovering the transistor and giving one of the most important theoretical developments of the Superconductivity (the BCS-theory). The world (especially the Physics fraternity) always feels incomplete with the physical absentees of such a great personality and always remembers him.

References:

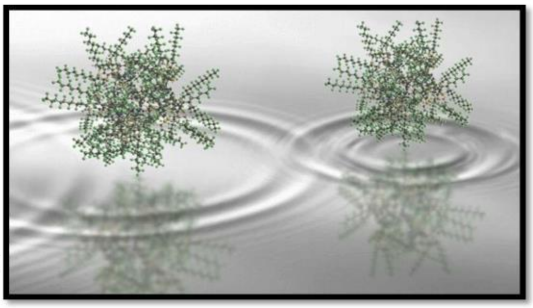
[1] L. Hoddeson & V. Daitch, True Genius; *The Life and Science of John Bardeen*, Joseph Henry, Press Washington, D.C. (2002).

[2] https://www.nobelprize.org/prizes/physics/1956/bardeen/biographical/, The Nobel Prize in Physics (1956).

[3] A. Malvino & D. J. Bates, *Electronic Principles*, McGraw-Hill Companies, Inc., New York (2007).

[4] http://www.brown.edu/Administration/News_Bureau/2006-07/06-129.html, Symposium Marks *50 Years of BCS Theory of Superconductivity* (2019).

2000 atoms in two places at once: A new record in quantum superposition



The quantum superposition principle has been tested on a scale as never before in a new study by scientists at the University of Vienna in collaboration with the University of Basel. Hot, complex molecules composed of nearly two thousand atoms were brought into a quantum superposition and made to interfere.

The experiments by Markus Arndt and his team at the University of Vienna approach this question in the most direct way possible, that is, by showing quantum interference with ever more massive objects. The molecules in the recent experiments have masses greater than 25,000 atomic mass units, several times larger than the previous record. One of the largest molecules sent through the interferometer, C707H260F908N16S53Zn4, is composed of more than 40,000 protons, neutrons, and electrons, with a de Broglie wavelength that is a thousand times smaller than the diameter of even a single hydrogen atom. Marcel Mayor and his team at the University of Basel used special techniques to synthesize such massive molecules that were sufficiently stable to form a molecular beam in ultra-high vacuum. Proving the quantum nature of these particles also required a matter-wave interferometer with a two-meter long baseline that was purpose-built in Vienna.

Source: https://phys.org/news/2019-09-atoms-quantum-superposition.html

COVER STORY - 2

Personal life of John Bardeen

Pramita Tiwari
M.Sc. (Physics), Fourth Semester, CDP, TU, Kirtipur

ABSTRACT
This article provides personal information about John Bardeen, The only individual to have won the Nobel Prize in physics twice.

The Bardeen legacy had been based on diligent work and high expectations. The New World as a contractually obligated slave for seven years, Thomas Boardman, from whom he was to become familiar with the carpenter trade. After seven months, nonetheless, before he had done as such, Bardeen was transferred to John Barker, an owner in the town of Marshfield, approximately 10 miles north of Plymouth. From Barker, Barden learned the most effective method to lay blocks and run a ship administration over the Jones River. In the end, Bardeen wedded Barker's little girl, Deborah, who was a lot more youthful than him. They constructed a house in Middleboro, Massachusetts, which still stands, and had 13 youngsters. Their relatives scattered across the continent.

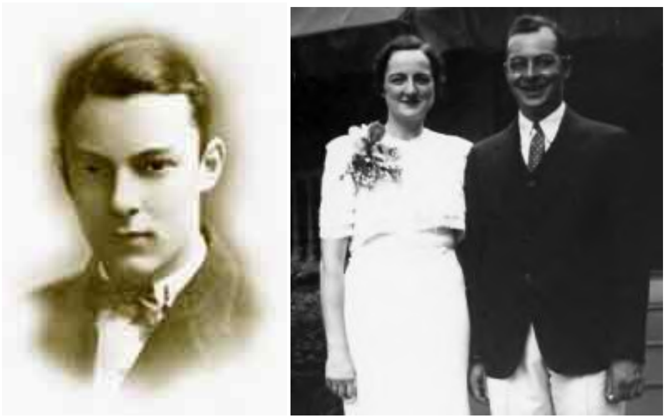


Figure 1*: John Bardeen when he was 17 years old, and with his wife Jane Maxwell.[4]*

It was Van Hise who brought John Bardeen's father, Charles Russell Bardeen, to the University of Wisconsin. Among Van Hise's plans for the University of Wisconsin was to set up a medical school. In 1903, very quickly upon getting to be president, he made a trip toward the East Coast to recognize the legitimate man to lead this undertaking. He found Charles Russell Bardeen at Johns Hopkins. A thirty-two-year-old associate professor of anatomy, Bardeen previously had a strong reputation based on his research in anatomy his teaching at Hopkins. Later, Charles Russell Bardeen married to Althea Harmer had classic features and long, dark hair that she sometimes pulled back into an elegant French twist. According to one Bardeen family story, Althea and Charles met in the context of her decorating business. She found herself working with him on the decor of the University of Wisconsin faculty club. During the spring of 1905, he came to Chicago to see her as often as possible.

On May 23, 1908, Althea and Charles had a second child, a ten-pound boy, they named John. After John the Bardeens had two more children in fairly rapid succession: Helen on October 13, 1910, then Thomas on April 10, 1912. John joined his sibling and other neighborhood youngsters in their interest with science and innovation. At around thirteen, he wound up inspired by science through perusing a book, Creative Science, which portrayed how American natural scientists had figured out how to make fake colors when the German supply of colors was cut off during World War I. During the 1920s John and a significant number of his companions were enthralled by the enchantment of radio. They spent endless hours outside tuning in to the sounds conveyed by the peculiar electromagnetic waves detected by their precious crystal sets. John constructed his own precious crystal sets and receiver hoping to hear voices or music from Chicago. From an early age, John accompanied his parents to the golf course caddying for his mom when he was still too youthful to even think about playing. He started to get familiar with the game when he was mature enough to swing a club. In time John's childhood enthusiasm for golf turned into an adult passion.

The years 1918 to 1920 were a roller coaster of hope and despair for the Bardeens family. Every time Althea recovered from surgery and the harsh effects of her X-ray treatments, new nodules would appear or she would become otherwise ill again. On the evening of April 19, John stopped by to see his mother. Even with the disruption of Althea's death, John completed all his Uni High course work by age thirteen. But as he was so young, he and Bill decided to attend Madison Central High School for two years, taking additional mathematics, science, and literature courses not offered at Uni. By the time John had turned fifteen and Bill seventeen, the two had completed every course of interest at Madison Central. There was no longer any reason to postpone entering college. In the fall of 1923 they both entered the freshman class at the University of Wisconsin. John lived at home while trying to be a "college man." Perhaps to appear older, he began to smoke cigarettes.

Figure 2: *(a) Father of Jhon Bardeen, Mr. Charles Russell Bardeen. He was an American physician and anatomist and the first dean of the University of Wisconsin Medical School.(b) John and his siblings, 1917 [4].*

Mathematics remained Bardeen's most loved academic subject. He enjoyed its puzzle-solving aspect. In any case, he was likewise persuaded that he would not like to "end up being a college teacher. An academic profession sounded uninteresting to him and to his companions, who were generally children of the local businessman. He chose to study electrical engineering since he "had heard that utilized a great deal of mathematics, and he realized that engineers stood a superior possibility of securing a decent living than did mathematicians. He began to study calculus on his own. At the University of Wisconsin, Van Vleck presented the new quantum physics in a two-semester course, Physics 212, which Bardeen took during the 1928–1929 school year. One of the earliest of its kind offered in the United States, the course was Bardeen's first serious introduction to quantum mechanics. He found it interesting.

As Bardeen was younger than his friends, he didn't think twice taking additional courses to explore different fields outside his course of study. He could stand to take a semester off and did as such in the fall of 1926 to extend the summer he was doing as a prerequisite for his engineering degree. The job, in the Western Electric Company's Inspection Development Department, consisted of creating assessment techniques for specific items of interest to the company. Bardeen thought it was intriguing to work. Bardeen also worked on electrical prospecting, in which data about oil stores originated from estimations of resistivity variation. The fundamental assumption was that "changes of resistivity pursue the bedding planes. In their 1932 article in Physics, Bardeen and Peters cautioned that the data picked up from such electrical estimations couldn't be depended on for depth of more than 2,000 feet. Dwindles depicted the hypothesis in more detail in a later paper, which won the Society of Exploration Geophysicists' Best Paper award for 1949.

Bardeen soon understood that to change careers and himself to mathematics or physics would require more education. He considered just a single graduate college—Princeton because there was an exceptional mathematics department as well as the Institute for Advanced Study that had quite recently begun there a couple of years ago. Bardeen later entered Princeton's program for the spring 1932 semester. Bardeen remained vacillating between physics and math. He thought he had more ability in math yet thought about physics more intriguing. Regardless, picking was pointless as the physics and math graduate students took similar courses. Despite the fact that his Ph.D. was in math, he chose a material physics issue for his thesis Bardeen understood that he would need to get a handle on a lot of what was thought about the physics of solids. He would need to figure out how the electrons in metals interact with each other and with the crystal lattice. These were issues that concerned him all through his career. Back at Princeton, he went to the library and turned upward all that he could discover on work function. Wigner, who urged every one of his students to immerse themselves in the detailed literature of their field. Bardeen included the propensity for investing everyday energy in the library to his armory of problem-solving tools. Throughout the years he developed a colossal store of knowledge about solid-state physics.

In his thesis calculation, Bardeen initially expected to make workable approximations for the electron interactions. Beginning with a strategy pioneered by Douglas Hartree and Vladimir Fock, Bardeen wrote down a wave function that described every electron approximately, with its own single-electron wave function. He next demonstrated the distribution of electrons at the surface of the metal, including higher contributions arising from electron forces that correlated electrons with other electrons. It was a heroic early work in the field. He was ready to write up the thesis by the spring of 1935, publishing it as a joint work with Wigner. As it turned out, Bardeen had the luxury of choosing between two attractive fellowships, for Princeton also offered him one of its prestigious Proctor fellowships for 1935–1936. As the Harvard fellowship paid substantially more ($1,500 a year plus board at Harvard's Lowell House) and was guaranteed for three years, the choice was easy to make. "*Three years of job security was no small item at the time.*" Another consideration was that Harvard's fellowship was in physics, whereas Princeton's was in mathematics. It was obvious that he went in the direction of physics.

Physics was not the only challenge Bardeen faced while at Harvard. Although he thought that his romance with Jane was flourishing, she disagreed. Nearing thirty, she wanted to know whether she and John were going to be a permanent couple. Unless they could see more of one another, how could they decide? "Every time I saw him I liked him better," but "I got small doses", Jane said. It frustrated her that John avoided all talk of marriage. Late in March, 1938, Minnesota offered Bardeen an assistant professorship. The salary, $2,600 a year, was less than he had made at

Gulf five years earlier, but Bardeen knew he was lucky to have any offer at all. The academic pay scale could not be compared with the industrial one. Most universities had no theoretical physicists on their faculty. He accepted the offer. Wedding plans now took center stage for John and Jane. They agreed to keep expenses down by scheduling the event directly after one of John's professional engagements. In July he had agreed to lecture on the physics of metals at a summer school hosted by the University of Pittsburgh. It made sense to have the wedding in Washington, Pennsylvania, where Jane's family lived.

After the war, in 1945, Bardeen joined the Bell Telephone Laboratories in Murray Hill, N.J., where he, Brattain, and Shockley directed research on the electron conducting properties of semiconductors. The work that led to the transistor began on October 22, 1945. The "magic month" that culminated in the transistor began in the middle of November 1947, three months after Bardeen and Shockley returned from Europe. Brattain had encountered an apparently innocent problem during the course of one of his experiments. Droplets of water condensing on the apparatus were causing a spurious effect. In an effort to avoid the cumbersome two-week-long job of pumping out all the water, he attempted a quick fix. In one of their first trials, at 1,000 cycles per second, they achieved a power gain of 1.3 and a voltage gain of 15. The transistor was born. The transistor supplants the bigger and bulkier vacuum tube and gave the Technology to keeping up the electronic switches and other part required in the development of PCs.

Figure 3: *Bardeen, Cooper and Schrieffer*

In 1953 Bardeen undertook an extensive literature study of superconductivity for an article that he agreed to author for the Handbuch der Physik, a major review encyclopedia. Bardeen concentrated on the review during 1954, writing almost 100 pages. Bardeen's article also explored the nature of the phase transition between the normal and superconducting states. Bardeen structured the BCS team on his favorite social model, the family. Like his own father, Bardeen treated his students as fellow explorers, giving them latitude and allowing them to suffer consequences of their actions. He shared with them his deep understanding of the quantum theory of solids.

On November 1, 1956 Schrieffer ran into Bardeen on the street. Bardeen smiled, "Oh, I just wanted to mention—I won the Nobel Prize. " Schrieffer, now a fourth-year student, also had mixed feelings about Bardeen's prize. He was enormously pleased for Bardeen and the excitement "sort of boosted us up." Schrieffer's wave function initiated "a period of the most concentrated, intense and incredibly fruitful work" that Cooper had ever experienced. The team announced the BCS theory in March 1957 at the annual meeting of the American Physical Society devoted to solid state physics. Bardeen gradually settled into the role of physics guru, the authority to consult on almost any problem, in both the physics and electrical engineering departments at the University of Illinois.

Giaever for his tunneling experiments, and Esaki for the observation of tunneling in p-n junctions. And the prize for BCS was awarded a year earlier, in 1972. Bardeen first learned that he had won a second Nobel Prize in physics from a Swedish journalist who called his home from New York on Thursday, October 19, 1972. According to one biography, he once made a hole-in-one and asked a question, "*How much is that worth to you, John, two Nobel prizes*?" Bardeen responded, "well, perhaps not two". After his second Nobel Prize, Bardeen began to prepare for his retirement, set for March 1975. Having taught for more than twenty years at Illinois, he looked forward to spending all his time on research. In September, 1990 Bardeen learned that he was to be named one of Life magazine's "*100 Most Influential Americans of the Twentieth Century*." Bardeen died in January 30, 1991.

References

[1] https://www.softschools.com (October 2018).
[2] https://www.brittanica.com/biography/john-bardeen (October 2018).
[3] https://www.nobelprize.org (September 2018).
[4] https://www.pbs.org/transistor/album1/bardeen/ (October 2018).
[5] https://www.famouspeople.com/profile/john-bardeen (October 2018).
[6] L. Hoddeson, V. Daitch, *True genius: the life and science of John Bardeen*, Joseph Henry Press (2002).

Researchers observe exotic radioactive decay process

Researchers from the National Superconducting Cyclotron Laboratory (NSCL) at Michigan State University (MSU) and TRIUMF (Canada's national particle accelerator) have observed a rare nuclear decay. Namely, the team measured low-kinetic-energy protons emitted after the beta decay of a neutron-rich nucleus beryllium-11. The research team presented their results in an article recently published in Physical Review Letters.

Source: https://phys.org/news/2019-09-exotic-radioactive.html

COVER STORY - 3

Invention of Transistor

Ajay Gopali
M.Sc. (Physics), Fourth Semester, CDP, TU, Kirtipur

ABSTRACT

John Bardeen, Walter Brattain and William Shockley were awarded with Novel prize in 1956 for invention of the point-contact semiconductor amplifier (transistor action) in polycrystalline germanium.

Introduction:

One of the foundational element of all electronic devices today is the transistor, a semiconductor device including three terminals, emitter, base and collector, arrange in such a way that two regions lies at the extreme section with same kind of majority charge carrier either electrons or holes, while the section middle has the opposite charges as the majority charge carrier. Transistor, forms a combination of two PN junctions,which is capable of amplifying an electric current or voltage which is applied to one of the terminals and output through another terminal.The first transistor, point-contact semiconductor amplifier in polycrystalline germanium or silicon, was invented by the theoretical physicist John Bardeen and Electric Engineer Walter Brattain on Dec, 1947 in Bell Laboratories.

Problem for invention

Bell Laboratories, one of the largest industrial laboratories, was the research lab of Telephone Company of American Telephone (AT) and Telegraph (T). In 1945, Bell Labs was researching some problems aroused in the system or devices due to use of Vacuum tubes amplifier. Vacuum tube first introduced by the American Inventor Lee. De. Forest for signal amplification but the device used for amplification was extremely unreliable, more power consumed and too much heat produced. After the Second World War, A team of scientists put a semiconductor switch for the replacement of Vacuum Tube Amplifier Shockley, Bardeen, Brattain and some others engineers and chemists were a member of the team.

At first, Shockley designed the semiconductor amplifier relying as 'Field effect' but a device, cylinder coated by thin silicon mounted close to a small metal plate, didn't work properly as expected. So, he assigned theoretician Bardeen and Experimenter Brattain to determine the problems. In 1947, Brattain built and ran the experiment, while dunking the apparatus-into tube of water, it worked. For better output, Brattain tried to experiment with gold in germanium eliminating the liquid but it didn't worked.

Later, Bardeen suggested very important point, he remembered some quantum mechanics research that had been done on semiconductors while he was at Princeton in the 1930s. He realized that everyone had been assuming electrical current travelled through all parts of the germanium but that was wrong electron behaved differently at the surface of metal. So finally, they abled to invent a Point-Contact Semiconductor Amplifier.

Point-Contact semiconductor Amplifier

Structure

The first transistor was about half an inch in height. Before Brattain started experiments, Bardeen suggested that metals contacts would be within 0.002 inches of each other about the thickness of a sheet paper but which was very small i.e. three times smaller than the smallest wire at that time.

Figure 1: *John Bardeen, William Shockley and Walter Brattain. Picture by AT&T (American Telephone and Telegraph).[1]*

So, instead of bothering with wires, Brattain attached a single strips of gold foil over the triangle. He sliced through the gold right at the tip of the triangle, two gold contacts just a hair –width apart. The whole triangle was held over a crystal of germanium of spring so that Contact lights touched the surface, the germanium itself sat on a metal plate attached to a voltage. This was the first semiconductor amplifier because when current came through one of the gold contacts, another even stronger current came out the other contact.

Working mechanism:

The point contact semiconductor amplifier works on minority charge carrier transport introduced by current. The introduction of minority carriers by a current is possible because its space charge can be neutralized by the concurrent introduction of an equal number of majority carriers. The change in minority carriers concentration can be enormous than the change in majority carrier concentration is trivial compared to the already existing majority carrier concentration. Bardeen and Brattain successfully negated the influence of the surface states on Nov 2, 1947. In Nov 17, Gibney noted on Brattain's electrolytic photovoltaic experiments might be enhanced by appropriately biasing the electrolyte to enhance neutralization of the surface states via electrolyte's ion.

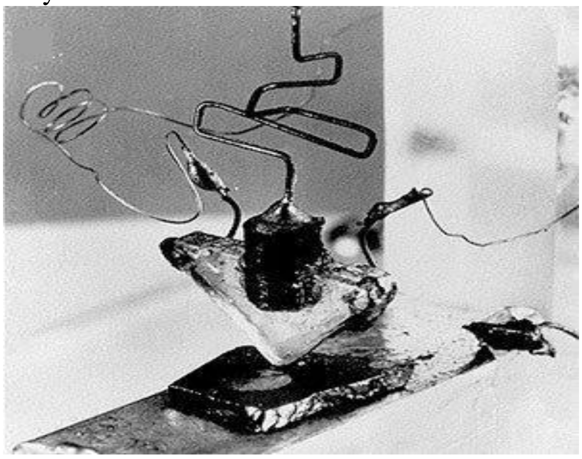


Figure 2: *First point contact transistor developed in Bell laboratory in 1947.[2]*

The change in polarity of voltage increased or decreased the change in the contact differential induced by photo voltaic effect i.e. the positive ions migrated to the p-type silicon surface in the positively applied bias where they neutralized the (negatively charged) surface states and enhanced the internal electric field at the semiconductor surface due to repulsive of the holes. The electric field lines of force from the positive ions that are not terminated on negatively charged surface are terminated on negatively charged accepter ions, leading to increased energy bandbending. The photo generated free electrons and holes one swept to surface due to electric field, thereby increasing the contact potential. Analogously, a negative biasedon the electrode, electrolyte aligns the negative ions to the surface decreasing the contact potential. This research culminated the concept of an amplifier. Concurrently, Bardeen comprehended that it was not efficient to modulate the conductivity of the slab of semiconductor via field effect.

In his Early research,Bardeen illustratedhis circuit configuration for the electrolyte control of surface states to manipulate the current flowing into point contact using p type polycrystalline silicon with an n-type inversion layer. As noted above, with the electrode in the electrolyte made positive, the positive dipoles aligned itself to the semiconductor surface neutralizing negatively charged surface states. This removal of the surface states influences permitted holes, from an insulated point contact electrode making electrical contact with the p-type polycrystalline silicon to the modulated. Therefore holes easily transferred to p-bulk from n-type inversion layer and free carrier was achieved by the control electrode. Alternatively, a significant number of the positive potential on the electrode flowed to the positively biased point contact also electron, already presented in inversion layer attracted to the point contact, there seems slightly current amplification.

This was the first power gain in solid state amplifier. In this way, Bardeen developed the concept of utilizing the inversion layer to find confine the minority carrier transport. Many experimental modifications were in Bardeen's circuit structure i.e. replacing Si by Ge, the tungsten by gold and fabricating the insulation on the probe structure with Duco lacquer with paraffin glue. With two critical concepts of the inversion layer and field effect principle along with solid dielectric concept, Brattain summarized device configuration.

Conclusion:

The point contact semiconductor amplifier was great invention in developments of many modern electronic devices. Many devices, from small radios to computers etc. consist of different type of many transistors for signal amplification. For this important invention of point contact semiconductor Bardeen, Brattain and Shockleyjointly awarded Novel prize in Physics in 1956.

References

[1] John Bardeen, Novel Lecture (1956).

[2] Haward R. Huff, International SEMATECH, Inc. 787411 (2001).

[3] Alaina G. Levine, American Physical Society physics (2006).

Life's building blocks may have formed in interstellar clouds

An experiment shows that one of the basic units of life—***nucleobases***—could have originated within giant gas clouds interspersed between the stars. Essential building blocks of DNA, compounds called ***nucleobases***, have been detected for the first time in a simulated environment mimicking gaseous clouds that are found interspersed between stars. The finding, published in the Journal ***Nature Communications***, brings us closer to understanding the origins of life on Earth.

"*This result could be key to unraveling fundamental questions for humankind, such as what organic compounds existed during the formation of the solar system and how they contributed to the birth of life on Earth,*" says Yasuhiro Oba of Hokkaido University's Institute of Low Temperature Science.Scientists have already detected some of the basic organic molecules necessary for the beginnings of life in comets, asteroids, and in interstellar molecular clouds—giant gaseous clouds dispersed between stars. It is thought that these molecules could have reached Earth through meteorite impacts some 4 billion years ago, providing key ingredients for the chemical cocktail that gave rise to life. Learning how these molecules formed is vital to understanding the origins of life.

Source: https://phys.org/news/2019-09-life-blocks-interstellar-clouds.html

COVER STORY - 4

Bell Lab and John Bardeen

Pradip Adhikari
M.Sc. (Physics), Fourth Semester, CDP, TU, Kirtipur

ABSTRACT
This article describes the different achievements made on Bell Labs and working of John Bardeen on Bell Lab.

"Mr. Watson--come here--I want to see you." It was March 10, 1876, The first words of Sir Alexander Graham Bell to his assistant Thomas Watson waved through the strings, the turning point for the means of human communication and the beginning of world-changing innovations: Discovery of Telephone. With the different funds and awards received from the discovery of telephone, Bell founded an organization named Bell Telephone Company which later in consolidation with American Telephone & Telegraph (AT&T) company and Western Electric company formed the Bell Labs in the year 1925, presently owned by Nokia.

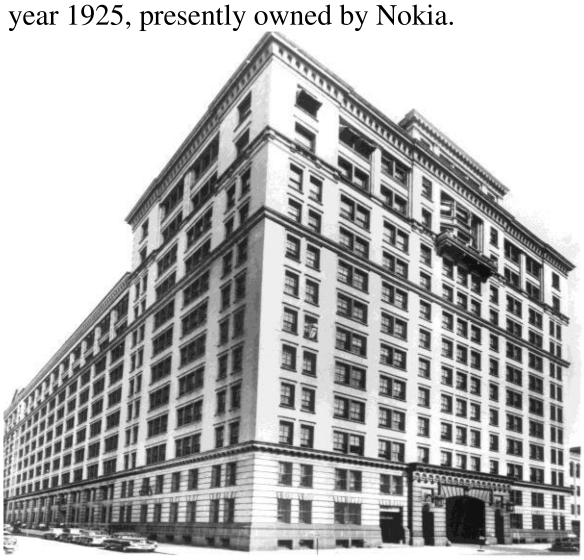


Figure 1: *The original home of Bell Laboratories beginning in 1925, 463 West Street, New York.*

By the beginning of the 20th century, AT&T had the monopoly over the telephone calls in the USA. After 1920, They started offering coast to coast telephone call service as the discovery of vacuum tube made possible to amplify the signals for long distance calls. The exponential growth on use of telephone and limited efficiency of bulky and power consuming vacuum tube set the necessity to the discovery of another efficient device for signal amplification and reliable electronic auto switching. Bell labs formed the eclectic mix of engineer, chemist and physicist for the discovery of such device to replace the then vacuum tube. John Bardeen, a brilliant theoretical physicist, an expert on the movement of electrons within semiconductors was invited to Bell labs research team along with William Shockley and Walter Brattain. John Bardeen was the precocious and mild-mannered person. Bardeen had played a significant role in the research at Bell Lab and discovery of the transistor. The teams attempt to seek the alternative of vacuum tube was previously based on the idea of Shockley about varying the conductivity of semiconductor using the external field. But this doesn't work. Bardeen invoked new idea and changed the focus of the study to the surface electrons of the semiconductors which were preventing field to penetrate. The ingenuity of Bardeen, deeper experimental knowledge of Brattain and their excellent teamwork finally lead to the discovery transistor. Shockley, Bardeen, and Brattain were jointly awarded Nobel Prize in Physics for their for their researches on semiconductors and their discovery of the transistor effect. This is the outcome and an epitome of confederacy on scientific discovery. But the clashing ego and rivalries made three of them never work again together. The rift arises as Bardeen and Brattain successfully made transistor in the absence of Shockley. Shockley was the man of competition and he exploited the group to work only on his ideas. Notwithstanding this Brattain refused to work with Shockley while Bardeen left Bell Lab and moved to the University of Illinois at Urbana–Champaign and continued further researches. In a memo to Mervin Kelly (The then director of the Bell Lab), he had written: "*My difficulties stem from the invention of the transistor. Before that, there was an excellent research atmosphere here*." Though Bardeen played a crucial role in the discovery of transistor, he didn't have much to do with its development. He began to pursue the theory of superconductivity and became the first man to get awarded with Nobel Prizes two times on the same field.

Apart from the discovery of transistor, Bell lab has made many revolutionary discoveries. Radio astronomy (Cosmic Microwave Background Radiation), LASER, C & C++ programming language, UNIX operating system, Charge-Coupled Device (CCD), Fractional Quantum Hall Effect are some of them. Eight Nobel prizes on Physics and one on Chemistry has been awarded to the discoveries made on Bell Lab.

References:

[1] M. Riordan, L. Hoddeson. Crystal Fire, *The Birth of the Information Age*, Norton Publication (1997).
[2] Awards and Recognition, https://www.bell-labs.com/our-people/recognition/ (November, 2018).
[3] John Bardeen, https://www.pbs.org/transistor/album1/bardeen/bardeen2.html (November, 2018).

COVER STORY - 5

Bardeen's contribution to SUPERCONDUCTIVITY

Bibek Tiwari
M.Sc. (Physics), Fourth Semester, CDP, TU, Kirtipur

ABSTRACT

BCS theory or Bardeen–Cooper–Schrieffer theory is the first microscopic theory of superconductivity since Heike Kamerlingh Onnes's 1911 discovery. The theory describes superconductivity as a microscopic effect caused by a condensation of Cooper pairs into a boson-like state. The theory is also used in nuclear physics to describe the pairing interaction between nucleons in an atomic nucleus.In this article, Bardeen's contribution to this area has been discussed.

Five decades of unsuccessful attempts to theorize and explain the hitherto seeming conundrum for understanding the phenomenon of the superconductivity fundamentally even under the luminaries of Quantum physicist like Bohr, Landau, Heisenberg, Feynman and many others made Felix Bloch crankily suggest a new theory to his dismay: "Superconductor is impossible". However, the underlying experimental truth of the superconductor brought into the picture by the Kamerlingh Onnes in the year 1911, is the fact of nature cannot be denied and it ultimately brought in the physics world the role of John Bardeen, Leon Neil Cooper, and John Robert Schrieffer. Their collective work entitled under the "BCS theory" not only surpassed the earlier attempt of brothers of London, and Herbert Fröhlich that partially satiated in explaining some features of superconductivity but also earned each of them the equal share for the Nobel prize in 1972. Outstandingly, Bardeen was successful in grasping the second Nobel Prize apart from his earlier work in 1956 for the research related to transistor effect.

The journey to understand the superconductivity giving the ultimate BCS theory has many research work behind for it and Bardeen had been doing a lot of researches in these areas. Bardeen, in particular, was a physicist who has a lot of friends in experimental works. Bardeen realized that the interaction of electrons and phonons plays a major role in superconductivity and his model based on small energy gaps reflects his theory consistent with the isotope effect. However, the model didnot explained the superconducitvity. Despite these failures, the concept of interaction between the electrons and phonons role in the superconductivity was a prominent one and several researchers started seeking the alternate models to find the experimental match. Later on, the mechanism on how the electron, in essence, could be in the attractive field of another electron through the electron-phonon interaction was known. However, John's and another independent researcher Herbert Frohlich attempt for a correct physical theory to explain the superconductivity failed. John Barden provided a list of research topics for Schrieffer where at the bottom of the list was about the superconductivity. Francis Low urged Schrieffer to give latter a try. Through the interaction with the distinguished experimenter, John realized that he had sufficient experimental facts that could restrict the direction to proceed for a better theory. John summarized such work in the review article published in Handbuch der Physik in 1955 along with a companion article by Serin indicating with the experimental situation of that time.

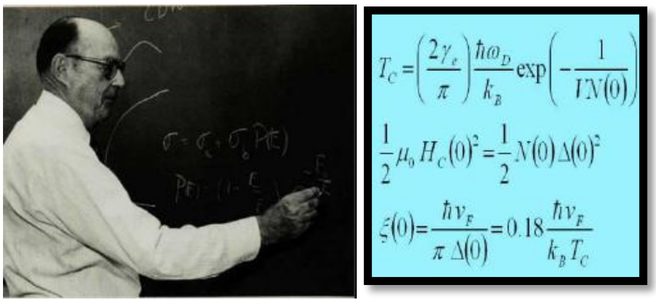


Figure 1: *Bardeen At the blackboard during 1982. [3]*

Brian Pippard through the magnetic measurements found correlations among nonlocal kernel that relates the vector potential and the current density. Bardeen through his consequences of energy gap model could obtain such consistencies. Moreover, Bardeen showed that the maximum distance over which the magnetic field at one location affects the current density also known as the Pippard coherence length varies inversely with the energy gap. Barden further highlighted the major role played by the electrons very near the Fermi surface for superconductivity. Bardeen realized a need for a new formalism to handle such a complex problem and in this regard, through Chen Ning Yang at the Institute for Advanced Study he got Leon Copper recommended. The Schafroth's theorem provided an implementation of diagrammatic perturbation theory that guided and in fact motivated and convinced that it could be at the rescue to solve such a complex problem. This definitely provided a pathway toward the direction to solve a problem.

Bardeen played a significant role in explaining the essential aspects of a successful theory of superconductivity to his team work which has some close connection in some respects to the ideas of Fritz London. Barden has deep insight that some until then unknown order parameter corresponding to the condensation of electrons in momentum space. He insisted that superconductivity was a consequence of such long-range order. Further Bardeen focused that an energy gap or at least a strong depression in the density of states of the excitations is characteristic of a superconductor. This model was consistent with the experimental results on the thermal conductivity, the electronic specific heat, and the microwave and optical conductivity. Bardeen deduced that the in the order of 10-8 eV per electron is for the condensation energy in going from the normal to the superconducting phase. This is in fact much smaller than the electron correlation. Calculating such condensation energy is the challenging problem for today too since one must isolate the essential physics of the transition. To rescue such problem Bardeen argued that normal phase is described using the Landau Theory of a Fermi liquid.

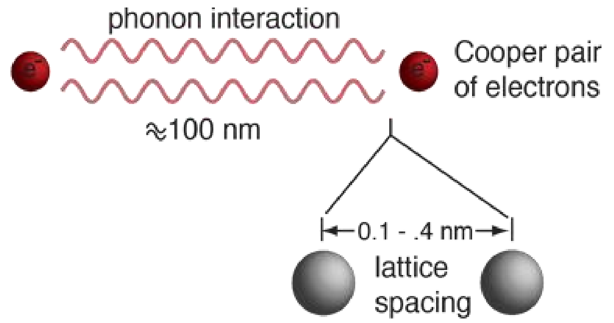


Figure 2: *Cooper Pair - electron pairs are coupling over a range of hundreds of nanometers, three orders of magnitude larger than the lattice spacing. Called Cooper pairs, these coupled electrons can take the character of a boson and condense into the ground state.*

Leon Cooper and Schrieffer started focusing on a gap between the ground state between the ground and the low lying excited states and later on a two-fluid model to explain the phenomenon of superconductivity. During 1956, Bardeen carried out rigorous study of two electrons interacting above a quiescent Fermi sea. Schrieffer also did research on Keith Brueckner's approach to many-body theory in search of an appropriate method for handling superconductivity. Cooper discovery of the instability of the normal state with regard to the formation of bound electron pairs convinced Bardeen that such discovery was an important clue. Then they collectively started working on the interaction of all the possible pair interactions keeping the full consideration of the exclusion principle. Bardeen reached the conclusion that the size of the bound state is very large with the mean spacing between condensed pairs. The situation of intense pressure was developed when Feynman was seeking a singular contribution to the electronic heat capacity through his fancy diagrammatic methods. John and Schrieffer started trying various variational-type wavefunction that might describe overlapping pair wavefunction. The continuous failure in the improvisation of the model had made the Leon Cooper and Schrieffer frustrated but Bardeen has insisted them on keep devoting on the topic as he had the feeling that he was about the breakthrough. In the meeting in January 1957, Schrieffer proposed many-body theory through statistical approximation analogous to a type of mean filed started with a wave function as:

$$|\Psi_0\rangle = \prod_k (u_k + v_k c^+_{k\uparrow} c^+_{-k\downarrow})|0\rangle$$

where the symbols have usual meanings.

There came the picture of the electron state with momentum k and spin up and an electron with momentum –k and spin down whereby they are either empty of simultaneously occupied. However, Bardeen argued that the pairs could not form the Bose state as it favors the no energy gap system. He said that the pair in different momentum state might satisfy the Bose statistics but there had to be the wide consideration of the exclusion principle so the pair hence must follow the Fermi Statistics. He deduced that without the exclusion principle one obtains the superfluidity but not the superconductivity. The pair overlap consideration later becomes crucial to the understanding of the superconductivity. The role of quasi-particles then came into the picture in finding the appropriate basis for the ultimate solution to superconductivity. The theory seemed to work when the result of the theory found a close match within the 10% accuracy to the experimental relationship between the critical magnetic field and the size of the energy gap, which Mike Tinkham and Rolfe Glover measured using far-infrared spectroscopy techniques. The first microscopic test of the theory was successful when the experiment of Charlie Slichter and his Student Chuck Hebel on NMR experiment to measure the longitudinal spin relaxation rate was conducted.

Over the next 13 days, three contributors to the theory worked rigorously to calculate all the observable properties from the theory and in fact did it correctly. In February 1957 the letter was submitted to Physical Review. In March 1957 Barden presented his work at the American Physical Society. The problem was regarding the lack of orthogonality between the excited and the ground state pairs. When this was tackled the problem of second-order phase transition was solved and in fact, this completed the problem beautifully. Several other problems that appeared were gradually resolved on subsequent papers by Bardeen, a fully gauge-invariant theory for instance. Several other theories started to evolve after then which has its all root to the BCS theory. In this regard, we can definitely say that Bardeen good grasp of experimental data had bounded the theory of superconductivity rigidly and his role is immnese for this successful theory.

References:

[1] https://phys.org/news/2014-07-science-stumped-einstein.html (September 2018)
[2] Nobel Prize site (October 2018).
[3] John Bardeen and the Theory of Superconductivity, Physics Today (https://physicstoday.scitation.org/doi/10.1063/1.881345).
[4] https://en.wikipedia.org/wiki/Superconductivity (Aug 2018)
[5] http://hyperphysics.phy-astr.gsu.edu/hbase/Solids/scond.html (July 2018).

COVER STORY - 6

The BCS Theory

Suvekshya Lamichhane
M.Sc. (Physics), Fourth Semester, CDP, TU, Kirtipur

ABSTRACT
The BCS theory is so far the most one successful in explaining the microscopic theory of superconductivity till now. This article talks about the BCS theory and the contribution of John Bardeen to it.

Introduction

Understanding the phenomena of superconductivity was challenging and perplexing during 19th century. During 1930 to 1950 considerable efforts were made by theoretical physicists to explain superconducting behavior from quantum mechanical model, using single electron phenomena until Bardeen, Cooper and Schrieffer came with the microscopic theory of superconductivity based on condensation of electron pairs into cooper pair in the year 1957. While this remarkable theory seemed to appear overnight, John Bardeen had been actually laying the groundwork for a period of years.[1]

Figure 1: *Left to right: Cooper, Bardeen and Schrieffer[1]*

Historical Background:

In 1911, Kamerlingh Onnes happened to find that the electrical resistance of mercury suddenly vanished at temperatures near absolute zero, while studying behaviors of materials at lower temperature. He called this phenomenon superconductivity, and additional materials were found that exhibited this property. However, no one could completely explain its underlying principles. Even the most prominent physicists of that time like Felix Bloch and Richard Feynmanwere failing in their efforts to solve the riddle of superconducting mechanism. While theorists were struggling to explain the phenomenon of superconductivity, experimentalists were discovering some interesting features of superconductorsin the years following Onnes's discovery. In 1933, Meissner found that superconductors would expel a magnetic field, which was called as Meissner effect. This interesting discovery added extra weight to understand superconductivity. John Bardeen was interested in solving the problem of superconductivity, but he went on working on Bell Labs to study transistor. [1]

There were theories like London equation, GL equations which were partially successful in explaining some features of superconductor but couldn't provide microscopic description of superconductivity. In 1950, Frolichs proposed the idea of interaction between superconducting electrons and lattice in an attempt to describe the dependence of critical temperature on atomic mass of superconductor, known as isotope effect. After this result Bardeen renewed his interests in superconductivity. Bardeen and Pine took into account the electron–phonon interactions that Frohlich had considered, and successfully determined how at low energies in a crystal lattice, electrons could overcome the Coulomb repulsion and attract each other.Another major concept in superconductivity came from A.B. Pippard in 1953 where he concluded that a coherence length which can be related to characteristic Cooper pair size, is associated with the non-local generalization of the London equation concerning electrodynamics in superfluid and superconductors. Bardeen had also assigned superconductivity as the subject for Schrieffer's Ph.D. thesis. Leon Cooper, whose background was in elementary particle physics, later joined them at the year 1955 after the invitation from John Bardeen himself. At that time Bardeen was looking for someone who was steeped in theoretical techniques of Feynman diagram and renormalization method so as to look the problem from different perspective. The trio then began working on constructing the framework of microscopic theory of superconductivity.Finally, they successfully explained the underlying principle of superconductivity and official announcement of this breakthrough was made in march 1957. They were awarded the Nobel prize in Physics for their land mark accomplishment in the year 1972. [2]

Theoretical Background:

a) Cooper pair

The attractive interaction between electrons due to exchange of phonons as pointed by Bardeen and Frolichs in 1950 serve as one of the pieces of puzzle towards a microscopic theory. An electron travelling in a lattice distorts the lattice; another electron in some distance away sees the distorted lattice and gets attracted.It is phonon mediated interaction as shown in the figure.The electron electron interaction in the presenceof phonon can be written as:

$$V(\mathbf{q},\omega) = \frac{4\pi e^2}{q^2 + k_s^2} + \frac{4\pi e^2}{q^2 + k_s^2}\frac{\omega_{\mathbf{q}}^2}{\omega^2 - \omega_{\mathbf{q}}^2} \quad (1)$$

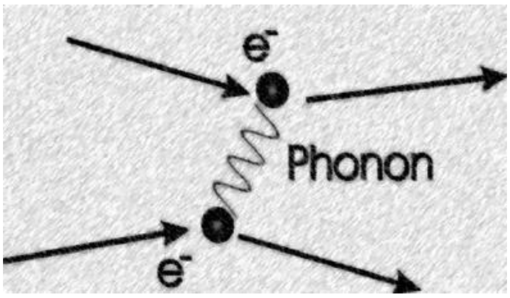


Figure 2: *Electron - Electron attractive interaction. [2]*

Where, the first term is screened coulomb potential which is repulsive and second term is phonon mediated interaction. It is clear that the second term is attractive for□<□q. Even though this equation is not much of use to describe superconductivity, it illustrates that negative interaction matrix element is in fact reasonable if electrons are restricted within a shell of width ħωq. [3]

Then in 1956 shortly before BCS theory, Cooper had been able to show that if there is a net attraction, however weak, between a pair of electrons in the vicinity of fermi surface i.e. state just above Fermi energy, Ef, these electrons can form a bound state. While looking at the matrix elements for all possible interaction between a pair of electrons from any two K values near Ef to any other two, Cooper finds that the matrix elements alternate in sign and all being roughly equal in magnitude give a negligible total interaction energy. He then took matrix elementsby requiring both k-state and its associate pair to be either occupied or non-occupied and obtained a coherent lowering of energy. While choosing the state to be paired with its given state, the momentum of the crystal must always be conserved which is given by equation (2).

$$k_1 + k_2 = k_1' + k_2' = K \quad (2)$$

It was found that the largest possible transition yielding the lowest energy state is for those pair whose total momentum vanishes i.e. K ≈ 0. It is also possible to show that exchange term tends to reduce the interaction energy for pairs of parallel spins. Hence the cooper single pair state is ├ $|k\uparrow,-k\downarrow\rangle$where,$k > k_f$.

These pairs of electrons behave very differently from single electrons. While the single electron acts like fermion obeying the Pauli exclusion principle, the pairs of electrons act more like bosons which can condense into the same energy level. Hence, the superconducting ground state is a highly correlated one with the vicinity of fermi surface fully occupied with pairs of electrons with opposite spin and momentum. [4]

b) The Ground State:

The formation of the BCS ground state is suggested by Fig. 5. It shows that with an appropriate attractive interaction between electrons the new ground state is superconducting and is separated by a finite energy E_g from its lowest excited state. At first sight the BCS state appears to have a higher energy than the Fermi state: the comparison of (b) with (a) shows that the kinetic energy of the BCS state is higher than that of the Fermi state. But the attractive potential energy of the BCS state acts to lower the total energy of the BCS state with respect to the Fermi state. [5]

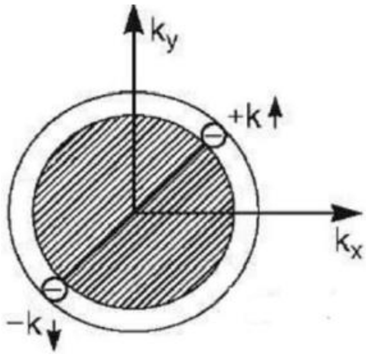


Figure 3: *Electrons interacting via an attractive. Pair states scattered are restricted to a* potential –V above fermi sea.

b) The Ground State:

The formation of the BCS ground state is suggested by Fig. 5. It shows that with an appropriate attractive interaction between electrons the new ground state is superconducting and is separated by a finite energy E_g from its lowest excited state. At first sight the BCS state appears to have a higher energy than the Fermi state: the comparison of (b) with (a) shows that the kinetic energy of the BCS state is higher than that of the Fermi state. But the attractive potential energy of the BCS state acts to lower the total energy of the BCS state with respect to the Fermi state. [5]

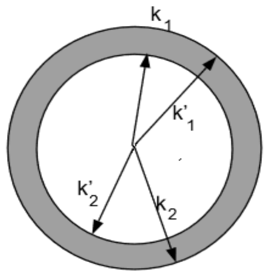


Figure 4: *Pair states scattered are restricted to a potential –V above fermi sea. narrow scattering shell of width ħω$_q$[3]*

The construction of ground state wave function for superconducting electrons was another challenge. Schrieffer was successful in figuring out the trial ground state as a product of operators one for each pair state acting on the state of no electrons. The ground state is

$$\psi_0 = \prod_k (u_k + v_k b_k^+)|0\rangle \quad (3)$$

Where, v_k is an amplitude that $(k\uparrow, -k\downarrow)$ is occupied in ψ_0 and $u_k = (1 - v_k^2)^{1/2}$is an amplitude that pair state is empty. b_k^+ is pair creation operator.

Implications of BCS Theory:

BCS theory was successful in predicting various effects which marked its success in giving theoretical description of superconductivity. An attractive interaction between electrons can lead to a ground sate of the entire electronic systems which is separated from the excited state by an energy gap. The critical field, thermal properties and most of the electromagnetic properties are the consequences of the energy gap. It correctly predicts Meissner effect. The London penetration depth and the Pippard coherence length emerge as natural consequences of the BCS theory. It also explains the isotope effects. Several specialized effects such as quantization of magnetic flux through superconducting ring, have given impressive evidence of BCS theory. [5]

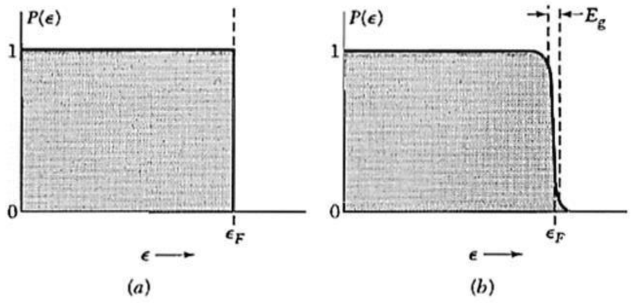


Figure 5: *(a) Probability P that an orbital of kinetic energy E is occupied in the ground state of the Fermi gas; (b) the BCS ground state differs from the Fermi state in a region of width of the order of the energy gap E_g. [5]*

Conclusions:

Although BCS theory is the only theory we have so far to describe phenomena of superconductivity, it has several shortcomings. It only explains Type-I superconductors but fails to explain phenomena of Type-II superconductor. It also couldn't explain high temperature superconductivity. In addition to these, it couldn't predict which materials are superconducting. These shortcomings suggest that there must be some different types of interactions occurring within superconducting system. The puzzle of superconductivity still prevails. [5]

References:

[1] https://www.aps.org/publications/apsnews/200707/history.cfm (October 2018).

[2] J. D. Doss, *An Engineer's Guide to High Temperature Superconductivity,* Wiley (1989).

[3] M. Tinkham, *Introduction to superconductivity*, Dover Publications, Mineola, N.Y. (2015).

[4] J. R. Schrieffer, *Macroscopic Quantum Phenomena from Pairing in Superconductors*, Science, **180** (4092), 1243-1248. doi:10.1126/science.180.4092. 1243 (1973).

[5] C. Kittel, *Introduction to solid state physics*, Wiley, New York (1956).

with younger sister William

with mother

"My father married twice. My mother had four children. She died of cancer when I was about twelve years old and then a year or so later my father remarried."

"My mother was an art teacher at the Drew Institute in Chicago, which later became part of the University of Chicago. Her specialty was Oriental Art, particularly Japanese Art, which was just coming to the notice of the West."

-John Bardeen

When Bardeen was 12, his mother became seriously ill with cancer … John didn't realize she was dying, and was stunned when it happened. His father quickly married his secretary, Ruth Hames … It didn't help Bardeen much -- he was ***heartbroken and distracted***, barely passing French that year. ***The death of his mother inspired him to do well in the future – to make a change.***

COVER STORY - 7

University of Illinois at Urbana Champaign and John Bardeen

Ganesh Pandey
M.Sc. (Physics), Fourth Semester, CDP, TU, Kirtipur

ABSTRACT

In this article, John Bardeen's association with University of Illinois will be discussed.

The University of Illinois at Urbana–Champaign (UIUC) is one of the US top-ranked public research university founded in 1867. It is R1 classified Doctoral Research University which means the highest research activity. Historically, it was one of the 33 colleges/university that was established after President Abraham Lincoln signed the Morrill Land-grant Act in 1962. Morrill Act reserved land for the establishment of the university that should aim to provide education on different sectors like agricultural, scientific, military, and technical to the people of the state of Illinois. At the time of establishment, it was named as "Illinois Industrial University". The university started its classes formally from March 2, 1968, with two faculty members and seventy-seven students. Later, in 1885, the university changed its name into "University of Illinois". By the time, other two campuses at Chicago were established under the University of Illinois System and people started to add Urbana—Champaign at the end of university name to represent the main campus because it is located at the twin city of Urbana and Champaign [1].

Figure 1: *Bardeen Quad viewed from Engineering Hall, UIUC*

Till this day, eleven alumni and fourteen faculty members of UIUC have won the Nobel Prizes giving rise to many innovative ideas that have the capability to change the world. Among them, John Bardeen is the only one in UIUC history and in the world's history to win two Nobel Prizes in the same field, Physics [1]. By December of 1947, John Bardeen and Walter Brattain were successful to invent the first point-contact transistor at Bell lab without any direct involvement of William Shockley, who previously used to lead that research group. However, all three people: Bardeen, Brattain, and Shockley were presented as co-inventors by the Bell Lab administration. This leads to the worsening of the relation of Bardeen and Brattain with Shockley. In addition, Shockley started to restrict the Bardeen and Brattain to work further on transistor [2].

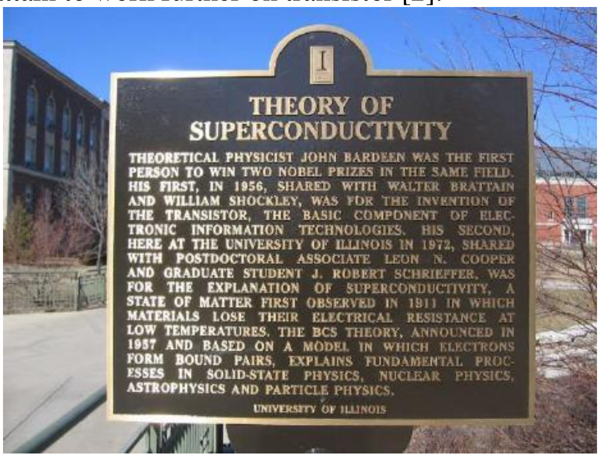


Figure 2: *Monument at UUC [6]*

That is why, Bardeen asked his grad school friend, Frederick Seitz, to find a job for him in the field of academia. Seitz was a professor of Physics at the UIUC and knew the potential of Bardeen. So, he convinced the dean of the college of engineering, William LittellEveritt to bring John Bardeen at UIUC. In the summer of 1951, Bardeen left the Bell lab and moved to Urbana, Champaign with his wife and three children [2]. Bardeen spent the longest period of his life at the University of Illinois at Urbana –Champaign. He worked as a professor of Electrical Engineering and Physics from 1951 to 1975. Bardeen formed a solid-state research lab at the Electrical Engineering department for the theoretical and experimental study of the semiconductor. One of the early research group members as well as Bardeen's first doctoral student, Nick Holonyak invented the Light Emitting Diode (LED) in 1962 which has become a major source of light till these days due to the low power consumption and longest lifetime [3]. Moreover, Bardeen focused on the research of superconducting phenomena, which has intrigued him since he was a PhD student at Princeton. Bardeen started a theoretical research group with his postdoc student, Leon Neil Cooper and doctoral student, John Robert

Schrieffer. The vanishing of electrical resistance in some metal below a certain temperature had been a mystery to the physicist and no successful theory was ever developed. In 1957, Bardeen, Cooper, and Schrieffer finally became able to discover the theory of superconductivity which is known as BCS theory [3].

Bardeen won many national and international awards, and honors including two Nobel prizes in Physics during his tenure at Illinois. The first Nobel prize of 1956 was for the discovery of transistor made at the Bell Lab along with Walter Brattain and William Shockley and the second one of 1972 for BSC theory with Leon Cooper and John Schrieffer [3]. Though he became Professor Emeritus in 1975, he incessantly devoted his life into the research, mainly focused on the understanding of the flow of electron in Charge Density Waves, in his later life.

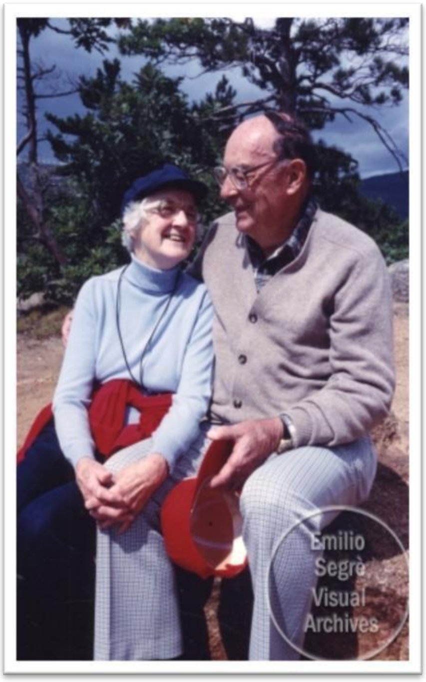
The University of Illinois at Urbana-Champaign have established or funded many prizes and fellowship in honor of John Bardeen. The Electrical and Computer Engineering (ECE) department have 'John Bardeen fellowship' and 'John Bardeen Undergraduate Award' for grad students and undergraduate students respectively [4][5]. UIUC, Physics Department has also set 'John Bardeen Award' to support outstanding works of the graduate student in condensed matter physics or in the physics of electronic device [6]. Similarly, the Department of Physics of the University of Illinois and the friends of Bardeen have sponsored 'The John Bardeen Prize' which was established in 1991 by the coordinators of the International Conference on the Materials and Mechanisms of Superconductivity (M2S) [7]. On October 14, 2004, UIUC had dedicated formerly called Engineering Quadrangular in the honor of John Bardeen which is now called as Bardeen Quadrangular or simply Bardeen Quad [8]. Furthermore, in Bardeen's honor, Sony Corporation endowed a $3 million faculty position at the University of Illinois. Professor Nick Holonyak is currently the John Bardeen Endowed Chair in Electrical and Computer Engineering and Physics [9].

John Bardeen, a meticulous thinker and brilliant scientist of the 20th century, spent the longest period of his lifetime at the University of Illinois, Urbana-Campaign (UIUC). His research works and inventions have become a priceless gift to humanity. Moreover, his presence and works at UIUC also played a significant role to uplift and make one of the world's prestigious University and Department of Physics and Electrical Engineering.

References

[1] https://illinois.edu/about/facts.html (February, 2019).
[2] https://www.youtube.com/watch?v=OyV8qSwGUHU (Published on Aug 26, 2010 By 'llinois1867') (February, 2019).
[3] https://physics.illinois.edu/people/memorials/bardeen https://ece.illinois.edu/academics/grad/ fellowships/bardeen (February, 2019).
[4] https://ece.illinois.edu/academics/ugrad/scholarships-and-awards/awards/bardeen (February, 2019).
[5] https://physics.illinois.edu/people/honors-and-awards/graduate-awards.asp#id4 (February, 2019).
[6] https://physics.illinois.edu/people/honors-and-awards/bardeen-prize.asp (February, 2019).
[7] https://engineering.illinois.edu/engage/distinguished-alumni-and-friends/hall-of-fame/2010/john-bardeen (February, 2019).
[8] https://www.nytimes.com/1991/01/31/obituaries/dr-john-bardeen-82-winner-of-nobel-prize-for-transistor-dies.html). (February, 2019).

Bardeen ***married Jane Maxwell*** on July 18, 1938. While at Princeton, he met Jane during a visit to his old friends in Pittsburgh.
While he served as a professor for almost 40 years at the University of Illinois, he was best remembered by neighbors for ***hosting cookouts where he would prepare food for his friends***, many of whom were unaware of his accomplishments at the University. He would always ask his guests if they liked the ***hamburger bun toasted*** (since he liked his that way). He enjoyed playing golf and going on picnics with his family.



Experience

Mr. Hari Timsina

2073 Entrance Topper

1) How did you get passionate in Physics? Share some of your experience.

From my childhood, I am crazy about new things. I was solely interested on math and science in school level and gave more priority on them than other subjects. Teacher used to ask me tough questions in the class that made me to study more at home. I love nature and was always curious about the phenomenon occurring in nature. Remembering the time that I frequently asked about rain and thunder to my mother and she answered me that was the act of god, I surprised. I was not quite satisfied with her explanation. I used to see moon, sun, stars and thought how they are made up of and why they are so distant from us. At the same time, I started to know about electrons, protons etc. When I knew that science especially physics can describe the fundamental particles as well as the whole universe, I decided to choose physics in future. Now, I am realizing that my decision was perfect.

My main source of inspiration was my family and teachers. They encouraged me to study hard and do well in examinations which ultimately lead me to the study well and understand the things. I explained about what actually physics is and subject areas of physics to my parents. After that they felt physics is interesting and support me for higher education in physics.

2) Have you ever thought that you could top the entrance examination of physics?

I did not think so. I always tried better and prepared like that which eventually paid for. After taking the entrance examination, I was confident that I had done well but not sure of being entrance topper. Since entrance was competitive and many other friends were also well prepared for entrance, I would be happy if other than me was topper. My family and friends always wanted to see me as a topper, being good learner and passionate student of physics, I was able to top the entrance.

3) What was your feeling when you knew that you were announced as the Entrance topper?

I was excited about the result after taking the entrance exam. There was fifteen days gap between the exam and result. On the day of result, I frequently checked the post about the result. When the result was published, I was at my hometown, Jhapa. After the result was published, I immediately downloaded the result and checked my name and roll number from the top so that I easily found my name on the top of the list. After knowing myself as entrance topper, I felt great and shared my happiness with my family. That moment was full of joy. This is the important step of my career as I am in the best place for physics students in Nepal.

4) Can you describe your preparation strategy of entrance examination? How do you distinguish this with the regular academic exams?

I mainly focused on the course that we have studied at B.Sc. I prepared for the entrance examination almost about nine months. After two months of final year examination of bachelor, I started my preparation. As the question pattern for entrance was objective, I decided not to go through lengthy derivations and explanations. I revised all the text books of B.Sc. thoroughly, trying to figure out the important concepts, physical meaning and application on each topic. As I work hard and practice a lot at B.Sc, I did not face much difficulties for understanding the basic things. I preferred reading and memorizing the formulas, their physical interpretations and practical meanings. The topics which I found hard and unclear before became clear at the time of preparation. I had a specific routine for study each day and after completing that I searched for the new things beyond the syllabus. During that period, I enjoyed physics much more than before and in one word my preparation was gone fantastic.

There is much difference between the regular academic exams and entrance exam. As the entrance exam model is objective type questions which requires the good understanding and depth concepts. You must be speedy for solving problems and should be able to take a quick decision. For the academic examinations, we focus on derivation and explanation of the necessary physics behind that. A lot of practice is necessary. But for doing good in both types of exams, you need to build proper knowledge on the topic and its applications.

5) Please give some advice to those who are willing to compete for the M.Sc. entrance exam?

Dear brothers and sisters, I advise you to develop the necessary concepts and basic ideas related to the contents so that maximum number of problems will be familiar and you can easily solve them. Don't fell stress while preparing for the entrance exam. If you enjoy and feel excited to learn more, you'll become successful. While preparing for entrance exams, go through the recommended text books and read line by line and try to grasp the knowledge from it. Read regularly. Do not depend solely on teachers, self -study will be fruitful. Whatever the strategy for your preparation, you should keep in mind that you have to be a good physicist in future. If your preparation is going well and if you are laborious, CDP is really waiting for you.

5) *Say something to motivate those who are having difficulties while studying physics?*

At first, everyone faces difficulties while studying physics. Once you entered in physics and realize that physics is interesting, you will enjoy it and don't want to return back. Proper time management and good knowledge of mathematics is necessary. As Einstein said, "Imagination is more powerful than knowledge", One should imagine the nature in various ways and think about it.

6) *Now a day, the trend of going abroad specially to the developed countries after the M.Sc. for Ph.D. In your opinion, what should be done to encourage them in local Ph.D. program?*

The political instability over a past decade have a seriously impact on the field of education. Due to the lack of proper opportunities in the field of science and technology in Nepal, the M.Sc. graduates are willing to apply for the abroad. If the government isn't serious about it, it is sad to say that the numbers of going abroad won't decrease. To encourage the M.Sc. graduates in the local Ph.D. programs, the government should play the crucial role. Promoting research activities within Nepal and providing the necessary facilities for researcher can keep the interested researcher in the country. The habit of doing research should be developed from the school level. Going abroad in not bad for the country but proper environment should be created to get them back with their developed skills and knowledge.

7) *Please relate success in some academics with the socio-economic success in the context of Nepal?*

The success in socio-economic sector directly relates with the success in academics. The collaboration between industries and universities can develop the country in better way. Without the development of science and technology, we cannot imagine the development of other things. In Nepal, the government only makes the plan to develop the country, but they do not have the proper design in the field of science and technology, that is why we do not have the taste of sustainable development yet.

8) *What do you think that the policy makers of Nepal should do to create for the proper employment/job for the physics graduates except teaching fields?*

Frankly speaking, as a physics student, I want to be a research scholar. The policy makers of Nepal should be aware of allocating the sufficient budget for the research program. Organizing scientific conferences and training programs regularly and keeping the physicists involved in such activities will encourage them to stay in Nepal. By utilizing the brain of physics graduates, we can find the better way to develop the nation.

9) *Finally, how do you plan to contribute to the society and nation after your graduation?*

I am thinking to go abroad for the further study. After completion, I will return in Nepal and I have a dream to develop the country through my knowledge and experiences. If government supports, I will mainly contribute to upgrade the academic system of the country and will attract the smart brains in research activities.

Discovery in gallium nitride a key enabler of energy efficient electronics

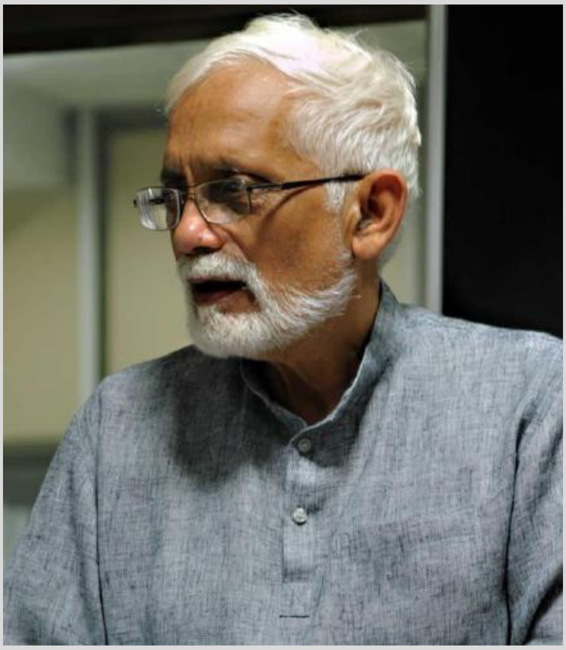
Gallium nitride, a semiconductor that revolutionized energy-efficient LED lighting, could also transform electronics and wireless communication, thanks to a discovery made by Cornell researchers. Their paper, "A Polarization-Induced 2-D Hole Gas in Undopped Gallium Nitride Quantum Wells," was published Sept 26, 2019 in Science.

Silicon has long been the king of semiconductors, but it has had a little help. The pure material is often augmented, or "doped," with impurities like phosphorus or boron to enhance current flow by providing negative charges (electrons) or positive charges ("holes," the absence of electrons) as needed. In recent years, a newer, sturdier family of lab-grown compound semiconductor materials has emerged: group III-nitrides. Gallium nitride (GaN) and aluminum nitride (AlN) and their alloys have a wider bandgap, allowing them to withstand greater voltages and higher frequencies for faster, more efficient energy transmission.

Source: https://phys.org/news/2019-09-discovery-gallium-nitride-key-enabler.html

An Interview

Dr. Subodh Raghunath Shenoy



TIFR, India

Dr. Shenoy is an Indian condensed matter physicist and a former professor at the Tata Institute of Fundamental Research. His research covered topological defect-mediated phase transitions, vortex dynamics and decay kinetics of metastability.

1) *Prof. Shenoy, at first we'd like to express our gratitude for your valuable time, did you enjoy your stay in Nepal? How did you find Nepal?*

My several stays here were all great! I found Nepal to be 'home-with-a-difference'. Perhaps Nepalis in India feel the same. Got a nice apartment in Lazimpat, an area with good restaurants and shops, saw most of the sights, taught at CDP, went to Pokhara with family, and also visited the TU Campus there. People in Nepal are warm, friendly and helpful. It is like being with cousins. Will visit again!

2) *How would you like to introduce yourself personally?*

Well, maybe human being, Indian, physicist, liberal democrat?We all have such multiple identities, nested sequentially inside each other.We need to consciously examine these, and think of what makes us what we are: to develop our own life philosophy,to help us make life decisions.

3) *What personally motivated you to choose Physics and condensed matter physics in particular?*

Every scientist has some trigger event in their youth, that started them on this path. See the personal stories in *One Hundred Reasons To Be A Scientist*, on the ICTP webpage. You can also ask your teachers, and visiting scientists, about how they were personally motivated to choose science. Each story is interesting!

A physicist from South Africa at one of the US National Labs, told me his own, funny story. He was in a school in South Africa that had both Boer (Dutch-origin) and English students, and a sophisticated English boy tried to put down this Boer student. "I know Matrices", he said grandly, "Do you know Matrices?" Our boy replied " Of course I know Matrices!" (although he had no idea.) So he rushed off, to learn what these things were, before their next meeting. And then found that Wow, this stuff is really interesting.. And read more, and more, and got hooked on science. And is now a physicist at a leading Lab. All because of that chance encounter, in childhood. The English boy is…somewhere.

Receiving Token of Love from HoD, CDP, TU

Myself? Well, I was a schoolboy in Ahmedabad, at St Xavier's School, joined a public library, started by a generous Gujarati businessman. It had a big dome, and metal shelves taller than my 13-year old self, lined with books. My uncle was an English Professor and writer, at University College, Trivandrum, and so far, I vaguely thought of doing BA English, andthen becoming a journalist, maybe. But I found a book: The Evolution of Physics, by Albert Einstein and Leopold Infield. (It was written by Infield, a poor Polish refugee in the US, who asked Einstein to put his name on it, so the book would sell.) Paperback, with the lovely, musty, dusty smell of old books that hold the promise of old wisdom. The book had magic words. It said that space around a magnet was modified: Every point had a mysterious something called magnetic field, which invisible little arrows was pointing in a pattern that moved as the magnet was moved. And it said that light was somehow connected to such moving fields.

I understood almost nothing. But wanted to know more of this field business: this strange and mysterious stuff of the universe. So for that, I needed to do a BSc Physics!

4) *You have provided valuable time on teaching Research Methodology to doctoral students, and*

Superconductivity to MSc students. Why did you choose those topics in particular?

Research Methodology has now become compulsory for a PhD degree in India, and I was teaching it at TIFR-Hyderabad. So when I was at TU to teach another course that was blocked by semester re-scheduling, this was a natural substitute, kindly arranged quickly and efficiently, by Prof. Binil Aryal. Also gave me a chance to type up some lecture notes on RM, for later use! Enjoyed teaching it, and hope students learned. Regarding the Superconductivity course taught in my next visit, well this topic has always been fascinating, since PhD student days. Quantum mechanics was invented for atoms, on the Angstrom scale. But here, it is operating on the centimeter scale: there is a giant coherent wave function you can pick up and move around! (This vivid comment was made by Nobelist AJ Leggett at a Low Temperature meet in Germany many years ago, and has stayed with me.)

In fact, I had taught Superconductivity to your own Prof Narayan Adhikari, decades ago, when he was a Diploma Student at ICTP, Trieste. The basic teaching philosophy wasthat students need to be taught in outline, but then work out the details in simple steps, as Exercises. To really understand, you must be able to really Do. Hope at least 80% of the class understood 80% of the material!

With participants

5) *You have cosmopolitan experience of teaching/learning in various countries like USA, India, Italy, and Nepal. How do you compare your experiences among those countries?*

Good question. Science is the same in every part of the planet, because Nature is the same everywhere. Drop a stone, and it will fall down faster and faster, gaining roughly 10 meters per second, every second. You will find this same result, regardless of your language, gender, religion, or passport. But the teaching of these same results can be different. Because you need to create a local version of the international scientific culture, of persistent questioning until there is personal understanding.

In some places, students are cursed with good memories. They remember details of formulas. But understand not so much, the science behind them. And they are shy about asking questions. (What if others laugh?) So the teacher must stop in the lecture and wait a few seconds, for students to gather courage and ask. Finally the local classroom culture will change to the global standard: Questions are Good Things. Ask, because others may have the same doubt. Science is understandings, and we ask and discuss, till we understand.

With faculties and participants

The other, related issue is getting some students even to trythings, and to do simple derivations/ substitutions in class. In some cases, they sit with pen over blank sheet, unable to make a mark. (what if it is wrong?) And they look at a teacher's face, to try and read from the expression, what they should do. This behavior comes from fear of making a mistake. The teacher has to be kind, and gently encourage this type of student, to trythings on their own.

In other places, lots-of-questions are the default setting. But there, you may face the opposite problem, of getting the students to first think a bit, and see if the question makes sense, before asking! In all places, both for teaching and research, we need to grow our own local scientific work culture that may be somewhat different from the surrounding culture. And all these worldwide pockets of culture are the same, and connected. You go halfway round the world, to a strange land. But you walk into a Physics Department, and suddenly you are home. We all share the same scientific method and values, and serve our countries, by representing themin this global Republic of Science. And it all starts, witha question.

6) *Developing countries like Nepal lose many of their graduates eventually to western countries. You, however, returned to India despite having studied in elite universities overseas. What is your advice to Nepalis pursuing PhD abroad?*

Well, there are many good institutions of the usual international standard, all over the world, including countries like India. And if you look at webpages of my colleagues, or other institutions, you will see that such bouncing around at good places and returning, is nothing special: literally hundreds of young Indians have come back, and over decades. Regarding young people from South Asia, studying abroad, my advice is this. Think about your long-term plans as early as possible. Do not drift accidentally into long-term life choices, but do things deliberately. Do you want to base yourself abroad and visit your home country; or do you want to be based at home and visit places abroad? It is not just a one-dimensional professional decision, but involves optimizing in multiple variables, with personal constraints: spouse's opportunities, caring for aging parents, how you want your children to grow up, what you want to build and leave behind. It has to be one, or the other: 0 or 1. Better to consciously choose the good host society; put down roots, with close friends from there; fully participate politically and socially; and let the children grow up naturally and freely, as citizens of the New Country.

But if you really intend to go back, then you need to plan ahead! On your summer visits,learn about conditions on the ground in your home country. Network with people, pick up useful bits of info, and prepare for eventual re-entry. Decide what savings you need to bring back, so the interest coversbare essentials, and job salary is a bonus. Keep up with your academic contacts in the PhD/ Postdoc countries, so you can visit yearly. Look up EU funding agencies, to see if they support joint projects with developing countries. Establish links with a larger country like India or China, so that nearby collaborations can emerge.

If you choose this path, you will be later able to point to the good papers you have written with a home byline; the students you have taught, who themselves returned; and the national institutions you have helped to reach the next level. You will have made a small, but real difference!

7) *This year's Symmetry magazine is dedicated to two-time Nobel laureate for invention of transistor, and for discovery of theory of superconductivity. As a condensed matter physicist can you shed some light on Bardeen's career and contributions?*

Well, cannot shed any new light, but old stories make good tales! Physics Today had an article on Bardeen, the modest genius. He played golf weekly with businessman friends for many years, without talking much about himself. Finally one of them asked the double Nobelist: 'You know John, have never asked, but what exactly do you do? '

Looking back at the Bardeen-Cooper-Schrieffer theory of superconductivity, that model (in two senses) of simplicity and power, one is struck by the foresight of Bardeen. He saw it was a quantum many body problem, unsolved for 50 years, that needed the new methods of quantum field theory invented by the particle physicists. So he hired the particle theorist Leon Cooper as a postdoc. And he had a good PhD student, Robert Schrieffer. (Imagine your boss giving you as a thesis problem –Go and solve Superconductivity!) The best account that I know of, is in The Engineer's Guide to High-Tc Superconductivity.

8) *The Government funding for research and development of technology is almost negligible here in Nepal. India, on the other hand has made huge progress in recent decades. In this regard, what can Nepal learn from it?*

Well, the political leadership of any country has to learn that the support of basic science is a small but essential part of national development. Without home-grown expertise in science and technology, the country will not even be able to technically assess proposals from foreign governments or private companies.And later, the country has to have its own people, to take part in innovation/ adaptation of technologies. Let the basic-science support be some small fraction of GDP, that is kept constant in real terms, and never decreased, no matter the party in power.

Choose the best young people in a totally professional way; fast-track admin procedures; encourage foreign colleagues to give talks (eg during their Nepal vacations!) Grow a local ecosystem of eg software firms from neighbouring countries, to hire some of the young MSc/ PhD manpower produced. They will stay in the country, and create a buzz! And other investors will notice.

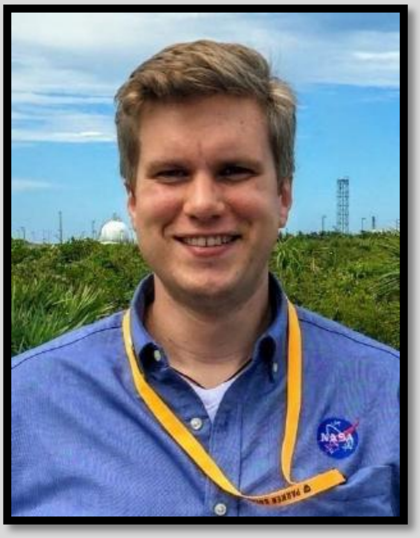
9) *It is necessary that general populace, and policy makers be scientifically literate as well – it helps with funding and but more importantly advances civilization at large. So how important do you think public outreach programs like exhibition, public lectures etc are?*

It is very important. We are asking a poor population to fund a tiny band of people, to do work of an international standard, as a patriotic contribution. They have a right to know what is being done with their taxes. But we must learn to be simple and speak of essential ideas, and of a unifying beauty. Use analogies, use humour. Say that now we too, are able to contribute to a global team effort. And we should convey that a scientific base is a national human resource investment, that will feed into future beneficial outcomes: Technological fruits need scientific roots!

10) *Increasing numbers of students are doing PhD in Nepal. Having spent time teaching both Doctoral and graduate students, would you like to give some suggestion/recommendation to them?*

There is only one common scientific standard of quality and competence. Meet it. CV Raman, as the story goes, had a PhD student who despaired of their low-power light sources, while foreign colleagues could work with high-power sources. No problem, said Raman. Just put a high-power Indian brain to work on the problem! I have taught students from here, and can say with confidence.

Dr. Michael S. Kirk, NASA Scientist, USA



(Dr. Kirk did Ph.D. in Astronomy from New Mexico State University, where his research focused on automated tracking of chromospheric bright points and their connection to solar eruptions. During this time, he also worked for the Air Force Research Laboratory at the National Solar Observatory in Sunspot, NM. In 2013, he joined the Heliophysics division as a fellow with the NASA Postdoctoral Program (NPP)..

1) *When did you come to Kathmandu?*

I arrived on last Monday it's just one week so I leave on Monday which is really not enough time to talk with students. But it's just not enough to do it so the idea is to come back again.

2) *That means your stay here is about one week.*

Yeah, just one week.

3) *And...What is your actual purpose of visiting Nepal?*

To visit Nepal is really to come here and work with the department of physics here so the idea is to come. Solar physics is an exciting discipline because all of our data is publicly available it's free all you just need an internet connection. It provides an opportunity for students to do projects for masters and for Ph.D. without having to get expensive observing time or without getting some sort of like supercomputer or anything like that. The data available is the same data that you get anywhere; all the professional's AstroPhysicists use this, so this is top quality data that you can have for free right here just right here. So that's part of why when it comes to talking about what exists, how to access it, what you can do with it and just kind of get some students some ideas of what they can do for their own research.

3) *Actually, you are delivering three lectures series here in our department about the Sun and related topics, what is the main purpose and expectations from this program?*

There are two expectations; one is to teach a little bit about the Sun. But there's just not enough time to teach. The other thing is to teach a little bit about programming because all professional astronomers and astrophysicists use programming they use some sort of programming languages and so to teach python specifically allow them to interact interface with researchers all over the world because researchers all over the world using this language. So the idea is to bring some knowledge of programming and data acquisition and data preparation as well as some of the theory about how the sun works with this scenario.

4) *Some students from Nepal, they want to research about the Solar Physics and some other related topics. So what would be your help and suggestions for those students?*

The first thing to do is to just some explorations either in literature or in online journals. Explorations of the data look at pictures of the things that initial exploration can give you an idea of what the field is there. And then the second thing to do is to contact the expert of whatever you're looking. All the papers have their authors and the contact informations, all the satellites have the mission of PI the person who runs a mission. So if there's something that you're excited about that's interesting or confusing, talk with that person directly send them an email introducing yourself saying I'm a student, I'm doing my master's degree, I'm very interested in in the phenomenon of solar tornadoes. Is there a solar tornado what are they? Could you tell me more about how the physics of Solar tornados works? Most scientists are free and very hopeful. So that is how you get started and build up relationships.

Delivering lecture at CDP, TU, Kirtipur

5) *Actually, I hear that besides Physics you are also interested in Music. I found it when I checked your bio in NASA 's official website. So, Could you please explain about your hobbies, passion other than Physics?*

Okay… I have lots of hobbies; I played saxophone in my free time. I think it was fifteen when I started playing the saxophone. So for more than fifteen years I have played the saxophone and play jazz I love it. I played the baritone saxophones bigger one it's a really nice a creative outlet it's just different than doing physics all the time. The other thing that I really love is food I love to cook. Which is one thing that I like about being here is that I can taste a bunch of new foods of a different flavor but yeah I love cooking as well. So those are my creative outlets it's important to have creative outlets. So, it's important to do some creative outlets besides just doing Science.

Dr. Kirk at National Observatory, Nagarkot

6) NASA, Europian Space Agency and other different research teams from a different part of the world are researching about Sun and other planets indeed overall Universe. How this will benefit the human kind, what's the real goal for the research of Extra-Planets and Sun?

Generally, research about astronomy is where there are the big questions the existential questions where do we come from, where are we going as a species, what will happen to our planet all of those big questions okay. In solar physics, there are much more fundamental questions about safety so when in solar physics there's stuff called solar wind. Material that leaves the sun and impacts the earth so that actually can harm anything that is in orbit. If astronauts are on their satellites, any sort of communication satellites and if that material hits the satellite it can cause electrical short. The company let's say cell phone company wants a satellite for communications, they can destroy the set. Okay, so that's a very immediate impact. Understanding how the sun works well hopefully prepare us so that we can change our technology, we can be protected from the sun, we can turn off sensitive equipment in orbit if the solar storm is coming, we can protect Astronauts. Those are some very immediate effect it's not like about Solar Physics. Is it balances between the two that you have the fundamental question of how did we get here and issue about the safety? But also this gives the answer to both the queries.

7) Actually, Our country Nepal is the developing country and its far more back than the developed countries in the context of Science and Technology. And recently the news is coming that Nepal is trying to launch the Satellite, it's good news for us. So, in this context how Countries like Nepal contributes to today's Science and Technology in the global world?

I'm going to answer that question more specifically how can you help the scientific community because that's what it is. Yes, Nepal could launch a satellite but why should Nepal spend a lot of Money to launch a Satellite, rather educate their people. So that's really where I see how they help. There are immediate ways they can help with especially with computer programs it's a way that you can you don't need a fast computer you just need a computer that works well to do some of these programming steps and that's where you can get involved immediately it's on the major research. If you want to help out on James Webb Space Telescope there are software consortium building. The software right now, you can become an expert in a software tool that will be used by the entire world right here and that's something you can do from this campus or from your own country and through that sort of open data and through that programming everybody has an opportunity to become an expert on the world. Is this something specific? So it's a big challenge in finding that area right? And that's part of why I'm here to help you. The landscape looks like to be able to find an area that you can specialize and you can be the expert. But there are all sorts of opportunities through that open data and through programming that you can become the expert you yourself. I think of it less about the entire Country and more about the individual people.

Inside the Dome: 24 inch telescope at Nagarkot, Nepal

8) Why did you choose the Astrophysics as the Major subject?

Yeah... So why I studied astrophysics? I've always been interested in it. I loved it since I was little. I wanted it also when I was five years old and I think my parents got one telescope for me. When I was eight or nine years old my aunt was a little telescope which wasn't very good but it was a telescope and I remember seeing the rings of Saturn for the first time through the telescope and felt just amazing. So I've always loved it. And then how I got into solar physics was a little bit different. After I finished high school and in my four years of undergraduate, I studied physics and astronomy. I always thought about I was gonna study galaxies, dark matter something really. But then, I realized that in studying galaxies and dark matter; if you take an image or take a measurement it doesn't change. Let's get better measurement it's just things happened so slowly that you take a picture now of the galaxy and you take a picture after twenty years of the same galaxy very very little change. Then I saw pictures of the sun and saw how it changes all the time and it's explosive instead. I realize that all those things I learned in school we're being demonstrated on some exciting way but just sucked me and so I kept on going. So my research now has largely been shaped by that I've been looking at things that change in the sun and images. So I've been doing a lot of image processing, image analysis to be able to identify things how the change makes very careful measurements and then go back to the physics and say how do physics describes what we see here in these images.

Token of love from HoD, Prof. Dr. Binil Aryal

9) For the young researchers in Nepal who are going to pursue their carrier in AstroPhysics and also in other branches of Physics. What could be your suggestions for them?

Two things; one is you have to think outside of Nepal you have to think more globally. Nepal is a great country it really loves country but science is international. I mean I'm here halfway around the world but science is a global community. And so in order to be in Nepal, you have done science you have to think about working with people outside of the country all over the world. So that is you know that's something that students who need to get used to doing it are that you gonna go to work here but then you broaden your ideas to email people from the US or talk to people from India or talk to people from Germany or wherever it is. And so building up that sort of communication being comfortable talking with other people from everywhere welcome you enrich your own experience and then that provides you opportunities to go into a Ph.D. somewhere. To go maybe you need somebody and from Max Planck institute German and you started working relationship during a master's degree. Then you go to Germany and works for five years or four years and do a Ph.D. in the future and then you can come back. That sort of global interaction is how you can move forward and. If you only think about Nepal, you're always limited and so think globally you always come back to Nepal you can always come but just think globally think about moving internationally.

10) Now, we are coming to the end of our interview. So, at last, do you have further plans besides this lecture series in Nepal now or in the future?

In terms of fun, I hope to do a little bit more sightseeing. Christmas is coming up in the U. S. and so I need to buy gifts from family. So you know there are other priorities I have to do. Since I leave in just a few days of the lectures we're gonna finish lectures talk students like you and then we'll go back the hope is that again. This will be ongoing that will come back again either to do a summer school or some other a little bit longer tutorials. This is just an introduction we can come back again.

11) At last, how you feel the culture of Nepal and hospitality that we Nepali do to the guest like you in Nepal?

Oh...it's very comfortable. I mean like I've been around the world in many different countries and it's just so much easier to be here than so many other places. Everybody is very friendly and willing to help but even people that I don't know what to sell you something they're being a little aggressive they want to sell you something and you say; no thank you. That doesn't happen other places it's really it's just everybody's just been so lovely that it's made my journey not only comfortable but someplace I look forward to coming back again.

Dr. Kirk, at Chandragiri Mountain, Nepal

12) Is there any recent plan to come back to Nepal again?

There are plans in the works I talked with professor Binil and we're looking at either in the spring of next year so April time may March-April or in the fall. That would be October of next year. So that's either in about a year or about six months and it depends on the class schedule here as well as NASA schedule. But I think we're working towards something into next year.

Hope to see you again….Thank you very much.

Dr. Farnando Quevedo

Director, ICTP

(Fernando Quevedo Rodríguez is a Guatemalan physicist. He was appointed director of the Abdus Salam International Centre for Theoretical Physics (ICTP) in October 2009. He obtained his Ph.D. from the University of Texas at Austin in 1986 under the supervision of ***Nobel Laureate Steven Weinberg.*** *Following a string of research appointments at CERN, Switzerland, McGill University in Canada, Institut de Physique in Neuchatel, Switzerland, and the Los Alamos National Laboratory, USA, as well as a brief term as professor of physics at the UNAM (Mexican National Autonomous University), Mexico, Dr. Quevedo joined the Department of Applied Mathematics and Theoretical Physics at the University of Cambridge, UK, in 1998, where he has been Professor of Theoretical Physics and Fellow of Gonville and Caius College.)*

1) First of all, we are very thankful to ICTP and its academic leaders for supporting our countries for Research and Development since last 30 years with limited resources for Researches and Development, what do you think now countries like Nepal contribute to Scientific advancement globally?

That's a very interesting question. In principle, we sometimes because I also come from the very smaller country and I even remembered my conversations with Abdus Salam when I was a young student or young postdoc and he was more or less challenging me in that regard. The thing that I always emphasize is that science has many aspects. The first one is cultural, so science is part of the culture. It has to be supported at the same way that people supporting art and literature and all that music as well so you need to have to establish a culture of science in each country that usually doesn't exist in our small countries because we had many limitations. So that's something we are lacking behind so in that sense for the reason that there is a big need to support. Culture science is needed for development? You cannot develop your country without the cultural part. Science is important for our future because we have all these potential risks that the only way to put the name into a person's through science. So in that sense, our countries small like Nepal has a lot to contribute on that and need of this aspects. So the part for the development of this is good for your Society that you need to have a strong base of science and to have a strong base of Science you need to have a cultural part. You have to have a status of culture in your country and then you know from many recent climate and earthquake and soon you need science to address the problems of your own country. So in that sense locally there's no problem but globally you say well, what about this is my case.

ICTP Director with faculties and students of CDP

I can tell you what Abdus Salam asked me when I was talking to him in one of my conversations. He told me, what do you think the String theory would be good for what about since I work in String theory? And of course, that was for me wasn't what is how can I answer that to the Great Abdus Salam? So the other thing that came to my mind is what may be as important as the standard model of particle physics was for Pakistan because team did he was behind that great hand so somehow I send the questions for him because somehow he devoted his life to something as useless as a string theory is he was developing weak interactions that are not doesn't have complete applications. But you can see the impact that Salalm has had globally and not only his country's a role model, but also globally as the source of knowledge for understanding basic science. So you can bring the questions, you saw the basic science are always questions not only for a small country. However also questioned in the developing countries, why should United States or Europe spend money in basic science is there all the sort of challenges that we have to address from climate as energy also into Military but at the end they invest. You have to convince them that there is a role for your basic Sciences countries because at some point you did have that background and you never know what would come out and the typical example I give them is CERN, CERN is the biggest laboratory in the world. It was this experiment that is LHC was this designed to look for mostly for one particle, which is the Higgs particle? The people have been working on that for 40 years and then now they manage to detect for a couple of years. But in the meantime, while they were working towards discovering the Higgs they came out with the World Wide Web. So imagine the impact that the world wideweb has had worldwide and then it was no plan. Nobody asked for them for a project to be funded to invent the worldwide web. They went they were looking for Higgs completely useless and then they came out with the World Wide Web that changes the lives very well this has much more impact than any applied subject.

ICTP Director Dr. Fernando Quevedo addressing at CDP

So in the center give you the strength of basic science. So in that sense, you can question for developing countries and for developing countries I always argued that the cultural part of your country is important and then we contribute a scientist, not as countries. So every scientist every place in the world has the same right that any other scientists to address basic questions, either pure or applied. So in that sense you ask a question of Big Bang, you don't have to be in Nepal, you don't have to be in United States you can be in many places, the question makes a lot of sense and we all have the same right to address it. But in our countries, we have some advantage. First of all, since we have soulless develop that there's plenty to be done. So everything is valuable because you need to establish a culture. Feeling for the future are mostly the countries that really suffer the most are the developed country's climate change and so on you can see where the country that will suffer the most of the time are developing countries. So we need to develop the Science there because we have to worry about our own country. So in that seems that Nepal has to strengthen the culture of science and every single country do the same thing to protect their own future. They have to know what the challenges are what to do and they don't have to wait for the big countries to solve the problems and to solve them yourself.

2) So, you mean that contributing to world-wide means, first of all solving our problem and…

Two independent things there should be scientists addressing your problem and there should be scientists addressing uselessness. Usually, policy makers and politicians, they are always short-term viewers. They only view for the short term views or the second part the applied part eg: how to solve the poverty problem and so on. That's not the Science does. For growing the Science you need to spend a lot of time and you need to establish for the Culture and on the useless things which are very important. Also, solve for the Country's questions and everybody knows the need of scientists. there are no discussions, but people who are not scientists want to fold the scientist to do exactly one thing that they think is the most important one. They don't sometimes they don't control the size of other thing is most important and sometimes they want to first scientist to do something that the scientists don't want to do.

NPS President Prof. Bhattarai facilitating ICTP Director

3) As a director of ICTP, how are you contributing to the scientific progress in the developing countries like Nepal?

Yes, as I mention in the presentation before, keeping this tradition alive is the biggest challenge. So I have been the director of ICTP nine years now. So that has been the biggest challenge is to keep it working as was that's what I always appreciated my student's this tradition they kept alive. So this is challenged people working. So that's the first person first most important. Second, you have to see that the changes what is happening in the world and they see what is you can do and in the case of Nepal For instance; the complete thing that we are doing is from the medical physics. There was no medical physics four-five years ago. Now we open a Master's in Medical physics. We have been training over four students of the higher level in medical Physics from Nepal in that sense that's the very concrete case. But also I was just suggested in my presentation we had the group in Earthquakes when we had 2014 earthquake here we use our talents in Nepal, our experts in Earthquakes, especially former students from Nepal come to Nepal to support their people from the Earthquakes and prevent them from further disturbances so it was something concrete things happen years ago. But of course, we used our experience over 50 years. So we have created over its network of this community that it was too good. So whenever there is an issue we can actually participate and help.

CDP welcomes ICTP Director

4) Is this your first visit to Nepal? How are you feeling about it?

Huhu... especially this moment when I came here that highlight's me. It's important to see my colleagues but also the students like you because you're the future of the country and your future for Science and you were the ones that we want to have more impact to encourage you to motivate you into science and to help you as much as we can to pursue your career because that's the mission of ICTP. That's why we exist. So this is our duty to do that was a pleasure for me to participate. It is a pleasure of us also to having here...

5) In Nepal about 500 students study Physics at M.Sc. level, most of them prefer to go to the US for further study, what is your message to the Nepalese Physics Graduates?

I can talk about my own experience. I was one of them since I was from Guatemalan (a Central American country south of Mexico) when I went to the US. I know that time it attracts more now it is less attractive. It is true because it is the biggest country, it has a lot of resources and quite a bit easy because if you get accepted there you would have got a job as a teaching assistant and you don't have to get an acceptance or fellowship letter, so in that sense I admire the US programs were attracted foreign students that's why all the foreign students are reaching the United States. In other countries is more complicated like in Europe, you have to get the acceptance and then the fellowship but it is the option and then I think that's a pretty good time. You know in ICDP we provide an alternative that I think it's good that we allow students to come to ICTP and then make them go to Europe. That's how it's easier to go to the United States because the entrance level United States is lower than the entrance level of Europe. So this is easy to be accepted in the entrance exam so for instance; I went to the United States but I couldn't have gone with my background to Europe because I didn't have a good enough background but in ICTP we feel that gap. So, in that sense going to the United States make sense or to the UK next person's will so because they are English-speaking but in other countries either language is an issue, now I think the world has been changing and I will say go to China because in this few years China has more resources than the United States and Europe also. I think they should be a room for everybody to do on the options something which I think is very important is to support the local Ph.D. and the students should not be feeling bad if they stay here for the Ph.D. But if they do that, I will encourage them to apply for the sandwich Ph.D. programs. We offer that also a similar program is offered in Germany and so that that as I say in my presentation is it's like a win-win scenario. Everybody wins. Student wins have the two experiences they still win because they don't break from their family and home the supervisor win because they have still working for him or with him and then we also win because it's cheaper to pay the sandwich Ph.D. student than another full-time student. of course, it is ideal if the level of the local Ph.D. level program gets better and it will get better precisely the program because then you can have more people doing that.

During Dr. Quevedo's talk at CDP

So I think that's my favorite combination at the moment. But all of all the options should be open because they should be free Mobility among scientists in general and if the best research in one subject is Harvard and you are accepted to Harvard one should not go to Harvard depending on his right. So, I always try to think in a global way without any boundaries you want to go anyplace you go to every place you are Nepalese or you are American or you are Sudanese, doesn't matter. If you go to work what you think is it's better for you. It's so and then at some point, hopefully, I used to certification to say people always give back to their countries. So do you don't just simply the couple? So that's some point people do something. Like first of all, I'm trying to do it with the Guatemalan all not only me all scientists are doing trying to do the same and they are their role. I'm sure the Nepalese scientist they try to do anything that will come back. So in that sense, it's not a lost and another point University should also be open to attract people from abroad imagine you have a good Ph.D. product. What if you get the student from Bangladesh from Pakistan to so they're here for me yesterday. So the flow should be in all directions that would be an ideal situation. The probability see now is a flow will only go in One Direction, which is developing to developed but the free Mobility I think is ideal, the problems here are mostly going in One Direction.

Addressing at CDP, TU, Nepal

6) I would like to ask you a few personal questions, how did you get passionate about Physics, shear us some experiences?

Some of the things that depend on when you see since I was very young. I liked mathematics very much and I questioned things. I never read books about the nature of some of the mathematics was a natural thing. They have some point. I started learning a bit about physics. I have to say and then I could passionate but I have to confess my case was ignorant. I didn't know that you could have studied physics as a career. So when I finish my high school, I look at the National University look at which career offer more physics and Mathematics courses, and I went to that one. There, of course, I enjoyed so much physics. I would I start talking to my professor that I wonder how to read more Heist. I remember spending summer holidays reading textbooks in physics. We still believe in love, but then he gave me this advice which I always give to people was to read. This famous Feynman lectures on physics that you know, so just to get more from what I was doing. So I got more and more excited and then it's something happened in my country. Also listen, what would happen here? We had an earthquake in 1976. So they feel that they were going to close the National University. And the meantime, I have learned that there was a small University in the city that they offer Physics and mathematics for the career. Since they were closing the National University, I went to the university.

7) So how do you get incline to Particle Physics, I mean how do you decide?

So I was curious about that when I was a student a very thin in physics and then I choose one research project went back 40 years or so on. There was something to do. I'd also like group Theory. So what can I do with group theory and particle physics? So I did my project on quarks so that then I was so fascinated to see how these things you know that possible how quantum mechanics was so intuitive and then object like quarks there were look like a Science Fiction at that time and that could be everything that able to make out of that. It was not clear that whether it was a real object or not. And I remember people laughing at me when I was talking about them, but then there was this book that I read it I was so excited. It was sent from Weinberg. So the universe single book if I do have seen the recommended it's an old book. It's called the first three minutes of the universe. The first three minutes of the universe is incredible. Goes through the part of this isn't this what was it? So, of course, this is an age-old book now because many things happened since the 1970's but it still is such an inspiring book that I just add it'll hit you this around you can actually say something concrete that is not random thoughts or something about the very beginning of the universe. So I got excited. Then, I choose Particle Physics and I did my thesis in Particle Physics.

During NPS official honorary member award speech

8) My question goes like this, you are the Ph.D. student of the Nobel Laureate Weinberg and now you are the director of ICTP which is also initiated by Abdus Salam also Nobel Laureate who shear Nobel Prize with Weinberg and how do you feel it personally?

There is some figure in my life that are so incredible and I have been so lucky to work with Weinberg that change my life. At some point I have to say before I able to come to ICTP, I visited ICTP before also and participated in programs after I finished my Ph.D. because it was the dream place in Europe but never work at the ICTP. And once I was applying for a job which is the difficult part of our carrier and so I went for a job interview in Oxford (I think years ago). They asked me who is the Physicist that admire you the most? So, I start thinking...Newton is very impressive and Einstein is great but I met Weinberg and Abdus Salam and I like Feynman because of his lectures also so I have hesitating and at the end, I have to choose one and I fix Salam I haven't told Weinberg that. The reason is that he was a complete scientist and he is a role model for all of us from the developing countries because what he had done is good enough so in that sense I was so lucky that a few years later I was ask for the director of ICTP. I wouldn't say dream come true because I never even dream. But the thing is these two persons are very important and they shear their opinions and they like very much each other. I was part of the last collaboration between them because when I went from Texas to CERN for my postdoc but I spent three weeks in ICTP where I was talking to Salam. There they had a nice collaboration.

9) Many students from Nepal are trying to pursue Ph.D./Masters in ICTP, how do you suggest them to create the proper background for this?

Yes, I think I can see you have a good undergraduate and Master's program. The experiences we have had the students come from Nepal are very good. Remember, we have students from many many countries some countries we have background very very less to the program. The Nepali students when they arrive are usually best. The background you have is much better than the average. So, in that sense, I wouldn't ask too much about the background. But, we have all the information about the course we offer and so, you can see the levels that we have on the website. If there is extra necessary you can fulfill your gap. But, in general, you have a very good background for applying the ICTP.

10) How Nepali students are performing there?

Yes, I think they are very good. We have in several subjects from Earth System Physics (ESP), Condensed Matter Physics (CMP), to Medical Physics in which they perform very well, they enjoy in groups, they work hard and they have good background as well. So, in that sense we are very very pleased also your lectures are known about ICTP, they make you what level you should have to apply there. But, we have the program Master's in High-Performance Computing, in which we have not Nepali students till now. So, I think it will be the challenge whether they perform it as in the other programs or not. So, I almost encourage you to apply for these programs.

We have almost coming to the end of this short interview…Thank you so much for your time….

The **Abdus Salam International Centre for Theoretical Physics** (ICTP) is an international research institute for physical and mathematical sciences that operates under a tripartite agreement between the Italian Government, United Nations Educational, Scientific and Cultural Organization (UNESCO), and International A tomic Energy Agency (IAEA). It is located near the Miramare Park, about 10 km the city of Trieste, Italy. The centre was founded in 1964 by Pakistani Nobel Laureate Abdus Salam.

Mission

- *Foster the growth of advanced studies and research in physical and mathematical sciences, especially in support of excellence in developing countries;*
- *Develop high-level scientific program keeping in mind the needs of developing countries, and provide an international forum of scientific contact for scientists from all countries;*
- *Conduct research at the highest international standards and maintain a conducive environment of scientific inquiry for the entire ICTP community*

In 2007 ICTP created the peer-reviewed open-access Journal "*African Review of Physics*" under the then name "*African Physical Review*". ICTP offers educational training through its pre-PhD program and degree program (conducted in collaboration with other institutes).

Source: https://en.wikipedia.org/wiki/International_Centre_for_Theoretical_Physics

An Encounter with

Prof. Dr. Kedar Lal Shrestha

Editors (Ajay Gopali, Amar Thakuri, Bibek Tiwari, Ganesh Pandey, Pradip Adhikari, Prakash Timsina, Pramita Tiwari, Suvekshya Lamichhane) with Prof. Dr. Kedar Lal Shrestha

Location: Prof. Shrestha's resident, 21/85 Pimbahal, Lalitpur

Date: 2019/02/14

BRIEF PROFILE

Date of Birth:	**23 October 1938**
Place of Birth:	**Pimbahal, Lalitpur, Nepal**
Father:	**Ratna Lal Shrestha**
Mother:	**Hari Devi Shrestha**
Spouse:	**Gauri**
Son/Daughter:	**Two (Kiran & Kundan) / Two (Kanti & Kasturi)**
Education:	
S.L.C. (1953):	**Patan High School, Lalitpur**
I. Sc. (1955):	**Tri Chandra College** *(Affiliated to Patna University)*
B. Sc. (1957):	**Tri Chandra College** *(Affiliated to Patna University)*
M.Sc. (Physics / 1960):	**Allahabad University, India**
Ph. D. (1967):	**Queensland University, Australia**
Phone:	**977-1-5533028; 5537059**
Mobile:	**9841208754**
Email:	**kedarshr@gmail.com**

1) How you are spending your retirement life? Are you involved in any Physics related activities these days?

Firstly, I feel myself as a lucky person to get a chance to study physics. Physics make understand lots of wonder of nature conveniently and is the great areas of research for human utility. As far as my current time is concerned, recently I have been appointed as an adviser for reconstruction of the temple which was destroyed by an earthquake in 2015. I am also involved in policy making for Kathmandu Metropolitan.

In fact, I am never away from physics, as my younger son is currently pursuing a doctoral degree in Physics in the USA and I keep myself update with the contemporary changes in physics. Also, the internet has helped me a lot in this regard. As a matter of fact, it is true that officially I am not working for any physics related project nowadays.

2) Please tell us something about your school life and your childhood moments?

I was born in Patan, Lalitpur in 1995. Being the only child in the family, I grew up with much care from the family members. In fact, my family always remained skeptical sending me away from the home also because I had poor health at childhood. I had a very good social circle and used to participate in various cultural activities: Newari Cultural shows. I studied at Patan High School which was nearby my house. My father was a businessman, a shopkeeper to be precise. We had a shop in our house. My leisure time was well spent in the shop. I still remember and rejoice those carefree days as do any one of my age now.

3) How you became interested in science?

My first attraction to study nature came from my teacher whom we called "GURU" in our culture. He once asked on how can one see an object? We simply replied it's because of our eyes. Then he turned off the light and asked can you see now? Physics of Image formation fascinated me and made me realize the role that light has on image formation. My passion for physics developed greatly after some of the formal courses of physics at the intermediate level.

4) What was your interest when you joined a higher study? How was your college life? Do you choose Physics, was it your correct decision or not?

There were very few colleges at those times in Kathmandu valley. After SLC, I joined Trichandra Colleges which was in Kathmandu and far from my home. We were only three in number from the nearby locality and due to lack of transportation then, the route to college used were passed by singing the songs. (Haha...). Sometimes we used to watch movies, Hindi and Nepali, in particular at the Ashok Hall. My father wanted me to be a businessman like himself but my mother favored for higher studies.

I had not any idea regarding the subject of interest at that time. At first, I joined in Arts faculty in TC but later-on my friends suggested me to study science then I changed my faculty. I was an average student in my college life but l was fond of experimental part of physics. There were very good lecturers at that time. They used to demonstrate in class for better understanding. I could remember, one of my professors taught us how to measure the weight of the air. He had shown, a flask tube making completely vacuum and measuring weight and again measuring weight with air. I was dedicated to my lab assignments in Physics and Chemistry. I remember my professor saying "*no* *learning unless you break the things*". We study many things in Physics from microscopic particles -- atom, molecules, and quarks to large scale structures like galaxies, quasars and origin of Universe to all stars in time scale. I remember an event with my friend Daya Nanda Bajracharya who said that one should now shift paradigm form Physics to Biology. I paused for a while and said deliberately, "*Yes! You are right it is time for biology but most probably molecular biology. You need Physics to study the structure of DNA. Physics knowledge is thus inevitable*."

Token of love from CDP (with editor)

5) *How was your M.Sc. journey? How you managed to study M.Sc, How expensive it was?*

No, I didn't spend any money on my higher study from I.Sc. to my Ph.D. I didn't study engineering and medicine because it takes 4 years to 6 years and my parents would not let me go abroad for such a long time as being the only child of a family. After finishing my B.Sc. level, I wanted to study further but there were no M.Sc. in Nepal. We had to go to either India or other countries. I felt so lucky when I got a scholarship for my M.Sc through a Colombo Plan. In the Colombo Plan, one seat was allocated for Physics and two seats were for Mathematics from Nepal. I had good marks in B.Sc. so I was quite confident to be selected but was not sure whether the selection would be for Physics or Mathematics. So I applied for both. But later, I decided to go for physics and gave an interview for it only. Luckily, I was selected for M.Sc. in Allahabad University. I was so happy at that time and so lucky too.

6. How was your first encounter with the Indian University at Allahabad? Did you felt it challenging? Could you just share your experience with new premise, languages and education.

Yes, indeed that was my first journey away from the Kathmandu Valley itself. I went by airplane from Kathmandu to Dhaka and then towards the university via train. In fact, it was the first time I wore a shirt and pant in my life. (Laugh)…... The cultures, environment, languages, etc and even the faces of people were quite different from Nepal. Somehow the food was alike: only the difference was that we eat rice and curry (Dal Bhat Tarkari) here but people there favored Roti Tarkari mostly. My familiarity with Hindi Languages through the Indian movies here at Nepal helped me a lot for the communication purposes there.

Further, I would like to add that I received my recommendation letter from quite lately under the Colombo Plan so I reached the university in September only. I found that the classes had started in early July. I, therefore, felt very difficult at the beginning. Also, the poor performance of the earlier Nepali students at the university distressed me. So, I had a great challenge in front of me, and frankly speaking, I didn't get any help from friends. The competition among the students was tough and to my surprise I found students even turning off the clock (Haha....) so that the sense of unlimited time boost their enthusiasm for study. They had their separate notes. It was very hard but I did. I completed my first year successfully.

6) *How you spent your time after Msc degree before enrolling to Ph.D.?*

After the completion of Msc, Mr. Phadindra Prashad Lohani sir called me to teach Physics at Tri-Chandra campus. Also, I started to teach at Public Science Campus (Present Amrit Science Campus) in substitute of Shankar Psd Pradhan Sir as he was on leave for his doctoral degree. I used to go to college on a bicycle from the Patan (Home). After the Public Science campus shifted to Thamel (present location), I was made permanent faculty there later on I was Head of Department. Later on I applied for the Ph.D. in Physics through the Colombo Plan and got an offer from Queensland University, Australia in 1962 September. I was lucky to be the student of Prof. Webster who is the friend of James Chadwick and student of Rutherford.

International workshop on 'Environmental Changes & Climate Apaptation Responses' Kathamndu (2010)

7) *Can you tell us about your experience during your Ph.D. and working under Prof. Webster?*

It was really an amazing experience. He was a bright and perfect person. He guided me to work on workshop for using a lead machine, drilling, welding and constructing circuits, glass blowing and so on. We made the necessary equipment for the study on our own. I had a dream to conduct such practicals on my homeland university too but never happened here. I worked to study the link of lower and upper atmosphere using radio waves under his supervision. Life was difficult at that time. We had busy schedule for work. I submitted my

Ph.D. thesis on 1967 January morning and returned back to home on the same day. My professor helped me a lot on research work, writing research papers and polishing my English proficiency.

Front Row (L to R): B. C. Shrivatava, Y. M. Gupta, P. Tiwari, B. R. Joshi, K. L. Shrestha, V. M. Shrestha, L. N. Jha. Standing First Row (L to R): M. M. Udas, B. P. Upadhyaya, unknown, unknown, R. Shakya, P. B. Shakya, K. J. Thapa, N. Tamrakar, R. S. Ray, K. P. Pathak, U. C. L Das, L. P.Shah. Standing Second Row (L to R): R. B. Khadka, G. B. Khadka, 3. Unknown, S. K. Aryal, B. N. P. Kurmi, D. D. Mulmi, D. D. Poudyal. Standing Third Row (L to R): S. Gurung, K. B.Thapa, L. P. Sah, C. B. Singh. Standing Fourth Row(L to R): M. M. Maharjan, N. N.Yadav, K. N. Baral, S. Upadhyaya.

8) *How had you prepared graphs at that time, sir?*

The computer had just begun at that time. Mainframe computer was available. For those needed there used to be training. I too had taken FORTRAN training. For a graph, an input is needed to provide by punch-card. Desktop developed very late. Here in Nepal, there was IBM 1601 for census data processing. Do you know what the memory was? Just 16 K. (laugh…)

9) *Which university would provide the certificate when a student passed B.Sc from Trichandra Campus?*

Nepal was just in the phase of transition to modern education and during its early time, Patna University used to offer the certificates of B.Sc. for the students enrolled in the now so-called Amrit Science Campus.

10) *What was the infrastructure of the Central Department of Physics then?*

During that time the infrastructure of the Chemistry department was well but that of physics was not in good condition.

11) *What was the basic mode of the teaching Physics: Experimental/theoretical were in those days?*

I can say that even in those days we had good faculties for both the theoretical and experimental one. Since the department was just emerging we used to have several pieces of equipment from the foreign and I was lucky enough to test and explore various instruments by myself and teach other students. Likewise, Shankar Prasad Pradhan was proficient in theoretical methods and approaches and had the capacity to do the derivation with full rigor. I personally learned a lot from him.

12) *Through the archive, we found that you are the one who started the research work i.e. commenced the first Ph.D. thesis under your supervision at the department. Can you just enlighten it a bit more?*

I had my Ph.D. at Australia in the field of the ionosphere. My Professor too helped me in these areas and also in the atmospheric physics and earth tides. Under my supervision Kedar Nath Baral did Ph.D. which I think is the first Ph.D. at Nepal.

13) *How were you appointed as the professor on TU?*

After the advertisement, I applied for the professorship. I remember Mr. Bhagwati Prashad Singh, chief justice (1964-70) was the chair of the interview committee and also Mr. A. R. Verma, director of Delhi National Physical Laboratory was in the committee. To my surprise, without being the reader, I was offered a professorship. The salary of the professor was NRs 1265 at that time. Later on, I was offered a position of assistant dean of science too.

14) *What sort of things you did during your position as Assistant Dean?*

I found that during that time there used to be no rules and regulations regarding the criterion of the Ph.D.

applications/enrollment and registrations. Also, there wasn't any provision for the time period of the Ph.D. completion, the criterion of the Ph.D. supervisor. I designed the basic outline for all these sorts of things that are mandatory for academic-related activities.

Second Ministerial Conference on Space Application for Sustainable Development in Asia and the Pacific, New Delhi, India, 18-20 Nov, 1999 (with Dr. Murali Manohar Joshi)

	EMPLOYMENT
1974 - 2001	**Professor, CDP, TU**
2002 - 2004	**Chief Scientific Advisor, MoST, HMGN**
2000 - 2002	**Scientific Advisor, MoST, HMGN**
1998 - 2000	**Coordinator, High Level National Council for Science and Technology, MoST**
1992 - 1997	**Vice-Chancellor, Royal Nepal Academy of Science and Technology (current NAST)**
1992 - 1997	**Ex-Officio Member, National Development Council, HMGN**
1992 - 1997	**Ex-Officio Member, National Environment Protection Council, HMGN**
1979 - 1986	**Executive Director, Research Centre for Applied Science and Technology (RECAST), TU, Kirtipur**
1979 - 1986	**Ex-Officio Member Secretary, National Council for S&T, (NCST), HMGN**
1976 - 1979	**Assistant Dean, IoST, TU, Kirtipur**
1974 - 1976	**Professor & Head, CDP, TU, Kirtipur**
1971 - 1974	**Head, Dept. of Physics, TU, Kirtipur**
1967 - 1974	**Lecturer, Dept. of Physics, TU, Kirtipur**
1962 - 1966	**Tutor, Cromwell College, Queensland University, St. Lucia, Brisbane, Australia**
1962 - 1967	**Lecturer (on study leave), Public/Amrit Science College, Kathmandu, Nepal**
1960 - 1962	**Lecturer / Head of Physics dept., Public Science College, Kathmandu**
1960 - 1962	**Lecturer, Trichandra College,Kathmandu**

15) What sorts of activities did you bring on during your position at RECAST?

We launched the program related to improved stoves, improved water mills and conducted several health programs awareness campaigns that helped the several villages of Nepal.

16) You have worked as a policy maker in the past. Can you please elaborate on your experience in policy making, and how can one have good policies?

"Right Man Right Place", we should pursue this creed. While figuring the policies, it must be founded on evidence: why it is reasonable and why it isn't? One must study the subject completely and ought to be familiar with the subject if he/she is in the position of policy-making. For eg; in the event that he is working for science and innovation and figuring the strategies, it is fundamental that he should be the scholar of STEM field or at least related with the given field academically or professionally. What's more, why I am stating this is: I have worked in a policymaking position and have felt it as a need. In our cases, we are not intellectually in Physics. We are tied by different policy or system which never encourage innovation. If we get that opportunity then we can also be the game changer in this field. But if your system is not encouraging enough or the policy are not friendly enough then it isn't possible. So if we expect the innovation or changes in our field then the policymaker must be from our respective field who have enough knowledge about this field and can advocate our requirement. If this happens, we can see the revolutionary transformation within a few years.

University of Queensland, Australia (where Dr. K. L. Shrestha did Ph.D. during 1960-1965)

17) What do you think would the world be like in the next fifty years? What accomplishments in physics do you expect to be achieved in that period?

Fifty years from now, the world is going to see a huge change in Science and Technology. The hardware, instruments, labs and so forth will be exceptionally exact and refined. Other than these, I will play a significant job in the invention and experiment. The technology will be guided by AI which guarantees the productivity of any model. If we talk about "space-travel", we have seen a lot of works on progress. In many cases, we have already seen the efforts and results; we can travel from one planet to another or collect the information that we need.

18) You have some pictures with the late King Birendra. Can you tell us at what time that picture is clicked?

The image was clicked during the interaction. When I was the director of RECAST, The king asked me what's going on. TU Council, for instance, there used to be curtain all around and on that time curtain opened. I simply needed to state "Time is imperative". In Nepali, what we used to say "Nepali time" (everyone chuckles). We should do everything on time.

19) While you were in RECAST, does everything implemented well according to your plan?

It wasn't that simple for me. That is the reason I submitted a report against the government. I was denied to do my work. Besides, what I concentrated in my report was that it must be comprehended by why I needed to do.

20) What Suggestions (message) would you like to give to newcomers?

I needed to state all of you are ordained. All of you are foreordained that you are studying Physics. Not every person will get this chance. There will be bunches of chances which relies upon oneself so that one must be dedicated and should do diligent work. The individual will be valuable through diligent work. It is hard to get a chance to study physics. You are among rare individuals that is why should feel lucky yourself.

21) What do you want to say to the students who are going out of our country?

In one hand, anyone who goes to a foreign country is doing really well, but we shouldn't forget our place. In another hand, in order not to forget our place, we shouldn't put our career in a dangerous situation. The ones residing here in our own country should create a helpful environment to initiate innovation. If they are getting the opportunity there, itself, then one must not shatter it.

Honored at the Central Department of Physics, TU.

Contributions/Publications

1. *Bowman, G. G., Shrestha, K. L., 1965. 'Atmospheric pressure waves from the Japanese earthquake on 16 June 1964 ', Quarterly Journal of the Royal Meteorological Society, Volume 91, Issue 388, p. 223–224, April 1965.*
2. *Bowman, G. G., Shrestha, K. L., 1966. 'Ionospheric Storms and Small Pressure Fluctuations at Ground Level, Nature 210, 1032 - 1034 (04 June 1966); doi:10.1038/2101032b0.*
3. *Shrestha, K. L., 1967. 'Observation of infrasonic waves in the F-region of the Ionosphere ', Journal of Atmospheric and Terrestrial Physics, Volume 29, Issue 1, Pages 107-108, January 1967. https://doi.org/10.1016/0021-9169(67)90161-4*
4. *Shrestha, K. L., 1967. 'Microbarometric Oscillations and the Ionosphere', Ph. D. Thesis submitted to the University of Queensland, Brisbane, Australia, January, 1967.*
5. *Shrestha, K. L., 1967. 'Continuous regular pressure oscillations in the atmosphere at night ', Quarterly Journal of the Royal Meteorological Society, Volume 93, Issue 396, Pages 254–266, April 1967.*
6. *Shrestha, K. L., 1971. 'Sporadic-E and atmospheric pressure waves', Journal of Atmospheric and Terrestrial Physics, Volume 33, Issue 2, Pages 205-206, IN1, 207- 211, February 1971. https://doi.org/10.1016/0021-9169(71)90196-6*
7. *Shrestha, K. L., 1971. 'Anomalous ionospheric absorption and microbarometric activity at ground level ', Journal of Atmospheric and Terrestrial Physics , Volume 33, Issue 2, Pages 213-219, February 1971. https://doi.org/10.1016/0021-9169(71)90197-8*
8. *Shrestha, K. L., et al., 1976. 'Nepal: The Energy Sector', Energy Research and Development Group, Institute of Science, Tribhuvan University, Kathmandu, Nepal. Page 1 – 243.*
9. *Shrestha, K. L., et al., 1978. 'Application of Science and Technology for Natural Resources Development in Nepal', Proceedings of the first National Science Convention organized by the National Council for Science and Technology at Kathmandu, Nepal from 12 – 15 May 1978.*
10. *Shrestha, K. L., Sharma, C. K., Singh, R. and Chalise, S. R., 1978. 'A Preliminary Draft Proposal on Establishment of Research Centre for Water Resources Development and Management in the Tribhuvan University',. Tribhuvan University, Kathmandu, Nepal. Page 1 – 56.*
11. *Shrestha, K. L., 1981. 'Role of Renewable Energy Resources in the Nepal's Energy Situation', Renewable Energy Resources in Nepal, Proceedings of the Workshop Seminar, Organized by Research Centre for Applied Science and Technology, Tribhuvan University, Kathmandu, Nepal in Collaboration with Swiss Federal Institute of Technology, Zurich, Switzerland. Page 35 – 46.*
12. *Shrestha, K. L., 1986. 'Technology Policies and Planning: Nepal', Country Study Series, Asian and Pacific Centre for Transfer of Technology (APCTT), Banglore, India.*
13. *Bowman, G. G., Shrestha, K. L., 1997. 'Ionospheric spread-F occurence associated with tropospheric at mospheric gravity waves', Indian Journal of Radio and Space Physics, Volume 26, Issue 6, Pages 324-331, December 1997.*
14. *Bowman, G. G., Shrestha, K. L., 1998. 'Tropospheric atmospheric gravity waves and their relationship with geomagnetic activity ', Indian Journal of Radio and Space Physics, Volume 27, Issue 3, Pages 110-118, June 1998.*
15. *Shrestha, K. L., 2001. Global Change and the Himalayan Mountain Ecosystem. Global Change and Himalayan Mountains, K.L. Shrestha (Ed.), Proceedings of the Scoping Workshop, 2001, Kathmandu, Nepal*
16. *Shrestha, K. L., Shrestha, M. L., 2003. 'Climate change and water resources of Nepal ', Climate change and water resources in South Asia, Published by Asianics Agro-Dev. International (Pvt) Ltd., Pakistan.*
17. *Shrestha, K. L., 2004. 'Higher Education: Research Funding and Student Research', A Report submitted to World Bank, Kathmandu, December 2004.*
18. *Shrestha, K. L., Sherchand, K., Sapkota, B. K. and Ghimire, M., 2005. Socio- Economic and Physical Perspectives of Water Related Vulnerability to Climate Change in the Bagmati River Basin in Nepal ', Science and Culture 71(7/8): 260–272.*
19. *Shrestha, K. L., 2005. Trends of Climatic and Hydrological Changes at Different Altitudes in the Himalayan Regions, Paper presented at GLOCHAMORE 4th Thematic Workshop on "Process Studies along Altitudinal Gradients to serve Conservation and Sustainable Development" Samedan, Switzerland , 27 – 30 July 2005.*
20. *Shrestha, K. L., 2005. Global change impact assessment for Himalayan mountain regions for environmental management and sustainable development. Global Environmental Research, 9 (1), p 69-81.*
21. *Shrestha, K. L., 2005. Perceived and Projected Impacts of Global Change on the Food Security in the Himalayan Mountain Regions. Paper submitted for the Session on "Livelihoods, vulnerability and conflicts" at the Open Science Conference (OSC) in Perth, Open Science Conference: Global Change in Mountain Regions, Perth, Scotland, UK, p 2-6.*
22. *Shrestha, K. L., 2006. 'Impact of Climate Change on Himalayan Glaciers', Climate and Water Resources in South Asia: Vulnerability and Adaptation, APN Fred J. Hansen, Institute for World Peace and START (IHDP-IGBP-WCRP).*
23. *Shrestha, K. L., 2009. 'Impacts of Global Change on the Dynamics of Snow, Glaciers and Runoff over the Himalayan Mountains and their*

Consequences for Highland and Downstream Regions', Science Peaks, Mountain Research Initiative (MRI) Newsletter, Vol. 2, No. 3, p 6-9.

24. *Shrestha, K. L., 2012. 'Impacts of Global Change on the Dynamics of Snow, Glaciers and Runoff over the Himalayan Mountains and Their Consequences for Highland and Downstream Regions ', ARCP2009-04CMY-Shrestha, http://www.apn-gcr.org/resources/items/show/1555, Asia Pacific Network for Global Change, Research (APN) Newsletter, Vol. 18, No. 3, p. 21-25.*
25. *Shrestha, K. L., 2015. 'Investigating Impacts of Global Change on the Dynamics of Snow, Glaciers and Run-off over the Himalayan Mountains', R. Joshi et al. (eds.), Dynamics of Climate Change and Water Resources of Northwestern Himalaya, Society of Earth Scientists Series, DOI 10.1007/978-3-319-13743-8_3, Springer.*

22) You may have gone through symmetry? Would you like to give any suggestions?

All things considered, I discover it great. There are the profile of faculty of CDP and their published papers' list. Its a material of support for all the physicist. I need to state that it should not be ceased. What happens frequently is that something comes and after a certain span, it vanishes. There must be continuity for this type of work. Science has likewise been the subject of design without information on science. So, for General, mass, information of science is imperative. As I am highly engaged with the school sector, I found the components of science less during school days. If a person is good at the concept, He/she will do very good in life. Although minimum works and greatest expectations are there, I can see the future in them. In any case, it shouldn't be that way.

23) Sir, are you interested in writing? Philosophy? Please tell something about this.

Well, I have considered it, yet I haven't enthusiasm for philosophy. We have just a single life to live. What we can do, we should do that is important.

24) What is life for you?

Life is like that full of uncertainty and possibilities. What will happen next, we are all unknown among many possibilities? It depends upon the individual. We should never give up.

25) What is your special hobby?

When I was in Australia, I was a little bit interested in sports. I have an interest in music too.

26) After studying physics, talking about the profession, Teaching is the only option for us. What can we do for this? What have you thought about the subject?

We are different for being a physics student. I found physics students different from others. Teaching is a good profession though. Teachers can't be compared with other professions. Individuals must play an important role rather than depending upon others. When I was in Australia There used to talks about what a person would do after getting a physics Ph.D. To these extents, what I have felt is individuals must focus on what they know and what they can do. Although to try something individually and to bring change is difficult, one should never give up. My suggestion for you all is that never give up the hope.

In Bhutan (discussing with students)

There are two kinds of trends in education. One is to make the world class university is growing up these days. For that, it is very necessary to have good publications. While focusing only on quality articles, we may not stand on the floor. So that another trend is also coming out. That is, to make one's base strong first of all. If today's student became well educated, our future will be automatically bright. Our aim should be to reach the summit-- to make a world-class university. But, at first, we should make our foundation strong. Otherwise, we will just float.

In a conference in Kathmandu (2008)

27) Previously you said, they (westerners) made many machine guns while our ancestors used to the made temple, bell, etc. What can be the reason behind it? Was it the need of society or anything else?

What I feel personal is that our society was affluent earlier. But they were grown in some sort of hardship. People had to be involved in killing and robbery for food. So, their mind developed in that way. I just guessed. In the other hand, we were rich in aesthetic and cultural kinds of stuff. But we didn't have that knowledge in written form. Our ancient engineering techniques were not insignificant. But we lack drawing, systematic documentation and record keeping system.

28) (Ques for Madam): How do you feel to get a Physics veteran like KLS sir as your husband?

I feel very happy. I luckily got the chance to study at that time. My other sister didn't get the chance to study. And, He was also searching for a girl with SLC degree/literate wife. (laugh..)

Sir & mam (during interview)

29) Ques for madam, what are the professor's good and bad habits in your view?

His good habit is he is guileless a naive person. But he does not allow me to visit my parents' home much. (laugh….)

30) Sir, how much support you got from your life partner?

A lot of help! If there would not be her support, I won't be the person I am today. But she would have always a complain because I could not take her where I used to visit in the course of various programs.

31) Students are moving abroad for their PhD study. How do you see this trend?

Actually it depends on the environment and I am hopeful that such environment will be created in the future. Nowadays opportunity is in computational physics which has greatest potential where analysis of data plays a vital role. We have that within us (thinking power). Collaborations trend is also building up so I see the potential.

32) Do you feel like anything is left to do or you wish you had done?

I don't feel anything like that but I feel really sad to see the condition of RECAST nowadays. At my time I had put all my efforts and impact of RECAST was clearly visible around Nepal. When I was in ministry office I did a science and tech agreement with Indian government where Nepali scientist going to Delhi was funded my Nepalese government and from Delhi to any lab across India, the cost was bared by Indian government. But now no such agreement is there. I guess I did a good job but seems like it's not continued in today's time. Although I am happy with the progress of physics students.

33) Who do you think is your role model among scientists?

My teachers are my role model. I am here because of them and their support. Those days teaching and learning physics and teaching were tough. And there were teachers who were best giving concept to students. And I was completely inspired by them.

34) During your regime of HOD position, a drastic deduction was seen among the number of students pursuing physics MSC what do you think is the reason?

Physics as a subject matter is tough in itself as compared to other subjects, considering its depth of study. This might be one reason for student not choosing physics. The next reason I think is because to reach kritipur was very difficult. Previously direct enroll of Nepalese student for PHD in abroad was very less possible. Then summer school by ICTP was conducted in this depart, which helped in reach of capability of Nepalese student globally. This exposure resulted in direct entry as well increase in number of students aspiring to be a physicist. To conduct summer school was a challenge in itself. Prof Abdus salam, the one to conduct summer school, was reluctant to come to Nepal. Later, I managed to convince him by writing pages of mail requesting him to share tremendous knowledge he has within him.

35) Please share your view on semester system.

I had experienced both the system of study. But semester system didn't go well in the past in Nepal. I hope it is running well now.

36) What is your view about eastern philosophy?

In context of Nepal, the techniques used for molding metals and forming alloy; Nepalese had capability to compile such a huge mass and chemically advance things. It is comparable to western technology in the sense that they focused their knowledge in forming guns and weapons and became powerful, but we missed that. Thus we are lagged back in terms of technology despite having knowledge.

Medals & National Awards

- Suprabal Gorkha Dakshin Bahu: 1975
- Mahendra Vidya Bhusan: 1968
- Prof. Phanindra Prashad Award: 2003

37) You have worked in various sectors (RECAST, professor) which were the most satisfactory ones?

I am satisfied with being a professor. When I see my students doing very well in their field I find it the most satisfying. It gives me immense satisfaction. I used to teach electrodynamics but I wanted to teach quantum electrodynamics. Unfortunately there was no syllabus.

During interview (with editor and Dr. Sanju Shrestha)

38) Kedar Baral who was the first Phd Physics scholar under your supervision. Is it true that 20 years after him was the next Ph.D. students at CDP. Why such a long gap?

I feel supervisor has great role in Ph.D. While I was doing my Ph.D. Australia, I used to get updated with everyday research going around the globe. But, when I came to physics department TU for a research paper to be read I had to order it from Delhi. Nowadays there are so much opportunities for students.

39) Could you please share something about your family?

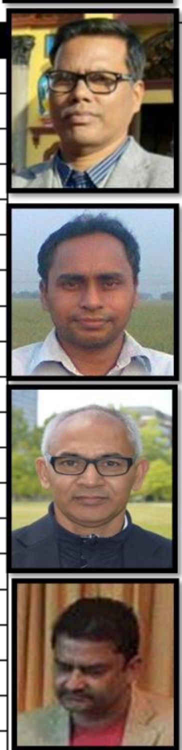
All my children, Kanti, Kundan, Kiran, Kasturi, are scholars. Kanti my eldest child; a phd scholar in chemistry, Kiran physicst in USA (PhD), Kasturi is a medical doctor, Kundan is PhD in environmental science.

Thank you very much sir. We are indebted for your precious time.

Thank you so much to you all. I am so glad you came. The door is always open.

20 Ph.D. Awarded in Physics

S.N.	Name	Supervisor
1	Dr. Kedar Nath Baral	Prof. Dr. Kedar Lal Shrestha
2	Dr. Jeevan Jyoti Nakarmi	Prof. Dr. Lok Narayan Jha
3	Dr. Nanda Bd Maharjan	Prof. Dr. Devi Dutta Paudel
4	Dr. Sanju Shrestha	Prof. Dr. Pradeep K Bhattarai
5	Dr. Kanchan Pd Adhikari	Prof. Dr. Lok Narayan Jha
6	Dr. Neelam Shrestha	Prof. Dr. Jeevan Jyoti Nakarmi
7	Dr. Indra Bd Karki	Prof. Dr. Jeevan Jyoti Nakarmi
8	Dr. Gopi Chandra Kaphle	Prof. Dr. Narayan Pd Adhikari
9	Dr. Shiv Narayan Yadav	Prof. Dr. Binil Aryal
10	Dr. Nurapati Pantha	Prof. Dr. Narayan Pd Adhikari
11	Dr. Prem Raj Dhungel	Prof. Dr. Udayraj Khanal
12	Dr. Sanat Kumar Sharma	Prof. Dr. Udayraj Khanal
13	Dr. Krishna R Adhikari	Prof. Dr. Shekhar Gurung
14	Dr. Shashit K Yadav	Prof. Dr. Lok Narayan Jha
15	Dr. Ajay Kumar Jha	Prof. Dr. Binil Aryal
16	Dr. Kisori Yadav	Prof. Dr. Jeevan Jyoti Nakarmi
17	Dr. Pitri Bhakta Adhikari	Prof. Dr. Kedar Nath Baral
18	Dr. Ghanshyam Thakur	Prof. Dr. Raju Khanal
19	Dr. Arjun Kumar Gautam	Prof. Dr. Binil Aryal
20	Dr. Saran Lamichhane	Prof. Dr. Narayan Pd Adhikari



Brain Drain in Nepal: A Painful Reality

Prof. Dr. Binil Aryal
HOD, Central Department of Physics, TU

ABSTRACT

At first a brief description of the current available data of Nepali S&T graduates in abroad are presented. The reason for their stay in various developed countries will be discussed. Advantages and disadvantages of the brain drain in the context of our nation will be described. Finally, a road map will be proposed to stop the brain drain and encourage them and brilliant young scientists to do work in government services as well as to bring back our brain from abroad to the nation for the development.

Introduction

When our child score good marks in the school, we became very happy and usually say that our baby will study science and become scientists in the future. We believe that he/she will make us happy and wealthy and keep the name of the nation at the top. This is the story of a typical Nepalese family, whether they live in village or town or city. A sort of attraction towards science education is inherently there in our society. Even today, about 75% of students with distinction in the SLC prefer to study science, wish to become doctor, engineer and scientist. Therefore our children are self motivated towards S&T by the parents, society and community from the very beginning of their study. So, the S&T discipline has already recognized by the Nepalese society but unfortunately it is less recognized by our government. Though, leader and high ranked government official repeatedly quote that the 'development of nation is impossible without proper use of science & technology'. This slogan has most repeated but less implemented in the nation. Still our government of Nepal is not providing sufficient fund (much less than 1% of GDP) for the S&T sector. The result is the MoST, which is obviously one of the least important ministries of the nation.

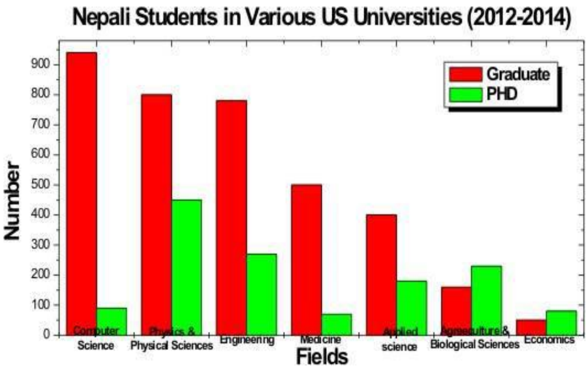


Figure 1: *Nepali students either doing graduate or Ph.D. in computer science, physical and biological sciences, agriculture, engineering, medicine and economics during 2012-14 in various US Universities. [1]*

Brain Drain Rate

Figure 1 shows a histogram of Nepali students studying either graduate study or Ph.D. at various US universities in different important disciplines, e,g. computer science, engineering, medical, biological and physical sciences. In some discipline (e,g, physical science, agriculture and biological science), a large number of Ph.D. students are carrying out their research work.

Migration as well as brain drain is a global phenomenon. Brain drain is taking place at a very fast rate in developing countries; Nepal being no exception. Young Nepali science students leave the nation primarily for the *higher studies* and *training*. Later, they expand their interest and look for better opportunity in their field of interest in the developed countries. Young graduates get disenchanted with low rewards available for their qualifications and experience, which compels them to migrate to developed countries in search of greener pastures. Evidence indicates, however, that low-income countries are disproportionately affected by the exodus of young, skilled people.

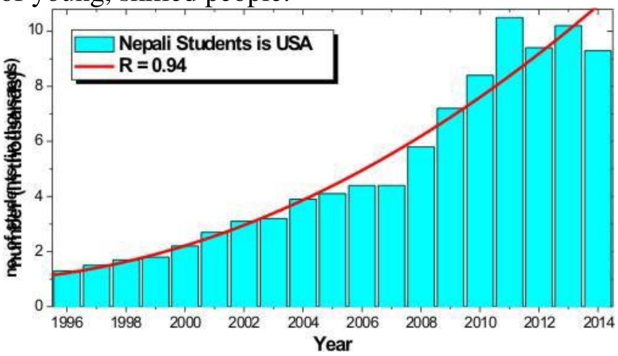
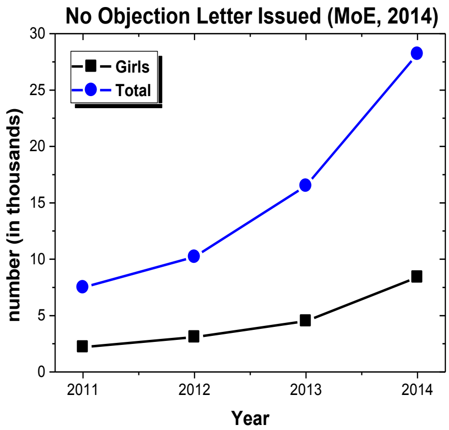


Figure 2: *Rate of increase of Nepali students in United States of America (1996 to 2014). A significant rise can be seen after 2007 and 2010. [1]*

Figure 2 shows a rate of increase of Nepali students in US in last 10 years. A significant increase of about 900% can be seen in the histogram. The rate was rapidly increased since 2008, the year when constitutional monarchy was step down and the nation become republic. Figure 3 gives a list of no objection letter granted for abroad study issued by ministry of education for various nations. A plot between girls and the total is shown. These data indicates a serious situation for our nation. Our educated younger are going abroad for better education. Country is losing a lot of money to these nations. In addition, we can say our university and institutions are incapable of stopping them. Their academic program is very traditional with a very poor infrastructure.

Types of Brain Drain

There are two broad groups causing this brain drain in Nepal - first, *the skilled workers* - those who have acquired professional skills, training or knowledge usually through a college degree. These represent doctors, lawyers, accountants, engineers, IT technicians, skilled physicists, chemists, analysts and so on. The financial well being that these professions experience in Nepal is but a small, really small fraction of what they would otherwise earn in first world nations. So therefore, the Nepalese who get their education abroad usually end up getting a job and starting a life in that nation. This makes sense too, as it is financially justified to have an earning comparative to the cost of your degree. The *semi-skilled manpower* (plumbers, drivers, waiters - you get the idea) are extremely useful for the nation. As higher portions of the world's population get higher education, there is a scarcity in the 'lesser' jobs. And this is spurred by sudden and rapid growth in certain areas of the world like the middle-east.



NUMBER OF NO OBJECTION LETTER/ CERTIFICATE ISSUED FOR ABROAD STUDY

S. No.	Country	FY 2068/69		FY 2069/70		FY 2070/71	
		Girls	Total	Girls	Total	Girls	Total
1	Australia	1398	3644	1770	4408	4142	11184
2	Japan	199	1310	803	4272	1917	7933
3	USA	296	849	281	809	485	1456
4	India	220	812	251	1211	239	1003
5	UK	233	577	276	627	163	438
6	China	113	453	92	340	163	581
7	Bangladesh	77	307	123	377	146	473
8	Germany	41	275	51	412	57	366
9	Finland	52	220	43	276	37	166
10	Philippines	75	216	46	126	53	172
11	Malaysia	17	84	111	830	243	1190
12	Norway	23	106	155	517	71	279
13	Mauritius	10	25	53	360	18	126
14	Denmark	37	180	59	235	90	404
15	Others	286	1200	331	1699	538	2355
	Total	3077	10258	4445	16499	8362	28126

Figure 3: *A list of no objection letter granted for abroad study issued by ministry of education for various nations. A plot between girls and the total is shown. [2]*

The brain drain is clearly, very clearly evident in our GDP, where remittances contribute to around 1/3rd of the GDP, and its growing year over year with no foreseeable stop signs ahead [3]. These high remittances have a lot of adverse economic effects as they do not represent fundamentally organic form of economic growth.

Why is Nepal facing brain drain?

It is because of the following reason, Nepal is facing brain drain:

- **Passive Education:** Universities and educational institutes of Nepal offer rather traditional courses in social, technical and natural science, have less competent faculties and hopeless academic calendar. The research infrastructure is rather poor.
- **Poor Entrepreneurship**: Entrepreneurship can mobilize people, resources and innovative practices [4]. The economical aspects of business based entrepreneurship, social aspects of civil society based entrepreneurship, and aspects of combining economical/social are important for Nepal. Unfortunately, no Nepalese universities have introduced systematic courses in entrepreneurship
- **Unreachable Access:** Because of poor entrepreneurship government and public sector job is the only way for young S&T graduates. Unfortunately their offer is very limited. In addition, the medical study is very expansive (about 60 lakhs for MBBS now?) as well as have limited quota in the nation. Similarly number of quota is Engineering is also limited. The masters' level business/commerce study is not competent enough. Therefore, students prefer to leave the nation to get better job and cheaper education.
- **Tough life:** Developed Nations like Australia, USA and other European Nations promise better life and living. Employment situation in Nepal is rather poor for S&T related experts. Nepal government has no any concrete plan for their younger S&T experts. Therefore, students prefer to fly abroad mostly for employment.

Brain Drain: Advantages & Disadvantage

Advantages:

- The money the emigrants have sent back home has helped in alleviating poverty in their homes. It has resulted in less child labor, greater child schooling, more hours worked in self employment and a higher rate of people starting capital enterprises [5].
- The money remittances have also reduced the level and severity of poverty. The income-maximizing level of a brain drain is usually positive in developing countries like Nepal, meaning that some emigration of the more skilled is beneficial.
- A brain drain stimulates education, induces remittance flows, reduces international transaction costs, and generates benefits in source countries from both returnees and the diaspora abroad [5].
- Appropriate policy adjustments, which depend on the characteristics and policy objectives of the source country, can help to maximize the gains or minimize the costs of the brain drain.

Disadvantages

- The effective brain drain exceeds the income-maximizing level in the vast majority of developing countries, and small countries like Nepal. Due to the influence of brain drain, the investment in higher education is lost as the highly educated person leaves Nepal and becomes an asset to other country.
- A brain drain may cause fiscal losses. There is a shortage of skilled and competent people in Nepal. Later a tremendous increase in wages of high-skill labor can be seen. The emigration has also created innumerous problems in the public sector.
- Above a certain level, brain drain reduces the stock of human capital and induces occupational distortion. Also, whatever social capital the individual has been a part of it is reduced by his or her departure.

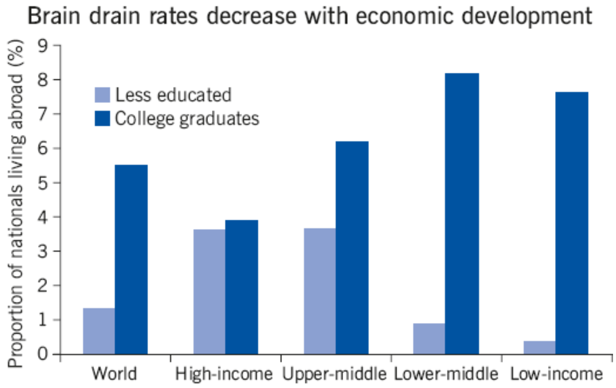


Figure 4: *A decrease of brain drain with economic development of the nation. [7]*

Stopping Brain Drain

Following measures can be effective to stop or reduce the rate of brain drain from Nepal:

- **Economic Development:** The overall economic development of the nation is extremely important to decrease the rate of brain drain. Entrepreneurship is a critical driver of innovation and economic growth. Therefore, fostering entrepreneurship is an important part of the economic growth strategies of many local and national governments around the world [6]. To this end, governments commonly assist in the development of entrepreneurial ecosystems, which may include entrepreneurs, venture capitalists, and government-sponsored programs to assist entrepreneurs, These may also include non-government organizations, such as entrepreneurs' associations and education programs. Figure 4 shows a decrease in the rates of brain drain with economic achievements.
- **National Pride:** Brain drain can be significantly reduced if a feeling of national pride is induced among the students in an early age. The curriculum of primary and middle school is very important in this regard. Unfortunately, our school curriculum has been cutting the content of Nepalese history, geography and culture since last 15 years.
- **Payback Rule:** If in case, the student is provided any scholarship by the Government, he should be made to work in Nepal for a certain period of time. This is mainly because the Government institutions especially, bear a huge part of a student's fees in order to promote his/her education. The students should therefore also take it as their moral responsibility to pay-back the country by working in the country and hence for the country.
- **Compulsory Civil Service:** A compulsory civil and/or army training are extremely important for the undergraduate and graduates of the nation. At least six months compulsory military or social service is made to the compulsory for graduates and 9 months for undergraduates. This will provide our brilliant students and scientists to understand the nation's problem as well as realize the importance of self discipline.
- **Research Facility:** Most of students going outside have something like *research in back of their mind*, so government should initiate providing a platform for research orientated along with scholarship to stop brain drain. Government should provide sufficient research fund to the students of S&T.
- **Encourage Entrepreneurship:** An entrepreneur is an individual who, rather than working as an employee, runs a small business and assumes all the risks and rewards of a given business venture, idea, or good or service offered for sale. The entrepreneur is commonly seen as a business leader and innovator of new ideas and business processes.
- **Re-capture Our Brain:** A very large number of Nepalese S&T students are leaving Nepal every day. Their return rate is rather poor. Nation should make a policy to make our S&T experts return back to the nation. For this, a proper identification of the specific area should be important in the beginning. For example, if we need engineers, biotechnologists, medical scientists or chief executive for the nation, we have to find the best Nepalese from abroad. An attractive salary, job assurance with a very good contract will compel them to return back. Everybody wish to stay in their motherland if they get opportunity.

Encouraging Brain for Government Services

It is our reality that the outstanding students and scientists of Nepal do not prefer government job in Nepal, particularly if they are from the science & technology sector. IoST has carry out a survey before implementing 4 year B.Sc. in natural sciences. One question was 'are you willing to stay Nepal to work after the completion of your study?' Seventy three percent students denied going to government job. They rather preferred to go middle-east for the low-grade job. The main reason is the lack of attractive and appropriate jobs, overdose political biasness and curruption in the government sector.

(1) Enforce Public Sector: Government should motivate industries and private sectors to recruit Nepalese science & technology experts as possible as they can. For an example, Tribhuvan University produce '*Tea-technologists*', but they do not get job in Nepalese tea industry. These industries hire non Nepalese experts to improve tea quality. The Public Service Commission of Nepal do not offer job to them. However, Nepalese tea-technologist has gain a reputation at the regional and international level. A similar trend can be seen for microbiologists and biotechnologists. They are important for Nepal but government do not have any plan to absorb them.

(2) Establish Research Centre: Government should establish research centre on priority basis. Recently MoST has initiated nuclear, space, information and biotechnology research centre at least at the advisory level. Sufficient grant should be provided to these centres so that young students and scientists motivate to contribute.

(3) Better Link-up with University: University can provide students for the preliminarily research in the various field of S&T. These days about 5000 students do project work at B.Sc. level and about 500 students carry dissertation work at the masters' level every year in Nepal. UGC provide nominal research grant to 50-70 students per year in S&T sector. Government should provide scholarship or research fund at least to 50% Bachelor and 100% masters' and Ph.D. students for research work. This will motivate young students to work with government in the future.

(4) Fruitful Link-up with INGOs & NGOs: Well reputed and professional INGOs and NGOs should be identified for the research work. University should have fruitful relation with INGOs and NGOs for the research work. Government need to motivate both to work together in many issues.

(5) Increase Government Outreach: The S&T related jobs and its importance for the development should be popularized particularly in the government and community school. The MoST, MoE and its substructures should take a systematic and regular plan.

Summary

The proportion of foreign-born people in rich countries has tripled since 1960, and the emigration of high-skilled people from poor countries has accelerated. Many countries intensify their efforts to attract and retain foreign students, which increases the risk of brain drain in the sending countries. In poor countries, this transfer can change the skill structure of the labor force, cause labor shortages, and affect fiscal policy, but it can also generate remittances and other benefits from expatriates and returnees. Overall, it can be a boon or a curse for developing countries, depending on the country's characteristics and policy objectives. Government of Nepal should make appropriate policy to stop brain drain, attract young graduate and scientists to government service in the nation as well as return back our brain for the nation. A proper implementation needs honesty at the political and administrative level.

References

[1] https://raunakms.wordpress.com/2012/06/02/a-decade-in-nepali-biotech-bitter-side-of-a-tasty-fruit/ (Jan 2017).

[2] Press Release, Ministry of Education, Nepal Government of Nepal (2015).

[3] T. Boeri, H. Brücker, F. Docquier, and H. Rapoport (eds). *Brain Drain and Brain Gain: The Global,* Springer (2011).

[4] N. Sion, *Competition to Attract High-Skilled Migrants*, Oxford University Press (2012).

[5] P. F. Drucker, *Innovation and Entrepreneurship*, Springer (2016).

[6] B. R. Chiswick, (ed.), *High-Skilled Immigration in a Global Labor Market*, Washington, DC, AEI Press (2011).

[7] C. Özden, and M. Schiff (eds), *International Migration, Remittances and Development*, Palgrave Macmillan (2006).

[8] The brain drain from developing countries, IZA World of Labor: 31 (2014).

Brain Gain Centre in Nepal

The Ministry of Foreign Affairs has set up a unit named ***Brain Gain Centre*** with an aim to tap the expertise of Nepali diaspora and encourage them to contribute to Nepal's social and economic development. Major objectives of the centre include maintaining up-to-date information about Nepali diaspora and their expertise, thereby creating access to the vast amount of intellectual resources they possess. The centre also aims at giving recognition to the work by individual diaspora experts and groups, promoting their contribution among government and non-governmental agencies, and fostering respect for diaspora experts among the people back home.

Condensed Matter Physics Course at Tribhuvan University

Prof. Dr. Narayan Prasad Adhikari
Central Department of Physics, TU, Kirtipur

ABSTRACT

In this communication we briefly discuss condensed matter physics. Its importance to civilization as well as its significance to develop other areas of physics has been mentioned. Further we discuss about the course of condensed matter physics at Tribhuvan University which was approved in 1999 and revised in 2017.

The uses of matters especially in their condensed phases (liquids, solids or soft matter) have advanced civilization and technologies. Historically, the serious scientific study of condensed matter started after Newton. At the first people tried to understand the macroscopic properties of matter they primarily used. It includes material properties like mechanical, thermal, electrical, magnetic and optical properties. For this purpose Thermodynamics, Hydrodynamics, Elasticity etc played important role. The most familiar condensed phases which play important role in our daily life are solids, liquids and soft materials. Superconductivity, exhibited by certain materials at low temperature, the ferromagnetic and anti-ferromagnetic phases of spins on crystal lattices of atoms, and the Bose–Einstein condensate found in ultra-cold atomic systems are called exotic phases. In condensed matter physics we measure various material properties via experimental probes along with using methods of theoretical physics to develop mathematical models that help in understanding physical behavior. The diversity of systems and phenomena available for study makes condensed matter physics the most active field of contemporary physics and the Division of Condensed Matter Physics is the largest division at the American Physical Society. The field overlaps with chemistry, materials science, and nanotechnology, and relates closely to atomic physics and biophysics. The theoretical physics of condensed matter shares important concepts and methods with that of particle physics and nuclear physics [1-3].

Condensed matter physics (CMP) is important not only from fundamental physics point of view but also from practical point of view. If one asks which branch of physics serves our demands most the answer is CMP. CMP has served from different tools human beings used when civilization began to invention of plastics to invention of transistor and latest technology “Cell Phone”. Even in cell phone we use different materials like Liquid Crystal Display, Transistor, magnetic devices, spin valves, piezoelectric materials, Li ion battery, RAM memory, HRI Lens, CCD Camera etc which are the results of breakthroughs in CMP. All these materials and cell phone are results of research in CMP in last century. CMP has changed our lives deeply like the way we travel, communicate, medicine, computing, efficient way to use energy sources etc. The phrase Condensed matter physics that is study of collection of many atoms/molecules was popularized by Phil W. Anderson in his famous article “More is Different” [4]. Some time back, people thought that we understand the materials only from fundamental particles. It’s not correct as explained by Anderson in his book “More and Different” [5]. If we collect a few particles (atoms/molecules) they behave differently like in metal clusters [6]. This is why in recent years, nanomaterials is attracting a great deal of attention.

Consider the fact that when most bright-eyed physics majors either not aware, or hardly know anything about a field of physics majors in their first year entering a university, they are either not aware, or hardly know anything about a field of physics known as condensed matter. Yet, if they go on to receive their Ph.D. in Physics, there is highest chance that they will be graduating with a specialization in such a field! It is estimated by various professional physics organizations that roughly 70% of all practicing physicists are in condensed matter physics or related areas [7]. Then the question comes why it is interesting. The reasons may be many but I think it’s because it studies less and more both, small and big both and fundamental and industrial applications both. Further all of the advances in modern electronics came out of our understanding of the properties of materials and our ability to fabricate, manipulate and control them. The non-obvious reason that is equally important is that the advancements and discoveries coming out of CMP have important and wide-ranging implications throughout physics. At the most fundamental level, CMP studies how things interact with each other. This knowledge transcends CMP and is important in any field of physics. Important discoveries made by Phil Anderson on the broken gauge symmetries are now common principles used in field theories and particle physics. The Anderson-Higgs mechanism itself came out of CMP. Majorana Fermion came out of CMP. Thus, the progress in the theoretical understanding of CM systems has wide-ranging impact on practically all of physics. Another reason why CMP is so important is because this is the area of physics that consistently produces a description of a phenomena with some of the highest degree of certainty. Because of the ability to fabricate and control a measurement, CMP phenomena can often be tested repeatedly, often by simply changing one parameter at a time. This allows for some of the most reproducible results anywhere in physics, giving it the highest degree of certainty. In fact, the value of physical constants such as the Planck’s constant "h" and the elementary charge "e" are determined from values measured from CMP experiments. CMP experiments also produce some of the most convincing evidence for the validity of quantum mechanics and special relativity.

Considering above mentioned facts and importance of CMP we wanted to revive the course of CMP at Tribhuvan University. Even though the course entitled "Condensed Matter Physics" looks new, the course was approved in 1999. The course was revised in 2017. The main aim of the course was to provide the knowledge of physics of condensed matter and to prepare students for the higher studies and research in this field. It provides students with basic theoretical knowledge in this field and also to prepare students to solve real physical problems. Condensed matter physics includes "Solid state physics", "liquids" and "Soft matter physics". Therefore when we talked to our graduates from TU many of them said that it would be useful to study CMP as its areas are broad which includes even liquids and soft matter apart from electronic structure of solids. This is main reason what motivated us to start this course at TU.

The CMP course at TU contains mainly theory and applications of various theories in real life problems. In CMP course at TU (i) Mean filed theory, (ii) Field theories, critical phenomena & renormalization group theory are taught in 3rd Semester. Similarly (i) Dynamics –Correlation and Response, (ii) Topological defects (iii) The behavior of electron system (iv) Electron correlation (v) Two dimensional electron system and (vi) Superconductivity & Superfluidity are taught in 4th Semester. The main text books are (a) Principles of Condensed Matter Physics by Chaikin and Lubensky and (b) Condensed Matter Physics by Isihara. Both books are available in the Market/Library. The course fulfills main aim of the CMP as it helps build up theory and to apply it in many common CM systems. Further the 4th Semester course contains modern topics like Quantum Hall Effects, Phase transition in 2D electron systems, Superconductivity & Superfluidity.

References

[1] Condensed Matter Physics Jobs: Careers in Condensed Matter Physics, *Physics Today* **62**, 90 (2009).

[2] https://www.aps.org/units/dcmp/ (October 2018).

[3] Cohen, M. L., Essay: *Fifty Years of Condensed Matter Physics,* Physical Review Letters, **101**, 25 (2008).

[4] Anderson, P.W., *More is different*, *Science,* **177** (4047), 393 (1972).

[5] Anderson, P.W., *More and different*, World Scientific Publisher, Singapore, (2011).

[6] Adhikari, N.P., *Size effects in metal clusters*, M.Sc. Thesis, Central Department of Physics Tribhuvan University Kathmandu (1996).

[7] https://en.wikipedia.org/wiki/Condensed_matter_physics (October 2018)

List of M.Sc. Dissertation 2017-18 (1)

Central Department of Physics

Name of Student	M.Sc. Dissertation Title	Supervisor
Abhinna Rajbanshi	A STUDY OF FAR-INFRARED LOOP AT -61o LATITUDE	Prof. Dr. Binil Aryal
Anil K Khadka	AIR POLLUTION DISPERSION MODELING AND AIR POLLUTION AIRSHED MAP OF HETAUDA CEMENT INDUSTRY LTD	Prof. Dr. Ram Pd Regmi
Antim Sinjali	METEOROLOGICAL AND AIR POLLUTION DISPERSION MODELING OF CHAUDHARY GROUP CEMENT INDUSTRIY, NAWALPARASI, NEPAL	Prof. Dr. Ram Pd Regmi
Arjun Ghimire	ELECTRONIC AND MAGNETIC PROPERTIES OF ZINC DOPED PHOSPHORENE	Prof. Dr. Narayan Pd Adhikari
Ashwin Thapa Magar	A STUDY OF PLANCK FUNCTION DISTRIBUTION IN THE FAR INFRARED LOOP G067+00	Prof. Dr. Binil Aryal
Bibash Sapkota	FIRST-PRINCIPLES STUDY OF THERMOELECTRIC PROPERTIES OF BROMINE FILLED M4Sb12 (M= Co, Pd)	Prof. Dr. Narayan Pd Adhikari
Bikash Panthi	HYDROPHOBICITY OF SMALL ALKANE MOLECULES (PROPANE DIMER) IN SOLVENTS: A CLASSICAL MOLECULAR DYNAMICS STUDY	Dr. Nurapati Pantha
Binod Joshi	STUDY OF HYDROGEN BOND EFFECT ON THE –C=O GROUP IN QUINONE MOLECULES	Dr. Hari Prasad Lamichhane
Binod Prasad Bhatta	ADSORPTION FREE ENERGY OF BIPHENYL AND ANILINE ON THE SURFACE OF GRAPHENE AT DIFFERENT TEMPERATURES	Dr. Gopi Chandra Kaphle
Bipin Bhattarai	FIRST-PRINCIPLES STUDY OF THERMOELECTRIC PROPERTIES OF CALCIUM (Ca) FILLED SKUTTERUDITE Ir4Sb12	Prof. Dr. Narayan Pd Adhikari
Deepak Pandey	TRANSPORT PROPERTIES OF VALINE IN WATER AT DIFFERENT TEMPERATURES	Prof. Dr. Narayan Pd Adhikari
Dinesh Kumar Yadav	CO-OPERATIVE EFFECT OF ELECTRON CORRELATION AND SPIN-ORBIT COUPLING ON DOUBLE PEROVSKITES SrLaBB0O6 (B=Ni,Fe; B0=Os,Ru)	Dr. Gopi Chandra Kaphle
Esha Mishra	TRANSPORT PROPERTIES OF GAMMA-AMINOBUTYRIC ACID IN WATER	Prof. Dr. Narayan Pd Adhikari

Surface Plasmons and Nano-electronics

Dr. Bal Ram Ghimire
Associate Professor, Central Department of Physics, TU, KIrtipur

ABSTRACT
In this article, a brief description about the surface plasmons and its applications in nano-electronics will be discussed.

Introduction

In 1902 Robert W. Wood observed optical reflection on metallic gratings. In 1904, Maxwell described the bright in metal doped glasses. In 1908 Mie developed theory of light scattering by spherical particles. In 1956, David Pines described the Plasmon, the collective oscillation of electrons, as a source of energy losses experienced by fast moving electrons through metals. In 1957 Ritchie published a paper on electron energy losses in thin films,showed the existence of Plasmonmodes near the surface of metals. In 1968 Ritchie and co-workers described the anomalous behavior of metal gratings and Andre presented methods for the optical excitation of surface Plasmon on metal films.

The collective electronic excitation at the interface between a metal and a dielectric was given the name "plasmonics" by a group at the California Institute of Technology. Surface plasmons are the density waves of bunches of electrons passing a point regularly along the surface of metal. Surface plasmon wave propagate only in the thin plane at the interface."The oscillations of electrons at the surface match those of the electromagnetic field outside the metal [1]". The field's energy is dissipated during the electrons' oscillation, driven by an electromagnetic field, collides with the surrounding lattice of atoms. An article in the Scientific American, July 2007, reported that plasmon losses are "lower at the interface between a thin metal film and a dielectric than inside the bulk of a metal because the field spreads into the nonconductive material, where there are no free electrons to oscillate and hence no energy dissipating collisions [1]'.From research on single nobel-metal nanoparticles, it was well established that light at the surface plasmon resonance frequency, typically in the visible or infrared part of the spectrum, interacts strongly with metal nanoparticle and excite collectively the electron motion. Researchersare thinking to develop new techniques for transmitting optical signals through nanoscale components, these plasmonic components that could perform many of the same functions such as splitting wave guides as done by dielectric devices. Nanoscale wires along whichplasmons could travel are called interconnects. Therefore interconnects carry information from one part of a microprocessor to another. "*Plasmonic interconnects would be a great boon for chip designer* [1]".Results from different research predict that plasmonic devices could prove useful in transmitting data from one part of a chip to another.

Theoretically it was shown to be possible to employ plasmonic components in a wide variety of instruments and medical applications. By designing tiny particles that could use plasmon resonance absorption, cancerous tissues could be killed. Investigators are studying plasmonics because the new field may shine a light on the nano-world [1, 2].

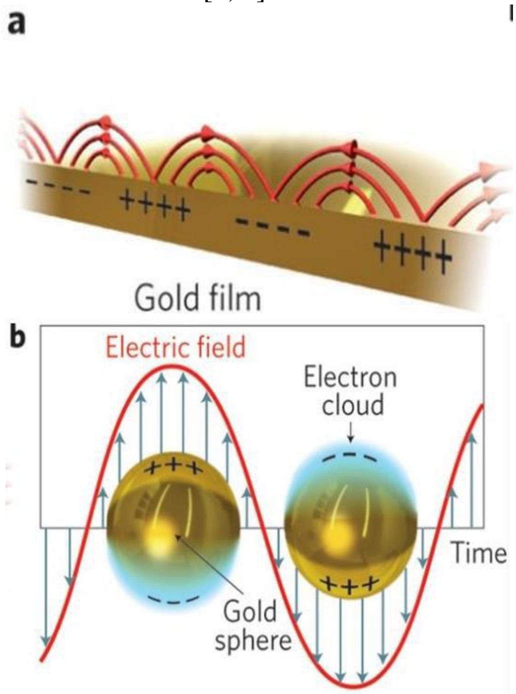


Figure 1: (a) Propagation of Surface Plasmon Polaritons (SPP), and (b) Oscillation of Localized Surface Plasmons (LSP) [2].

Different experimental and theoretical researches have been performed in the field of interaction of light with metal nanoparticles for a long time. Gold, silver, and copper nanoparticles are of special interest as they can exhibit particularly strong optical extinction in the visible spectral range due to resonantly-driven electron plasma oscillation. Such particle plasmas cause field enhancement and spectral selective light absorption. These properties are important in the context of future electronic and optical device application. The development of integrated electronic and photonic circuit has led to remarkable at processing and transport capabilities[3,4].

Stefan A. Maier and co-workers showed that, in particles much smaller than the wavelength of exciting light, plasmon excitation produce an oscillating dipole field [4]. From the study of numerical simulations, it has been shown that electro- magnetic energy can be transferred below the diffraction limit along linear chain of closely spaced metal nanoparticles. The electro-magnetic energy transport along the chains of metal nanoparticles relies on the linear field electro-magnetic interactionbetween metal particles that set-up couple dipole or plasmon models. This is analogous to the process of resonant energy transfer [2, 4, 5].

In a recent research paper, Stefan A. Maier and co-workers explained and showed that aligned silver, copper, and gold nanoparticles driven at the coupled surface plasmon resonance modes could propagate EM energy below the diffraction limit in a coherent fashion with negligible radiation losses [6]. It was shown in previous research that transmission losses for nanoparticle chain arrays, 900 corners and Tee-structure were negligible [3]. Researchers are hoping that plasmon wave guides and metallic nanostructures can lead to the construction of integrated nano-optical devices [2, 3, 6].

Due to high conductivity and low cost, copper is the most abundantly used metal in electronics applications. Because of the surface oxidation, the plasmonic properties of copper have not received much attention as compared to silver and gold. Various protection methodshave been implemented to prevent the oxidation of copper [7].

Link Between Nanoelectronics and Microphotonics

Information is transported in two ways, using electronic devices and using optical (photonics) devices. Electronic devices are small in size and can carry a very small amount of data, while photonics devices can carry a huge amount of data but are much bigger in size. Scaling integrated electronic and photonics circuits to smaller dimensions could create faster and more efficient devices, but there are big challenges. Two big problems preventing a significant increase in processor speed above a high frequency are thermal and RC delay time issues with electronic interconnection.

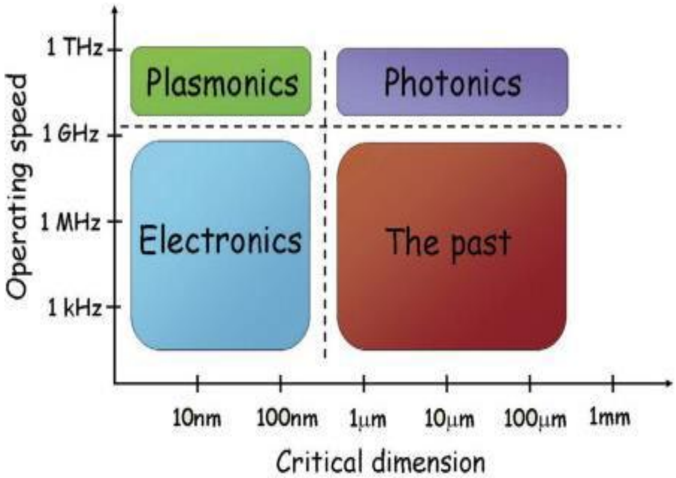


Figure 2: *Plasmonics: the next chip-scale technology. Operating speeds and critical dimensions of various chip-scale device technologies, highlighting the strengths of the different technologies.[8]*

We are living in the twenty first century, age of information technology; we always prefer devices which are faster, efficient and compact in size. Fig. 1 shows the operating speeds and critical dimensions of different chip-scale device technologies. In the past the devices were slow and bulky. Electronics devices are small in size because they have resisters and capacitors connected by metallic wires. Due to resisters and capacitors, devices face the heating effect and delay therefore we can not connect more and more components as we might desire. Photonics devices can not be reduced beyond a certain size because it has diffraction limits. Indeed, photonic structures tend to still be at least 1 or 2 order of magnitude larger than their electronic counterparts. This size mismatches between electronic and photonics components create major problems in interfacing these technologies. But nano-electronics (plasmonics) might hold the key because plasmonics devices are fast, small in size and can carry big amount of data and plasmonics devices do not face any heating effect, diffraction limit, and delay time[8].

Thus new device technology must be developed that can facilitate information transport between nanoscale devices at optical frequencies forming a bridge between the world of electronics and photonics [1]. M. L. Brongersmaet. al described "*a tremendous synergy can be attained by integrating plasmonic, electronic and conventional dielectric photonic devices on the same chip and taking advantage of the strengths of each technology* [9]" and they provided a perspective on future directions and possibilities for integrating plasmonic device on a Si chip.

Their experimental results suggested that the possibilities for using single metallic stripe for intra-chip communication may be limited to short distances but concluded that the active plasmonic devices can be used as a bridge between photonics and electronics [9, 10]. More research is needed to understand the physical and optical properties of such bridges.

References

[1] Harry A. Atwater, The Promise of Plasmonics, *Scientific American letter* (2007).

[2] John B. Pendry and David R. Smith; *The Quest for the Superlens*, Scientific American Letter (2006).

[3] Mark L. Brongersma et. al. Phy. Rev. B, **62**, 24 (2000)

[4] S. A. Maier, Mark L. Brongersma, and H A Atwater, *Material Science and Engineering*, C **19**, 291-294 (2002)

[5] R. W. Wood, on a remarkable case of uneven distribution of light in a diffraction grating spectrum, Phill. Mag.**4**, 396 (1902).

[6] Stefan A. Maier et. al, Optical pulse propogation I metal nanoparticle chain wave guides, Physical Review B, **67**, 205402 (2003).

[7] S. Hussain, R. K. Roy and A. K. Pal, Surface Plasmon effect in nanocrystalline copper/DLC composite films by an electrocomposition technique. J. phys. D: Appl. Phys **38**, 900-908 (2005).

[8] Zia Rashid et al., *plasmonics: the next chip-scale technology*, Materials Today, **9**, 7-8 (2006).

[9] M. L. Brongersma, R. Zia, J. A. Schuller, *Plasmonics-The missing link between nanoelectronics and microphotonics*, Appl. Phys. A, **156**, 221-223 2007)

[10] S. Roberts, Interpretation of the optical properties of metal surfaces, Physical Review, **100**, 6 (1955).

Correlation between Relative Humidity and Global Solar Radiation for Jumla

Dr. Krishna Raj Adhikari
Pashchimanchal Campus, IOE, TU, Nepal

ABSTRACT
The present study tries to correlate between the relative humidity and the solar radiation to examine the relative humidity to develop a model. It is found that the relative humidity impacts the global solar radiation negatively due to the absorption of infrared, visible and little U-V region of light. It is also observed that the global solar radiation has the smaller amount when relative humidity is higher and GSR has the higher amount when relative humidity is smaller. Moreover, it is also revealed that the weak correlation between the relative humidity and global solar radiation.

Introduction

Energy is an important issue in our daily life and can be broadly categorized into two groups; conventional and non-conventional. Conventional energy sources are generally called non-renewable. Their main components are fossil fuels (coal, oil and natural gas), wood and nuclear energy. Wood has been served the human energy needs since thousands of years back. Fossil fuels have been serving for a long time and nuclear energy has also been contributing since 1954, the date of world's first nuclear power plant establishment (Munawwar, 2006). Non-conventional or renewable energy sources consist of biomass, hydropower, solar, wind, tidal and geothermal energy. Based on the worldwide consumption pattern, biomass and hydropower are in the first and second position respectively among the renewable energy sources (IEA, 2014). In the following years, other sources also have made a significant contribution in global energy consumption.

So far, fossil fuel based energy has been unanimously used in domestic purposes, in industry and ubiquitously. The combustion of fossil fuel produces a huge amount of CO2 which is not all consumed by the plants, and other greenhouse gases (GHG). Consequently, the rate of the global warming is increasing. It deteriorates the environment as well as the human health. Each of last three decades has been successively warmer on the earth surface than any preceding decade since 1850. The upper 75 m of oceans is warmed by 0.11° C per decade from 1971 to 2010. Consequently, global mean sea level had risen by 0.19 m over the period of 1901 to 2010. The rise in sea level was 3.2 mm/yr between 1993 and 2010 (IPCC, 2014) which is the highest value known so far. The increase in temperature ultimately increases frequency and severity of natural disasters (Petritsch, 2000). On the other hand, fossil fuel reservoirs are limited and getting depleted gradually. The cost of this fuel is highly influenced by socio-economic and political situations (Adhikari et al., 2014; Janjai, 2006; Olayinka, 2011). The most abundant and easily available energy on the earth is solar radiation. The other energy sources, many chemical, physical and almost biological processes on the earth are also the indirect and direct consequence of solar energy, so it is a really important and promising energy source (Adhikari, 2017; Munawwar, 2006; Chen and Li, 2012; Wang et al., 2012). Moreover, electricity plays a vital role for the sustainable economic growth of a country which can be obtained from the solar energy as well.

Among the renewable energies, solar energy is inextinguishable and abundant everywhere. It is essential to know the solar energy potential for the better utilization and arrangement. It is equally important to identify the factors such as relative humidity, aerosol, etc they affect the solar radiation reaching the earth.

The best practice to recognize Global Solar Radiation (GSR) potential at a site is to install pyranometer(s) and look after their day to day maintenance and recording. In Nepal, one hundred thirty eight and one hundred thirty three stations have facility to measure temperature and relative humidity respectively. Only nineteen and sixteen stations measure the sunshine hours and GSR respectively (Personal communication with DHM/GoN personnel in 2017). This is a reality of Nepal and the similar situation is found even in developed countries.

The best alternative approach to know the solar energy in any site of a country is to develop a model based on meteorological parameters, where the data can be collected to estimate global radiation. The resultant correlation may then be used for locations of similar meteorological characteristics (Adhikari et al., 2013; Augustine and Nnabuchi, 2009).

The article aims to correlate the Relative Humidity (RH) and GSR for the root to develop model to predict the global solar radiation.

Method and Materials

Usually in Nepal, the relative humidity is measured by dry and wet bulb hygrometer and global solar radiation is measured by CMP 6 pyranometer. Jumla is chosen as a study site. The data of the site for the study were collected from the archive of Department of Meteorology, Government of Nepal. The instruments were installed in Jumla airport of the latitude 29°15' N, longitude 82°15' E and 2300 m above the sea level. Here, three years 2011, 2012 and 2013 data of relative humidity and GSR were taken to correlate between them. The relative humidity and global solar radiation data were separately changed into desirable form i.e., daily, monthly, yearly and monthly mean daily relative humidity and GSR.

Result and Discussion

In this study, we plot the daily and monthly mean daily relative humidity and GSR for Jumla against DOY and the months January to December respectively. Moreover, we plot the graph between monthly mean daily GSR and the monthly mean daily relative humidity to find the coefficient of determination and correlation coefficient.

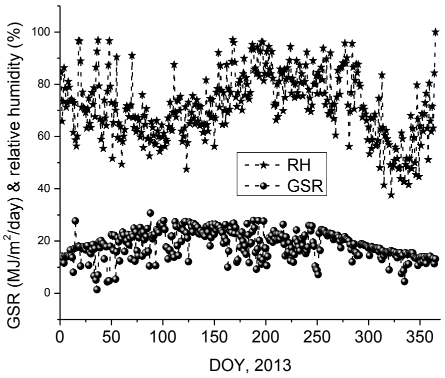


Figure 1: *Variation of mean value of relative humidity and GSR with DOY, 2013.*

Figure 1 is the plot of daily relative humidity and daily GSR with day of the year (DOY), 2013. Similarly, figure 2 shows the variation of mean value of monthly mean daily relative humidity and mean value of monthly mean daily GSR of three years data with the months. In figure 1, GSR is 27.66 MJ/m2/day (higher value) when relative humidity is 58.7% on DOY 15. Similarly for DOY 123 and 365, RH and GSR are found to be (47.5%, 23.11 MJ/m2/day) and (100%, 13.12 MJ/m2/day) respectively.

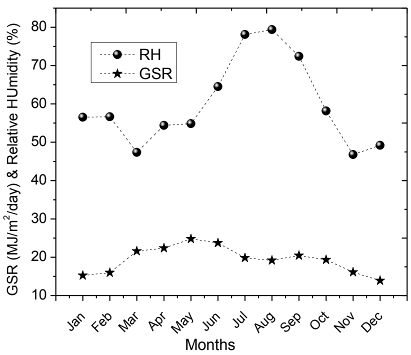


Figure 2: *Variation of monthly mean daily relative humidity and GSR with months*

In the plot of variation of the monthly mean of daily relative humidity and GSR with months, in figure 2, relative humidity is found to be minimum 47.36% in March when the GSR has the higher value 21.61 MJ/m2/day and maximum relative humidity is observed to be in August while GSR has the smaller value 19.17 MJ/m2/day. These figures have illustrated that GSR has the smaller amount when relative humidity is higher and GSR has the higher amount when relative humidity is smaller.

Water exists in atmosphere in three different states, gas, liquid as well as ice. The gaseous state of water is the water vapor which absorbs solar radiation when the solar radiation traverses it in the lower atmosphere. The humid air attenuates the GSR before reaching the earth surface due to the absorption of visible and infrared portion by the water vapor (Iqbal, 1981; Goody and Young, 1989). Water absorbs the radiation in the visible and infrared regions (0.54-9 μm) due to vibrational-rotational transition, in far infrared region (9 μm -1.5 cm) is due to the rotational transitional transition and in ultraviolet (< 0.2 μm) is due to the electronic transition (Kondratyev, 1969). Moreover, the water vapor scatters the solar radiation to attenuate it (Iqbal, 1981). Thus the relative humidity attenuates the solar radiation and has negative impact to the solar radiation.

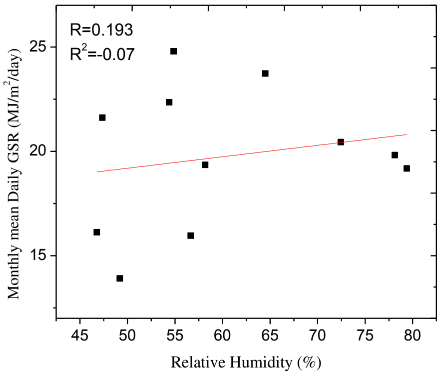


Figure 3: *Scatter plot of global solar radiation and relative humidity.*

Scatter plot of monthly mean daily global solar radiation and relative humidity and their correlation coefficient is shown in figure 3. Coefficient of determination (R-square) has a smaller and the negative value, -0.07 and correlation coefficient has a smaller value, 0.193.

Coefficient of determination tells the proportion of the dependent and independent variables. For the better correlation, their coefficients should approach 1. These smaller values for the coefficients of correlation and determination indicate the poor correlation between them. Negative value of correlation coefficient arises when fitting non linear function to the data (Ullah, 2012).

Conclusions

In the present study, it has found that the relative humidity has negative impact to the solar radiation due to the absorption of infrared, visible and little U-V region of light. Thus, the global solar radiation has the smaller amount when relative humidity is higher and GSR has the higher amount when relative humidity is smaller. The scatter plot of relative humidity and GSR has also revealed the weak correlation between the relative humidity and global solar radiation. Moreover, it can be used to develop model along with the other strong parameter(s) to prediction the GSR.

Acknowledgements

I acknowledge Prof. Dr. Shekhar Gurung, Prof. Dr. Bharat Pahari, Prof. Dr. Binil Aryal, Prof. Dr. Binod K Bhattarai and Prof. Dr. Narayan Adhikari for their constant support, care and inspiration.

References

[1] K. R. Adhikari, B. K.Bhattarai & S.Gurung, *Estimation of global solar radiation for four selected sites in Nepal using sunshine hours, temperature and relative humidity*, Journal of Power and Energy Engineering, **1**(3), 1-9 (2013).

[2] K. R. Adhikari, B. K.Bhattarai & S.Gurung, *Empirical model based on meteorological parameters to estimate the global solar radiation in Nepal*, Bibechana, **11**(1), 25-33 (2014).

[3] K. R. Adhikari, K.R., *Study on Daily Total Solar Radiation at Different Parts of Nepal to Develop Models and Numerical Simulation of Thin Film Perovskite-based Solar Cells*, PhD Thesis, Tribhuvan University, Kirtipur, Nepal (2013).

[4] C. Augustine & M.N. Nnabuchi, *Relationship between global solar radiation and sunshine hours for Calabar, Port Harcourt and Enugu, Nigeria*, International Journal of Physical Sciences, **4**(4), 182-188 (2009).

[5] J. L.Chen, & G. S. Li, *Assessing effect of time scale on the solar radiation sunshine duration relationship*, Quarterly Journal of the Hungarian Meteorological Service, **116** (2), 123-143 (2012).

[6] IEA, *Key world energy statistics*, World Energy Investment Outlook (2014).

[7] IPCC, *Climate Change 2014: Synthesis Report. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change* [Core Writing Team, R.K. Pachauri and L.A. Meyer (Eds.)]. IPCC, Geneva, Switzerland (2014).

[8] M. Iqbal, *An introduction to solar radiation*. New York, Academic Press (1983).

[9] S. Janja, *Assessment of Solar Energy Potentials for Lao People's Democratic Republic. Department of Alternative Energy Development and Efficiency*, Thailand, Department of Electricity, Lao PDR, and Solar Energy Research Laboratory, Department of Physics, Silpakorn University, Thailand (2006).

[10] K. Y. Kondratyev, *Radiation in the atmosphere*, New York, Academic Press (1969).

[11] S. Munawwar, *Modeling hourly and daily diffuse solar radiation using worldwide database*, PhD Thesis, Napier University, Edinburgh (2006).

[12] S. Olayinka, *Estimation of global and diffuse solar radiations for selected cities in Nigeria*, International Journal of Energy and Environmental Engineering, **2**(3), 11-33 (2011).

[13] K. Petritsch, *Organic solar cell architecture,* PhD Thesis. Technisch-Naturwissenschaftliche Fakultat der Technischen Universitat Graz, Austria (2000).

[14] M. I. Ullah, *Coefficient of determination: A model selection criterion*, Lecture notes on basic statistics and data analysis (2012).

[15] K. C. Wang, R. E. Dickinson, M. Wild & S. Liang, *Atmospheric impact on climate variability on surface incident solar radiation*, Atmospheric Chemistry and Physics, **12**, 9581-9592 (2012).

Tribhuvan University Service Commission

Curriculum Specification Chart for Written Examination / Position: Lecturer

First Paper: *Multiple Choice and Subject Specific Questions*

Full Marks: 100 — **Time: 3 Hours**

S.N.	Particulars	Mark(s)	No of Ques	Total Marks	Remarks
1	Foundational principles of Multiple-choice questions (a) Questions based on reproduction of information (b) Analytical questions (c) Creative questions	1	20	20	(a) Reproduction: Five (5) questions based on facts, information and knowledge (b) Ten (10) analytical and critical questions based on subject matter (c) Five (5) questions on original explanation/analysis of subject matter
2	Foundational principles of subjective questions (a) Questions aiming at facts, information, knowledge, analysis, criticism and interpretation based on subject matter.	8	5	40	(i) Two (2) questions related to informational and factual knowledge (ii) Two (2) analytical and critical questions based on subject matter. (iii) One (1) question demanding interpretation of subject matter.
	(b) Questions based on recent trends	10	2	20	Two (2) questions addressing the recent issues and challenges
	(c) Questions based on creativity	10	2	20	Two (2) questions for creative presentation of the subject from an original and innovative perspective.

Maximum mass of lightest neutrino revealed

The mass of the lightest neutrino, an abundant 'ghost' particle found throughout the universe, has been calculated to be at least 6 million times lighter than the mass of an electron. Neutrinos come in three flavours made up of a mix of three neutrino masses. While the differences between the masses are known, little information was available about the mass of the lightest species until now.

Source:https://www.sciencedaily.com/releases/2019/08/190822113407.htm

Physics behind Aurora

Dr. Lekha Nath Mishra
Associate Professor, Patan Multiple Campus

ABSTRACT

This article explains the physics behind aurora and its formation. Besides this, different myths regarding on aurora have also been explored. Whatever the myths, it usually occurs near the magnetic poles of the earth i.e. North and South poles though there is no connection between poles of magnet to the geographical poles. It is seen in the Arctic Islands such as Northern Norway, Northern Canada as well as Southern Hemisphere such as Australia. So, it is also called Northern light seen in the North poles and Southern lights are named Aurora Australis because it is the Latin word for South.

Introduction

Aurora coming from the Greek name Boreas as North wind. There are some myths behind it saying that the Roman Goddess of down. Whatever the myths, it usually occurs near the magnetic poles of the earth i.e. North and South poles though there is no connection between poles of magnet to the geographical poles [1]. It means that geometrical poles of magnet are opposite to the geographical magnetic poles.It is seen in the Arctic Islands such as Northern Norway, Northern Canada as well as Southern Hemisphere such as Australia. So, it is also called Northern light seen in the North poles and Southern lights are named Aurora Australis because it is the Latin word for South. So, it is worthwhile to know the Physics behind it.

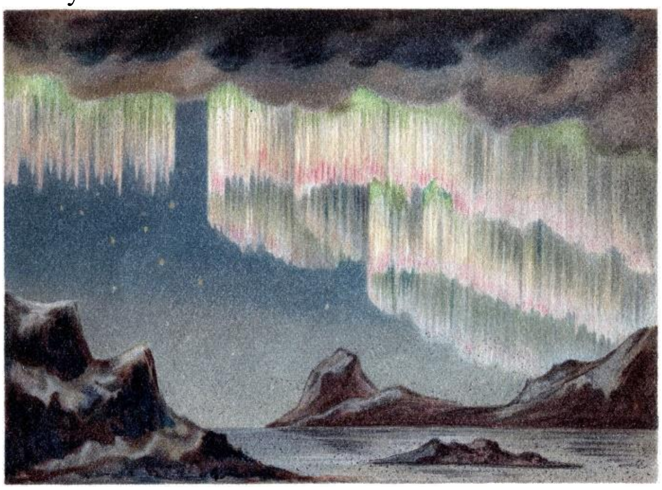


Figure 1: *Aurora Borealis[4]*

According to Bohr's theory of atomic model, when electron jumps from higher energy level to the lower energy level, it emits radiation in the form of electromagnetic wave. Same phenomenon is happened, when the electrons which are coming from the space i.e. specially from solar wind, blowing outward from the sun strike an atom or molecules in Earth atmosphere then it gets excited and moves to higher state called excited state. Thus, excited electrons do not reside at higher level for longer time. So, after a while, the electron in the excited state jumps to the lower energy state. As a result, it emits energy as light causing the aurora. Actually, it is same phenomenon that causes emission line spectra. So, it is also called the line spectra of the atoms in Earth's upper atmosphere. There are different colors of emission of light which depends on the molecules of gases present at the atmosphere. Hence, it is due to the interactions between electrons which are coming from the space to different gas molecules present at the atmosphere. For example, if the interaction between electrons and oxygen molecules occurs then the emission will be green Aurora but that of electron strikes to the oxygen atom, it produces red color.Similarly that will be blue color when electrons strike to the nitrogen. As we know that there are almost 78% nitrogen and 21 % oxygen occur in the Earth's atmosphere. Hence, generally, the blue and green aurora appears on the polar region. Since atomic oxygen occurs at high altitude, so a red color appears above the green. As a result, aurora has mixing colors. For simplicity, it can be compared with fluorescent lamp such as neon lamp, mercury lamp and so on. When electric field is applied on the neon lamp then neon gas gets excited and light is emitted which results the glow in the tube.

The aurora is also the electromagnetic phenomenon because the Earth's magnetic field is found to be significantly disturbed near on it. In 1903, Christian Birkeland (1867-1917) proposed that the magneticdisturbances in the vicinity of the aurora may be due to large electrical currents flowing up and down along the auroral features.In recognition of Birkeland's ground breaking research those currents are termed asBirkeland currents [2]. These currents are quite powerful which flows upward from the Earth's in the night and downwards in the day. The most of the charge carries of current are electrons which flow opposite direction of the flow of current. The streaming down of the electron at night comes into contact with the oxygen and nitrogen atoms gives rise the aurora.

Magnetic reconnection in Earth's magnetosphere is another responsible mechanism to form Aurora. Basically, magnetic reconnection is a physical phenomenon in which magnetic energy is converted into kinetic energy, thermal energy and particle acceleration. It occurs on timescales intermediate between slow resistive diffusion of the magnetic field and fast Alfvenic timescales [3].

More specifically in reconnection process, the magnetic field lines from different magnetic domains are splice to one another, changing their patterns of connectivity with respect to the sources. It is a violation of an approximate conservation law in plasma physics, called the Alfven's theorem and can concentrate mechanical or magnetic energy in both space and time. Solar flares which occur near sunspots are believed to be powered by magnetic reconnection. Solar magnetic activity, include flares, can eject high energy charged particles into space. On the side, the Earth's own magnetic field is constantly perturbed by the impinging field from the sun called solar wind.

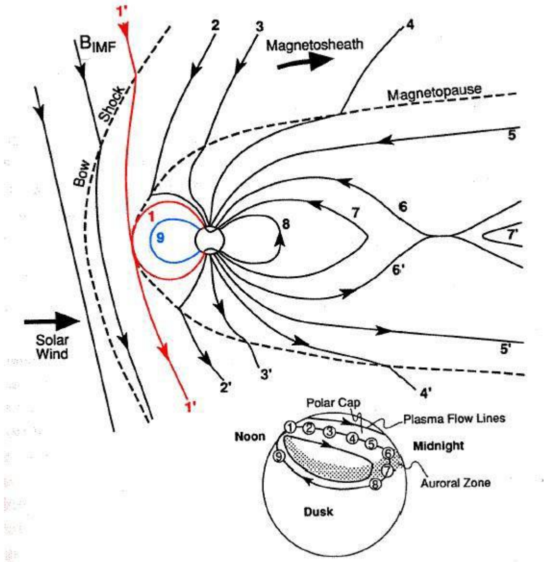


Figure 2: *Magnetic reconnection in Earth's magnetosphere [4]*

During the strong bursts i.e. solar flares reconnection can be induced in the near-Earth magnetotail.The tenuous plasma in that region is then accelerated down magnetic field lines into the polar-regions, striking Earth's atmosphere and exciting nitrogen and oxygen atoms as well as other atoms present in the atmosphere.The immediate de-excitation of these atoms gives the aurora.

According to simple resistivemagnetohydro-dynamics (MHD) theory, reconnection happens because the plasma's electrical resistivity near the boundary layer opposes the currents necessary to sustain the change in the magnetic field. The need for such a current can be seen from one of Maxwell's equations,

$$\nabla \times B = \mu J + \mu \in \frac{\partial E}{\partial t}$$

The resistivity of the current layer allows magnetic flux from either side to diffuse through the current layer, cancelling out-fluxes from the other side of the boundary. When this happens, the plasma is pulled out by magnetic tension along the direction of the magnetic field lines. The resulting drop in pressure pulls more plasma and magnetic flux into the central region, yielding a self-sustaining process.

Conclusions

Aurora is the electromagnetic phenomenon happening when the Earth's magnetic field is significantly disturbed near on it. The most of the charge carries of current are electrons which flow opposite direction of the flow of current. The streaming down of the electron at night comes into contact with the oxygen and nitrogen atoms gives rise the aurora. Magnetic reconnection in Earth's magnetosphere is another responsible mechanism to form Aurora. More specifically in reconnection process, the magnetic field lines from different magnetic domains are splice to one another, changing their patterns of connectivity with respect to the sources. Solar magnetic activity, include flares, can eject high energy charged particles into space. On the other side, the Earth's own magnetic field is constantly perturbed by the impinging field from the sun called solar wind. The tenuous plasma in that region is then accelerated down magnetic field lines into the polar region, striking Earth's atmosphere and exciting nitrogen and oxygen atoms as well as other atoms present in the atmosphere. The immediate de-excitation of these atoms gives the aurora.

References:

[1] R. M. Friedman, *Interdisciplinary Science Reviews*, **35**, 51(2010).

[2] K. Birkland, *Archives des Sciences Physiques et National*, **4**, 497(1896)

[3] H. Alfven, *IEEE transactions on plasma science*, **14**, 778 (1986).

[4] https://earthsky.org/earth/what-causes-the-aurora-borealis-or-northern-lights (Dec 2018)

Supercomputer shows 'Chameleon Theory' could change how we think about Gravity

Supercomputer simulations of galaxies have shown that Einstein's theory of General Relativity might not be the only way to explain how gravity works or how galaxies form. Physicists at Durham University, UK, simulated the cosmos using an alternative model for gravity -- *f(R)*-gravity, a so called Chameleon Theory. The resulting images produced by the simulation show that galaxies like our Milky Way could still form in the universe even with different laws of gravity. The findings show the viability of Chameleon Theory -- so called because it changes behavior according to the environment -- as an alternative to General Relativity in explaining the formation of structures in the universe. The research could also help further understanding of dark energy -- the mysterious substance that is accelerating the expansion rate of the universe. The findings are published in Nature Astronomy.

Source: https://www.sciencedaily.com/releases/2019/07/190708131153.htm

How common is our Galaxy Milky-Way?

Dr. Sanjaya Paudel
Department of Astronomy, Yonsei University, Seoul, South Korea

ABSTRACT

Our universe is full of mysteries. Milky-Way is our home galaxy. It is a rotation dominant spiral galaxy. It is located in a less dense part of the universe where the nearest massive galaxy (our friend galaxy Andromeda) is located at far away 2.5 Million light years from us. Although among the 200 Billion galaxies in the universe approximately 70 percent are Milky-Way type spirals, the Milky-Way contains some unique features that are not common in observation.

We are situated in a star-forming, spiral galaxy Milky Way (MW). It contains nearly 100 billion stars and it is currently forming new stars at the rate of approximately one sun like star per year. It is a member of the local group where the Andromeda is the nearest neighbor galaxy. Which is located at approximately 750 kilo parsec (kpc - 1 kpc = 3.26 light years) away and approaching toward us. Due its proximity, the local group galaxies are in many respect the best-studied galaxies in the universe. They have been a critical testbed not only for the cosmology, but also for the fundamental physics and characterizing the properties of dark matters. It is the only place where we can study the kinematic and chemical properties of galaxy's stars individually and detect faintest satellite galaxies. One of the most cosmologically interesting statistical properties of the MW is its number of satellites and this has been used to make a direct comparison between theory of galaxy formation and observation. Though a perfect match between the theory and observation has not been achieved yet.

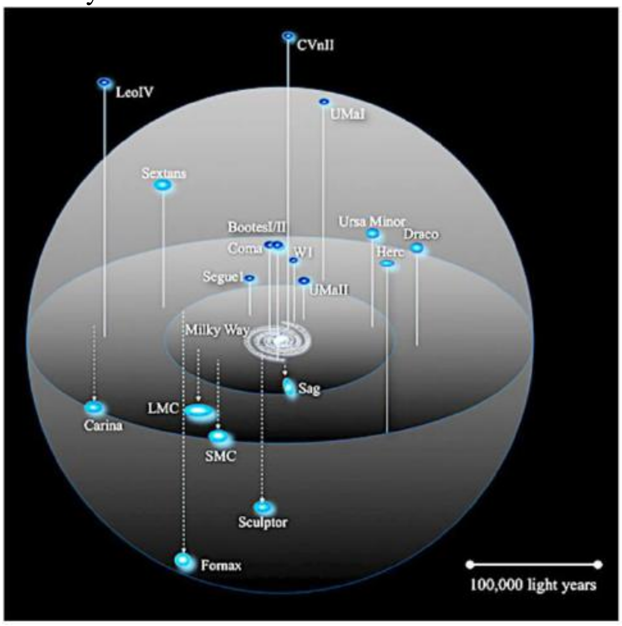


Figure 1: *Distribution of dwarf satellite galaxies around Milky-Way*

Milky-Way has a system of satellite galaxies which constitutes around four dozen of dwarf galaxies [1]. Like a planetary system, MW satellite galaxies are moving in a coherent motion making a thin plane of satellite galaxies revolving around the host MW [2]. They are distributed within a thickness of 10 kpc from the mid-plane. The plane axis ratio is around 0.2 and has an inclination of 73^o to 87^o relative to the MW plane. In addition, observed proper motion of satellite galaxies shows that their orbital motion is aligned closely with the plane. Such a tight alignment of orbital directions is very rare. Since our cosmology is based on an assumption of isotropic distribution of matter in the universe, such presence of anisotropic distribution satellite galaxies is a new challenge to the hierarchical cosmology. Where every large-scale structure, like MW satellite systems, are supposed to be build up by isotropic accretion of galaxies from the field.

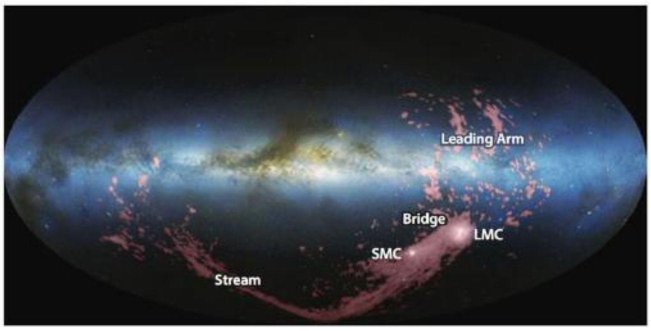


Figure 2: *Large and Small Magellanic clouds (Pink) around Milky-Way (the background). The extended tail and the Magellanic Bridge between the LMC and SMC are clearly visible.*

Among MW satellite galaxies Large and Small Magellanic clouds (LMC-SMC) are the most massive ones. They are located in the southern hemisphere with declination -70^o and -72^o for SMC and LMC, respectively. Therefore, we can only see them in southern hemisphere sky. They are the only satellite galaxy of MW that can be visible to naked eye in the constellations Dorado (LMC) and Tucana (SMC). They are located at a distance of 50 kpc from the MW center. They are the closest star-forming galaxies to the MW which therefore provide a unique laboratory to study the star-formation in external galaxies. They have a huge reservoir of neutral hydrogen that fuels their star-formation. Each one of them has around a billion stars.

The LMC and SMC are separated around 21oin sky but surrounded by an extended network of gaseous structures forming a continuous bridge, see Figure 2. This eminently proves their ongoing interaction. In our hierarchical cosmology, galaxy interaction plays a significant role in galaxy formation and evolution and it is not a smooth process. It changes the dynamics and morphology of interacting galaxies, in fact, it has been proven from both the observation and numerical simulation that elliptical galaxies are actually formed by merging of disk galaxies like MW.

Another interesting feature of LMC-SMC is presence of an extended tail of gas called Magellanic Stream (MS), which was first discovered by radio telescope by observing its 21-cm Hydrogen emission line in the direction of LMC and SMC [3]. It was first reported in 1974 and since then our knowledge has greatly improved with successive generations of radio telescopes. It is believed that MS is the outcome of the tidal interactions between the LMC-SMC and the MW and if the gaseous stream arrives safely in the disk of MW it can elevate the MW star-formation rate. Observations have shown that vast majority of satellite galaxies are gas-poor and non-star-forming galaxies. In fact, LMC and SMC are the only star-forming satellite of MW. But there is also a hypothesis that the couple have recently fallen into the MW system and they will lose their star-forming gas in the future by the effect of ram-pressure stripping as the Clouds pass through an external medium.

A number of studies have shown that a satellite pair of LMC-SMC mass around a MW mass host is extremely uncommon [4]. Theoretical study of galaxy formation and evolution has been done with numerical simulation which applies a hierarchical framework of structure formation and assumes the standard cosmology where matter energy is dominated by cold dark matter and dark energy. Form this simulation, we can predict the frequency of LMC and SMC mass satellites around MW host. There are less than 10 percent chance that a MW mass host galaxy host two satellite galaxies of mass of Magellanic Clouds. Similarly, using large set observational data and studying nearly a million of galaxies it is calculated that the probability of such a system is less than 5 percent. Following this statistic, the merger probability of LMC-SMC morphology dwarf galaxy satellites around the MW mass host may be even smaller.

While studying interacting dwarf galaxies in the local universe, we have recently discovered a Milky-Way twin, NGC2718 [5,6]. It is an isolated spiral arm galaxy which has similar number of star as in the MW. It is also a star-forming galaxy. It possesses two interacting dwarf satellite galaxies, like interacting Large and Small Magellanic Clouds around the Milky-Way. It is located at a distance of 180 Million light years away from us. UGC 4703 is one of the couple dwarf galaxies which are interacting and the companion is not previously identified. So we gave a name to the companion as UGC 4703B. The couple is located at distance of around 100 kpc from the host galaxy NGC2718. We observe the NGC2718 system using Giant Meter Web Ratio Telescope (GMRT) located at Narayan Gau, Pune, India, during the month of Jun 2017. GMRT data helps to study distribution of hydrogen in these systems by observing 21-cm hydrogen emission line. Hydrogen emits 21-cm radiation as it changes the energy state of neutral hydrogen atoms. Therefore, in astronomy 21-cm emission line is used to study the neutral hydrogen which is particularly important for the star-forming galaxies assuming that these neutral hydrogens are the fuels to form new stars in the galaxies. On contrary, neutral hydrogen content in elliptical galaxies are almost nil or marginal which, therefore, are not detected in 21-cm radio observation.

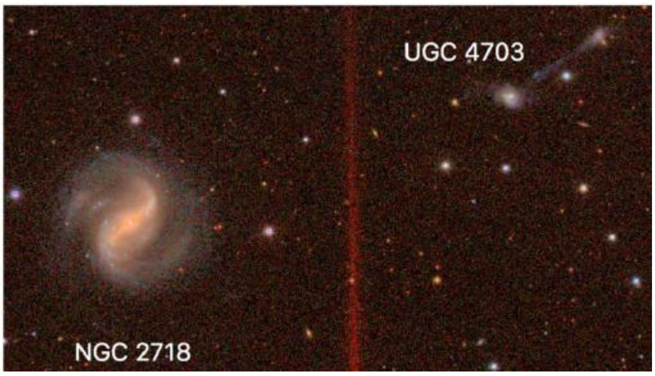


Figure 3: *NGC2718 and its interacting satellite system. The interacting two dwarf galaxies UGC 4703 and UGC 4703B are located at top right corner.*

GMRT data reveals large amount of neutral hydrogen on both NGC2718 and its satellite galaxies UGC 4703 as UGC 4703B. In this study, we also used different images that are take different wavelength of electromagnetic spectrum. We used Ultra-Violet (UV) image taken from the space telescope Galaxy Evolution Explorer (GALEX) and optical images taken from the Sloan Digital Sky Survey (SDSS). The UV emission mainly comes from young stars while the optical emission is dominated by sun like stars. Therefore, the UV data is used to study star-formation activity in the galaxies, while the SDSS optical images are used to estimate how many sun like stars are there in the galaxies.

By analyzing UV, optical and radio image of UGC 4703 as UGC 4703B pair, we also identified a bridge of stars and gas connecting the couple and star-forming activity at the center of both galaxies. In midway of the bridge, we have found a smaller galaxy (10000 times smaller than Milky-Way) born out of the interacting satellite galaxies, which is more unique compare to the Milky-Way system.

References

[1] A. W. McConnachie, AJ, **144**, 4 July (2012).

[2] P. Kroupa, C. Theis, and C. M. Boily, A&A, **431**, 517–521 (2005).

[3] E. D'Onghia, and A. J. Fox, ARA&A, **54,** 363–400 (2016).

[4] L. Liu, B. F. Gerke, R. H. Wechsler, P. S. Behroozi, and M. T. Busha, ApJ, **733**, 62 May (2011).

[5] S. Paudel, P. A. Duc, and C. H. Ree, AJ, **149**, 114 (2015).

[6] S. Paudel and C. Sengupta, ApJ, **849**, L28 (2017).

The Rise of the Data Science

Dr. Prajwal Kafle
Adjunct Lecturer, University of Western Australia (UWA)
Data Scientist, Virtual Gaming Worlds (VGW)

ABSTRACT

In this article, the scope, meaning and limitations of data science will be described.

From the stone age to to the modern era of the internet and globalisation, human civilization has traversed vast journey of the technical advancement. While the last century has been marked as an era of computers (hardware and software), at least the first half of the 21st century is seemingly being dominated by the power of the data. Furthermore, it is anticipated that the artificial intelligence will dominate the next half. This article focuses on the former, i.e., the data science and its direct or indirect applications as well as implications in important branches of science and many sectors of human life.

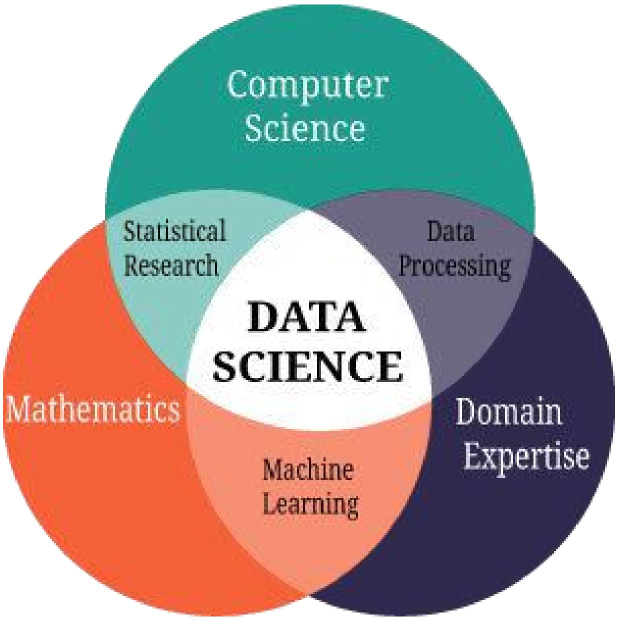


Figure 1: *Data science is a multi-disciplinary field that uses scientific methods, processes, algorithms and systems to extract knowledge and insights from structured and unstructured data.[1]*

The New York Times correctly identifies that the data science (DS) is hot new field that promises to revolutionize industries from business to government, health care to academia. Let us first ponder on what Data Science really is? In simpler terms, use of scientific methods, processes, algorithms and statistics to extract knowledge and insights from data, obtained from either primary or secondary source, structured or otherwise, can be broadly defined as the Data Science. However, unlike the well established branches of physical/natural sciences such as Physics, Chemistry, Biology etc, data science is not as such a specific branch but an amalgamation of quite a few field. By the above definition DS can be called an applied science. The crust of the subject is to extract a new body of information by analysing the data in-hand using machines/computers.

At this point it is important to make a distinction of DS from its siblings, i.e., Data Engineering and Data Mining. As it is the case in the pure science, here also, for some designed experiment measurements are made using some instrument or protocol, collect such data and store in some structured or unstructured table or schema. This process falls under the data engineering, where data is collected for some designed experiment and stored in certain formats. The experiment does not necessarily have to be scientific in nature. A typical example is marketing research/campaign that is usually done for businesses. Business firms usually store and maintain their data in some flavour of databases, e.g. mySQL, PostGRE etc whereas a small scale scientific data produced in the academic lab are mostly stored in some high-level language such as HDF or FITS (popular in astronomy) or sometime even in the CSV format. With the ever growing volume of collected data also an additional specialised field of data engineering has been necessitated, called the Big Data engineering that we will not discuss further in this article but the topic is also of growing importance due to ever increasing volume of the data.

Once the data is in the touch of your finger, the next natural step will be the data mining. Typically this involves querying databases, look for the important and useful features, and detect, if any, inconsistencies in the data. Some data may be missing sometime, say for example, in astronomy due to bad weather one is not able to observe the light from the star for every exposures or sometime some CCD might have a read out error. Here, one must decide how to augment those missing data. These processes fall under the data mining and is mitigated during the data pre-processing phase.

Finally, when data engineer and miners provide a comparatively neat, homogenous and ideally error or noise free data, the role of the data scientist come into play. First, the scientist makes some crude studies to indetify what features are prominent, how are the data correlated and what are the ranges of the data. They will also look for outliers, distributions of the variables, and finally, adopt a statistical tool or a combination of few to fit/quantify the trend. Once some empirical or theoretical trend is established between the independent variables and the dependent variables, called model, one could use it to predict future observations.

Some physical scientists may find the skill sets needed for the DS field quite similar to the one they already possess. Actually, the resemblance of the two fields make the skill sets transferable between them, which has led to the surge of physicist working in the DS field. In addition to the knowledge about the research methodologies, they also generally possess strong problem solving and data analysis skills. Modern days physicists are also largely proficient programmers or developers, which is a bonus. It is now very common to find Physicists with doctorate degree making stellar career in the field of Financial data analysis, Credit Risk Analysis, Gaming Industry, Medical Diagnosis, Pattern Recognition, Google, Amazon and beyond to name few.

At this juncture, if I am to make a few suggestions to aspiring scientist who wish to pursue career in research, I would say make yourself versatile enough. Master both the numerical (statistical) and computational (mainly programming) aspect of the research. Diversify your academic portfolio so that you could grasp any opportunity that may appear beyond your zone of comfort or specialisation. Many career paths that physicists eventually is found to take lead to, in one or the other way, preparing, collecting, keeping, mining and analysing data of some sorts. One must remain prepared with right set of skills before the data flood-gate is opened.

Reference

[1] https://towardsdatascience.com/introduction-to-statistics-e9d72d818745 (June 2018).

Second Paper: ***Curriculum, Subject Specific Problems, Teaching and Research Methods***

Full Marks: 100 **Time: 3 Hours**

S.N.	Particular/Details	Marks	No of Ques	Total Marks	Remarks
1	Knowledge of the curriculum	10	5	50	Curriculum of Bachelor's and Master's level: (i) One (1) question on the structure and specific features (ii) Two (2) questions on comparison and challenges (iii) Two (2) questions on relevance, application, and ways of improvement
2	Teaching methods and their application	8+7 = 15	2	15	(i) One (1) question on the usefulness, relevance and application of teaching methods (ii) One (1) question on the integrated use and usefulness of information technology in teaching
3	Research methods and their application	8+7 = 15	2	15	(i) One (1) question on the selection, appropriateness, usefulness, relevance and challenges of research method (ii) One (1) question on the use/application of research method like sample selection, delimitation, referencing and documentation
4	Subject-specific academic problems and solutions	10	1	10	One (1) question on cases, issues, challenges and subject specific academic problems
5	Higher Education Policy	5	1	5	One (1) question on nation's higher education policies, their implementation status and usefulness
6	Tribhuvan university structure and performance appraisal	5	1	1	One (1) question on the structure, performance appraisal and service conditions of T.U.

An artificial skin that can help rehabilitation and enhance virtual reality

Scientists have developed a soft artificial skin that provides haptic feedback and -- thanks to a sophisticated self-sensing mechanism -- has the potential to instantaneously adapt to a wearer's movements. Applications for the new technology range from medical rehabilitation to virtual reality. Just like our senses of hearing and vision, our sense of touch plays an important role in how we perceive and interact with the world around us. And technology capable of replicating our sense of touch -- also known as haptic feedback -- can greatly enhance human-computer and human-robot interfaces for applications such as medical rehabilitation and virtual reality.
Scientists at EPFL's Reconfigurable Robotics Lab, headed by Jamie Paik, and Laboratory for Soft Bioelectronic Interfaces (LSBI), headed by Stéphanie Lacour at the School of Engineering, have teamed up to develop a soft, flexible artificial skin made of silicone and electrodes. Both labs are part of the NCCR Robotics program.

Source: https://www.sciencedaily.com/releases/2019/09/190927074937.htm

M.Sc. (Physics) Program at Amrit Campus, T.U.

Dr. Leela Pradhan Joshi, Pitamber Shrestha & Dr. Rajendra Parajuli
Department of Physics, Amrit Campus, Tribhuvan University, Thamel, Kathmandu, Nepal

ABSTRACT

Public Science College (PUSCOL), nowadays known as Amrit Campus was established in Falgun 2013 BS by the late Mr. Amrit Prasad Pradhan to promote the study of science and technology in Nepal by providing Proficiency Certificate Level in Science. Amrit Campus has been a leading powerhouse of science and promotion of scientific knowledge. In these 62 years the campus has produced thousands of graduate students including some of the finest technical manpower. The campus's dedication towards research on different topics such as material science, computational and simulation works of Physics, along with regular and timely conduction of national and international conferences have honored the legacy of Mr. Amrit Prasad Pradhan and continued to promote its set objectives for the development of Nation.

Introduction

Mr. Amrit Prasad Pradhan, the namesake of today's Amrit Science Campus, was a pioneer in promoting the study of science and technology in Nepal. In Falgun 2013 B.S. he successfully established the Public Science College (PUSCOL), a new college dedicated to science education. During that era there were not many colleges for providing the course for Proficiency Certificate Level in Science (PCL in Science or ISc, equivalent to +2 now). As the college did not have its own building this course was taught at Tri-chandra College. The pioneering team of the college was group of young scientists and specialists in their fields. Some of the team members were Mr. Phanindra Prasad Lohani (First Principal); Mr. Moti Kaji Sthapit, Mr. Chitta Bahadur Tuladhar, Dr. Govinda Prassad Kafle & Dr. Shiva Prasad Daubdel (Chemistry); Dr. Kedar Lal Shrestha, Mr. Gauri Prasad Rajbhandari & Dr. Narayan Hari Joshi (Physics); Mr. Krishna Bahadur Manandhar (English); Mr. Mitra Nath Devkota, Mr. Satya Narayan Rajbhandari & Mr. Mohan Bir Singh (Mathematics); Mr. Brahmihhi Dutta Pandey, Mr. Amrit Man Singh Bania & Dr. Sarswoti Prasad Rimal (Botany); Mr. Rohini Prasad Bhattarai (Nepali); Mr. Shiva Shankar Singh, Mr. Dirgha Man Bania, & Mrs. Prem Lata Tuladhar (Zoology).

Figure 1: *Historical pic of founders of Amrit college, Lainchaur*

The college shifted to Lainchor to its own location in Falgun 2019 B.S., and Mr. Amrit Prasad Pradhan became the Principal of the school in Mangshir 2018 B.S. While travelling to the United States for a college related cause, he met an untimely demise in an airplane crash over Mt. Blanc on January 24, 1966 (Magh 11, 2022 B.S.). To honor the founding member and Principal, Public Science College (PUSCOL) became Amrit Science College (ASCOL). Then, under Nepal's 2028 B.S. education plan, ASCOL became a constituent campus of Tribhuvan University. Since 2030 B.S. the college has been referred to as Amrit Campus.

Since its establishment, Amrit Campus has been a leading powerhouse of science and promotion of scientific knowledge. In these 62 years, the campus has produced thousands of graduate students--including some of the finest technical manpower. These graduates are now involved in different development activities both at home and abroad.

In 2066 B.S., Tribhuvan University (TU) realized the unfeasibility of maintaining the Proficiency Certificate Level (PCL) in its curriculum program. A letter (No. 1/2066 dated 01/04/2066, Decision No. 7) was then sent to Amrit Campus (perhaps other campuses too) from the Office of Academic Council, Tribhuvan University to replace PCL with higher education programs like Graduate and Post-graduate with research facilities. The Department of Physics at Amrit Campus took this challenge - challenge in the sense that it did not have even basic infrastructure and formed a Master's Degree Organizing Committee. With the hard work of this committee the Department successfully managed to initiate the Masters in Science in Physics from the academic session 2067 (2010). The class of 60 Masters' students was conducted that year. Altogether, there were 36 faculties at the Physics department when MSc program started.

Objectives:

Master's Degree program in Physics at Amrit Campus had the following specific objectives when it had started:

1. To provide inside knowledge on physical sciences.
2. To provide a complete curriculum course of Master's Degree in Physics of Tribhuvan University for both 1st and 2nd academic year including dissertation.
3. To provide knowledge on current research in Physics.
4. To provide short term research programs
5. To produce trained man power which will be highly useful and beneficial for physical sciences in global context.
6. To conduct Ph.D. programs in near future.

Figure 2: *Gate of the college.*

Challenges:

We had following challenges when M.Sc. Program was started.

1. Lack of infrastructure such as physics general and nuclear laboratory, good dark room, electronics laboratory.
2. No research fund
3. Lack of research laboratory including seminar hall and skilled manpower
4. Lack of administrative officers

Student Enrollment and Research Statistics

Table 1 shows number of students (males + female) enrolled along with total number of thesis students (male + female) [1]. There was a significant increase in female students of physics in 2012 in the yearly system (see Chart 1). The total number of student enrollment was decreased when semester system started in 2014 though it was close to original number in the year 2015. However in 2016 initial enrollment of student was full, eight students dropped out in second semester. It may be due to slightly increase in tuition fee as well as well revised syllabus. Another reason could be due to already implementation of four year B.Sc. system which stresses them to feel long time to complete master's program.

Table 1: Number of enrolled students during 2010 to till date. [1]

Year	Seat	Enrollment			Dissertation		
		M	F	T	M	F	T
Yearly System							
2010	60	58	2	60	18	1	19
2011	60	57	3	60	24	1	25
2012	60	52	8	60	30	5	35
2013	60	53	7	60	26	3	29
Semester System							
2014	60	48	3	51	13 male students are involved in thesis work		
2015	60	53	5	58*	14 male students have been enrolled for thesis works		
2016	60	49	3	52*	Not yet decided		
2017	60	53	7	60	Not yet decided		

At the beginning, the task of initiating a research based Masters program was daunting due to the lack of basic infrastructure and funds for such research programs. These are some of the same issues colleges and higher degree programs face today. The Committee took these challenges in stride and started small. By the second year of starting our master's degree physics program, number of research grants such as institutional grants, faculty grants, mini-research grants from different sources such as University Grants Commission (UGC Nepal), Nepal Academy of Science and Technology (NAST), Research Center, TU, Ministry of Science and Technology were found to be flourished. This greatly helped the M. Sc. students to go ahead in their research works for their thesis work. The table given below also shows the growing number of thesis students though comparatively the number of female students are low than male research students.

Then, based on the results of these mini-projects, the faculty gained the knowledge and experience to apply for larger grants from the University Grants Commission. The money from these grants was used to build up the labs at Amrit Campus. In 2018, the Department of Physics at Amrit Campus successfully installed solar cells to power its offices. There is still more to improve at the Campus. The increased manpower at the college, today, faces the problem of space. There is not enough research area and lab for the faculty and students. Through ingenuity, we hope in the future, we will be able to solve this any other issue that may crop up.

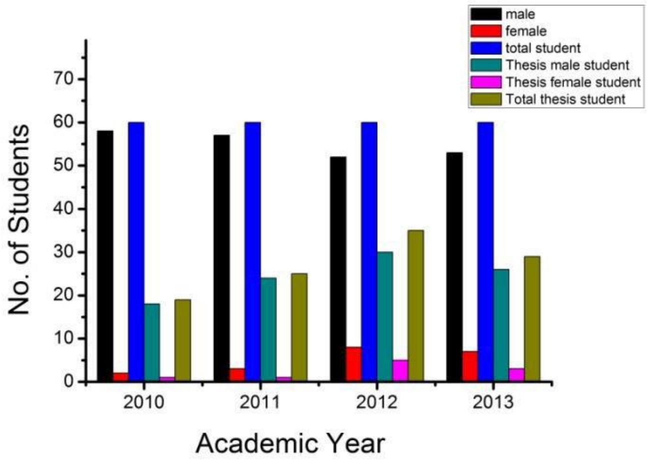


Figure 3: *Number of students and Thesis students in yearly system.*

Research Activities

Through the Department of Physics' continuous and tireless efforts to promote the standard of teaching and research quality of Physics, it was successful in organizing national as well as international conferences in Physics. Recently and historically, the department of Physics, Amrit Campus was successfully organized an international conference entitled "*International Conference on Explorations in Physics 2018*" in coordination with Nepal's higher and efficient bodies such as Ministry of Science and Technology, University Grants Commission, Nepal Academy of Science and Technology, Central Department of Physics, Nepal Physical Society etc.

The principle motivation behind organizing this conference was to expose young minds to innovate research being conducted in Physics. The program was successful in showcasing the research activities being conducted in Physics in Nepal to international researchers as well as new students. After participating in discussions, Nepali researchers and international researchers agree that collaboration is a must in order to advance a further research activity being conducted in Nepal. During conference, Nepali researchers were given the opportunity to display their works and were and were inspired by the potential of future collaborations between themselves and their international colleagues. Some Nepali researchers were successful in setting up these international collaborations in their Physics research activities during conference, itself. Through the discourse of the conference, the organizers, lecturers and participants agreed that the Nepal government and the colleges of national universities should talk appropriate measures to establish research development and innovation funds. This conference is only the initial step in persuading the Nepal Government to make a fair, inclusive and progressive science policy. It will help in promoting research activities in Nepal. It will raise the prestige of the national universities.

Concluding Remarks

As the Department of Physics continuous to evolve from its humble origins, we hope to carry on the legacy and memory of Mr. Amrit Prasad Pradhan. Though the Department of Physics, Amrit Campus had many challenges to fulfill the initial objectives, physics faculties including administrative staffs and campus administration have been greatly helping to run the program successfully. We hope to transcend the limitations of our challenges and continue to promote science in Nepal.

References

[1] Amrit Campus, Adsministration (2018)

Mysterious Jurassic crocodile identified 250 years after fossil find

A prehistoric crocodile that lived around 180 million years ago has been identified -- almost 250 years after the discovery of it fossil remains. A fossil skull found in a Bavarian town in the 1770s has been recognised as the now-extinct species Mystriosaurus laurillardi, which lived in tropical waters during the Jurassic Period. For the past 60 years, it was thought the animal was part of a similar species, known as Steneosaurus bollensis, which existed around the same time, researchers say.
Palaeontologists identified the animal by analysing fossils unearthed in the UK and Germany.
The team, which included scientists from the University of Edinburgh, also revealed that another skull, discovered in Yorkshire in the 1800s, belongs to Mystriosaurus laurillardi. The marine predator -- which was more than four metres in length -- had a long snout and pointed teeth, and preyed on fish, the team says. It lived in warm seas alongside other animals including ammonites and large marine reptiles, called ichthyosaurs.

Source: https://www.sciencedaily.com/releases/2019/09/190912094709.htm

Meta-Materials and its Applications

Amrit Sedain[1] & Suraj Neupane[2]
Fourth mester, M.Sc. (Physics), CDP[1] & Amrit College[2]

ABSTRACT

This article provides the brief history and fundamental properties of metamaterials. Metamaterials are the artificial materials which show peculiar nature from those of normal materials. As well as, physics of negative refractive index of materials and some applications of metamaterials are explained.

Keywords: Metamaterials, Negative refractive index, Superlens, Cloak

Background:

Horace Lambin (1904) gave a hypothesis of negative phase velocity accompanied by an antiparallel group velocity which is noted in his book hydrodynamics for the first time in the history. However the practical implementations of these ideas were impossible to perform at that period.

After World War II, Researchers were interested to the artificial dielectric in microwave engineering, which is the initiation for the discovery of metamaterials (began to explore). V. E. Pafomov (1959) independently, and some years later V. M. Agranovich and V.L.Ginzburg (1966) noticed the repercussions of negative permittivity, negative permeability and negative group velocity in their study of crystals and excitons. One year later V.G. Veselago (1967) published a paper, which is related to the theoretical work related to metamaterial research. However, it took 33 years for researchers to perform it practically in laboratory due to lack of sufficient materials and computing power [1]. After the development of technologies and arrival of micro- and nano-fabrication, new possibilities opened for the researches to perform the physical phenomena of metamaterials practically [2].

In 1990s, Pendry et al. made sequentially repeating thin wire analogous to crystal structures which increase the range of material permittivity. Later in 2000, a team of University of California San Degio (UCSD) researchers performed the experiment of metamaterial which shows the different physical properties rather than the normal materials, one of them is violation of Snell's law which is the peculiar properties in the history of material for the microwave frequency domain. Thus, the testing of the physical properties of metamaterials purposed theoretically 30 years earlier by victor Veselago had begun [1].

What are Metamaterials?

Metamaterials is composed of two Greek words 'meta' and 'materials', where 'meta' means 'beyond' so, for this reason, we call the material exhibiting optical properties beyond anything that can be found in nature named as metamaterials.

Metamaterials are artificial materials engineered to have properties that may not be found in nature. They usually gain their properties from structure rather than composition, using small inhomogeneities to create effective macroscopic behavior. Due to the particular design and structure of metamaterial they show the unusual behavior. Somehow similar to conventional crystalline materials, metamaterials typically consists of many identical inclusions arranged in a regular lattice. The dimensions of the inclusions are much smaller than the wavelength of radiation. However, unlike the usual solid state materials, the effective permittivity and permeability of a metamaterials are mainly determined by the geometry of the inclusions, rather from the chemical composition of the constituent basic unities. The shape, size and chemical composition of the matter play an important role to get final result. The possibility for metamaterial processing is provided by the dimension of the inclusion.

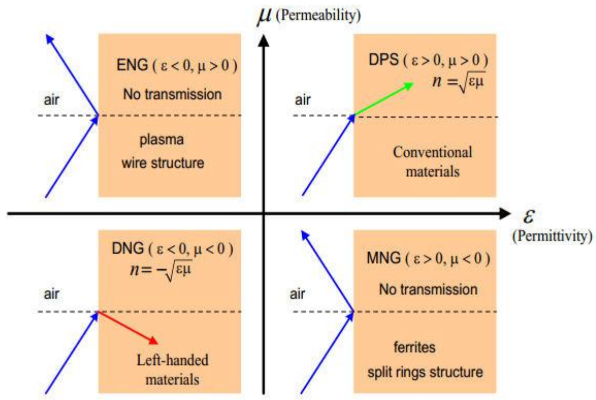


Figure 1: *Classification of metamaterials [3]*

The response to the electromagnetic field by the metamaterials can be explained by two macroscopic parameters: permittivity (ε) and permeability (μ). Using these parameters, metamaterials are classified as follows [3]. There are various types of metamaterials but in this paper we will discuss physics of negative refractive index metamaterial (NRM), whose permittivity and permeability both are negative and is classified under double negative metamaterials (DNG material) [3].

Negative Refractive Index Metamaterials (Left-Handed Materials)

Conventionally, the refractive index of the material is to measure the 'optical density' and is defined as:

$$\eta = \frac{c}{v} \qquad \dots\dots\dots\dots\dots\dots\dots\dots\dots (1)$$

(Symbols have their usual meanings)

From Maxwell's equations the refractive index of materials is given by

$$\eta = \sqrt{\varepsilon\mu} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2)$$

Where μ is the relative magnetic permeability and ε is the relative electric permittivity [4]. As the common optical materials have both positive μ and ε so the refractive index is positive. To account for anisotropic materials and absorption phenomena, it was realized that the refractive index must be a complex quantity which was earlier described by the Veselago in 1967. At that time he explained the unusual behaviors of the NRMs such as modification of the Snell's law of refraction, reversal of the Doppler's shift and obtuse angle for the Cerenkov radiation however, such materials are unavailable at that time [5].

If both μ and ε are negative in a given wavelength range, we can write μ=|μ|exp(iπ) and in equivalent fashion ε=|ε|exp(iπ). Thus, the complex refractive index is given by

$$\eta = \sqrt{|\mu||\varepsilon|\exp(2i\pi)}$$

$$\eta = \sqrt{|\mu||\varepsilon|}\sqrt{\exp(2i\pi)}$$

$$\eta = -\sqrt{|\mu||\varepsilon|} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (3)$$

That is the refractive index of a medium with simultaneously negative μ and ε must be negative which is shown in the figure below [2]. Another unusual behavior shown by the NRM is the reversal of the Cerenkov radiation. For the charge particles moving at speed more than speed of light, in that medium emits Cerenkov radiation in a certain angle. But in NRM the radiation is emitted in backward direction making an obtuse angle. By the use of left handed materials we can make Cerenkov detector which could be useful for detecting the charge particles of various velocities [6].

Similarly, In Doppler effect the wavelength of the approaching object will shift into red where as in receding case it will shift into blue, which is contrary for the normal phenomenon. Let us consider a moving source emitting radiation with frequency ω in NRM with velocity υ with respect to the medium. The observed frequency by the detector is given by the relation:

$$\omega' = \gamma(\omega + k.\nu) \quad \ldots\ldots\ldots\ldots\ldots\ldots (4)$$

Where γ is the relativistic factor and |k|=ηω/c, for emission along the direction of the motion of the source in the NRM η=-1, on substation we get:

$$\omega' = \omega\sqrt{\frac{c-\upsilon}{c+\upsilon}} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (5)$$

Both phase and group velocities have opposite sign in NRM medium, this medium is explained by the reversed propagation. Nevertheless, under no situation the causality is violated and that in that respect the propagation under NRM corresponds to that in positive index media [2].

Applications of Metamaterials:

Metamaterial as Antenna

For the enhancement of the radiation and matching properties of electrically small and magnetic dipole antenna metamaterial coatings are being widely used. These Antennas have extraordinary potential of overcoming restrictive efficiency-bandwidth limitations for natural or conventionally constructed electrically small antenna. Experimentally, the latest metamaterials antenna radiates 95% of input radio signal at 350 MHz frequency. Since, metamaterials antenna are five times smaller than the wavelength, which is possible due to the properties of having larger aperture than its physical size [2,7].

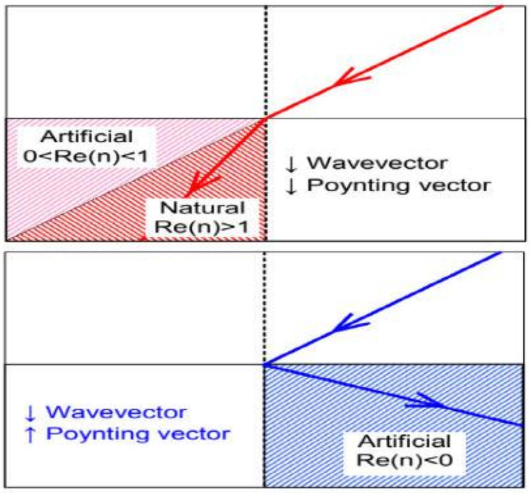


Figure 2: *refraction in conventional materials(top figure) and that in NRM(bottom figure)*[2]

Metamaterial as Superlens

Superlens uses metamaterial to gain resolution beyond the diffraction limit although for the conventional optical lenses, it suffer diffraction limit because only the propagating components are transmitted from the light sources. The evanescent waves, which are non-propagating, are not transmitted through optical materials. In 2005 Ramakrishna demonstrated that the metamaterials have higher resolution capabilities than ordinary microscope. However, scientists are unable to design a superlens which can constitute all evanescent waves to get perfect image [7].

Metamaterial as Cloaks

Cloaking phenomena can be gain by cancellation of the electric and magnetic field generated by an object or by escorting the electromagnet wave around the object. The cloak deviate the electromagnetic beams so they confined inside the hidden object making little distortion making it appears invisible [7].

Metamaterial as Sensor

Metamaterial can be used for manufacturing sensor with specified sensitivity as well as enhancing the sensitivity and resolution of sensor. These sensors are used in the field of agriculture, biomedical and many more [7].

Seismic Metamaterial

In order to counteract the adverse effects of seismic waves on manmade structure seismic metamaterials are used [3].

Future Prospects:

The metamaterials have drawn considerable attention of the researches due to the potential ability of minimizing the components and maximizing the performance of electronic devices, medical equipment and as well as in optoelectronics applications.

Conclusion:

Due to the slow technological advancement, it took more than a century for metamaterial to become a burning issue in order to modernized science and technology. Since , from the past few years it gives some glimpse of possibilities of metamaterials to use in different field such as electronic and communication, bio medical, optoelectronics and many more. Nevertheless, the field of NRM has exponentially increased over the very short period and its physics slowly transits to technology. Currently, the scientists are concern to shift the frequency of microwave application towards terahertz and optical frequencies.

References:

[1] https://en.wikipedia.org/wiki/Metamaterial (Aug, 2018).

[2] Z. Jaksic, N. Dalarsson & M. Maksimovic, *Negative Refractive Index Metamaterials: Principles and Applications,* Microwave Review, **12**, 36(2006).

[3] S.E. Mendhe & Y.P. Kosta, *Metamaterial Properties and Applications*, International Journal of Information Technology and Knowledge Management, **4**, 85 (2011).

[4] S.A. Ramakrishna, *Physics of Negative Refractive Index Materials*, Reports on Progress in Physics, **68**, 449 (2005).

[5] V.G. Veselago, *Electrodynamics of Substances with Simultaneously Negative Electrical and Magnetic Permeabilities*, Soviet Physics Uspekhi, **10**, 509 (1968).

[6] J. Lu, T. M. Grzegorczyk et al, *Cerenkov Radiation in Materials with Negative Permittivity and Permeability*, Optics Express, **11**, 723 (2003).

[7] K.Gangwar, P. Pant & R.P.S. Gangwar, *Metamaterials: Characteristics Process and Applications*, Advance in Electronic and Electric Engineering, **4**, 97 (2014).

List of M.Sc. Dissertation 2018-19 (2)

Central Department of Physics

Name of Student	M.Sc. Dissertation Title	Supervisor
Gopal Neupane	REFLECTION AND TRANSMISSION COEFFICIENTS OF ELECTROMAGNETIC WAVE EQUATION IN SCHWARZSCHILD BLACK HOLE	Prof. Dr. Udayaraj Khanal
Govinda Kharal	ELECTRONIC AND MAGNETIC PROPERTIES OF MOLECULAR NITROGEN ADSORBED PHOSPHORENE	Prof. Dr. Narayan Pd Adhikari
Harilal Bhattarai	DUST COLOR TEMPERATURE DISTRIBUTION IN THE FAR INFRARED CAVITY NEARBY KK-LOOP G172+01	Prof. Dr. Binil Aryal
Hem Prasad Bhusal	MOLECULAR DYNAMICS STUDY OF TRANSPORT PROPERTIES OF CYSTEINE IN WATER	Prof. Dr. Narayan Pd Adhikari
Jeewan Panthee	FIRST-PRINCIPLES STUDY OF ELECTRONIC AND MAGNETIC PROPERTIES OF Ge DOPED HEXAGONAL BORON NITRIDE	Dr. Nurapati Pantha
Jeewan Poudel	AIR POLLUTION DISPERSION MODELING AND ENVIRONMENTAL IMPACT ACCESSMENT OF MITTAL CEMENT INDUSTRY, NEPAL	Prof. Dr. Ram Pd Regmi
Kashmir Lamichhane	CONPARITIVE STUDY ON VIBRATIONAL PROPERTIES OF QUINONE MOLECULES	Dr. Hari Prasad Lamichhane
Khagendra Katuwal	STUDY OF DUST COLOR TEMPERATURE AND DUST MASS OF A FAR INFRARED CAVITY NEARBY KK-LOOP G134+00	Prof. Dr. Binil Aryal
Krishna Khatri	METEOROLOGICAL FLOWS AND AIR POLLUTION DISPERSION MODELING OF UNITED CEMENT FACTORY, DHADING, NEPAL	Prof. Dr. Ram Pd Regmi
Krishna Prasad Gautam	HYDROPHOBICITY OF ETHANE DIMER IN DIFFERENT SOLVENT ENVIRONMENT: A CLASSICAL MOLECULAR DYNAMICS STUDY	Dr. Nurapati Pantha
Manoj Chhetri	MESO-SCALE METEOROLOGICAL FLOWS AND AIR POLLUTION DISPERSION MODELING OF Narayani Cement Industry, Parsa, Nepal	Prof. Dr. Ram Pd Regmi
Najin Kadel	NEUTRON YIELD AND SCALING LAWS OF THE PLASMA FOCUS DEVICE PFMA1 FOR DIFFERENT PRESSURES	Prof. Dr. Raju Khanal
Narayan Budhathoki	STUDY OF PLANCK FUNCTION DISTRIBUTION OF A FAR INFRARED CAVITY USING AKARI SURVEY	Prof. Dr. Binil Aryal
Nirmala Adhikari	TO STUDY DOPING EFFECT ON ELECTRONIC AND MAGNETIC PROPERTIES OF PEROVSKITE TYPE KTa1-xMnxO3 (x=0,0.50,0.67)	Dr. Gopi Chandra Kaphle
Nirmala Shrestha	FIRST-PRINCIPLES STUDY OF ELECTRONIC AND MAGNETIC PROPERTIES OF SODIUM(Na) DOPED HEXAGONAL BORON NITRIDE MONOLAYER	Dr. Nurapati Pantha
Pawan Giri	A STUDY OF FAR INFRARED CAVITY NEARBY KK-LOOP G265-04	Prof. Dr. Binil Aryal
Prakash Bissokarma	FIRST-PRINCIPLES STUDY OF ELECTRONIC AND MAGNETIC PROPERTIES OF NICKEL DOPED HEXAGONAL BORON NITRIDE MONOLAYER	Dr. Nurapati Pantha

Physical Analysis of Hitting Sixes in Cricket

Hum Prasad Shrestha
Lectrurer, Tribhuvan Multiple Campus, Tansen, Palpa

ABSTRACT

Nowadays, Cricket is being a very popular game in the world, especially in South Asia. It has mainly 3 sections; batting, bowling,and fielding. Every section is related to laws of physics and they can be analysed physically. Here, the article is centered on batting; especially, about the physics of hitting sixes. Although every ball cannot be converted into six practically, it to possible theoretically.The question is in what extent the theory is implemented in reality.

Keywords: Momentum, projectile, dragging force, bat efficiency, back-lift angle, follow through an angle, sweet spot

Introduction

The performance of Nepalease cricket team is very remarkable inthe last decade not only among the associate nations but also in full ICC tournaments like worldcup of T-20 inspite of very few facilities. Due to lack of effective management and proper implementation of cricket policy, we are not able to give the sufficient infrastructures and plans thatwould secure the life of cricket and cricketers.

Although playing a game is more practical than theory, all practical depend on theory. The performance will be better if errors and lacks are corrected withthe help of formulas established in theory. Hitting the ball with the bat is called batting. Its aim is to make more and more runs in quick rate without losing a wicket. The maximum run that can be made by a batsman from a ball is six. It is scored if the ball lands outside boundary rope. If the ball is caught inside the rope, the batsman will be out. So, the effort of hitting sixes is not only fruitful but also risky. To hit every ball to make six is foolish work because the pace, line and length of the ball are continuously changed by the bowler and it is difficult to give the required force of impact to the ball by the bat at best angle in desired direction by adjusting the position within the fraction of second. This article will analyze the different shots which are hit by the different batsman to get six runs. This analysis is to find how the errors and positivity of any shots determine the range of the shot.

Theory

The ball hit by the batsman in the air can be taken as a projectile. The length of six is approximately equal to the range of the projectile which is given by

$$R = \frac{v^2 sin2\theta}{g} \quad \dots\dots\dots\dots\dots\dots(1)$$

Where v = velocity of the ball projected by the bat,
θ = angle of projection with horizontal, and
g = acceleration due to gravity.

The equation (1) is true when the air resistance is neglected. The air resistance is significant. It cannot be neglected. For a ball of area 'A' travelling in theair of density 'ρ' with velocity 'v', the air resistance or the air dragging force is given by

$$F = \frac{1}{2}\rho CA\, v^2 \quad \dots\dots\dots\dots\dots\dots(2)$$

Where '*C*' air drag coefficient and its value for smooth cricket ball can be taken as 0.5.

Thus, the air drag (Newton's drag) is proportional to the square of the velocity of theballand opposite to its direction (for small speed, it is better to take drag force proportional to the velocity and called as stokes drag) and opposite to its direction.

For the new ball moving at the speed of 40m/s; the drag force nearly comes out to be 0.55 N that produces a retardation of 3.43 m/s^2. But atthe same time, it is accelerated downward with 9.8 m/s^2.So the trajectory is not parabolic. The path in thesecond half is more vertical. The range is significantly less than the ideal value. It depends on velocity and angle of projection along with shape and size of ball and nature of air. Also, the angle for maximum range is slightly less than 45 degree. The figure (1) depicts a comparison between thereal and ideal case of one example.

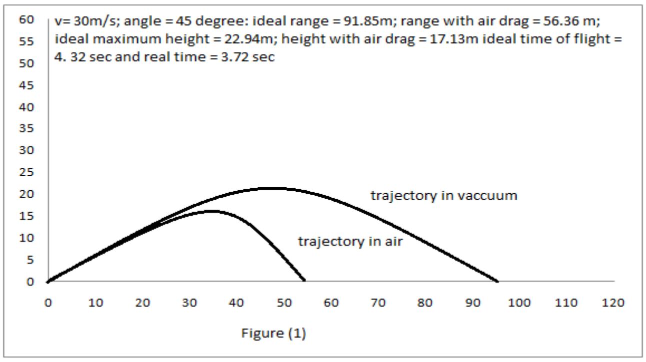


Figure 1: *Comparison between theoretical and ideal case.*

A batsman cannot control the air drag.But,he can manage a suitable angle of projection and the direction at which air is blowing.To get long range, the effective factors arethe velocity of projection and angle of projection. The velocity of projection is determined by the force of impact between bat and ball. The force of impact at thecollision of bat and ball is given by

$$\vec{F} = \frac{m\vec{v} - m\vec{u}}{\Delta t} \dots\dots\dots\dots\dots\dots(3)$$

Where m = mass of ball,
V = velocity of ball after impact,
u = velocity of ball before impact, and
Δt = time of impact

The force will be large if the time of impact is small. A new, hard bat along with ball is preferred to reduce time of impact. The good timing of ball also minimizes the time of impact. Also, the high momentum of thebat, which is the product of mass and velocity of the bat, is essential to produce the large velocity. For it, a heavy bat should be swung at large speed. Transformation of the momentum of bat to the ball is more important than the production of large momentum. The skills like good timing and middling the ball are required. If ball and bat are in same direction; the equation (3) suggests that even a small force of impact produce large velocity of projection. The shots like upper cut and Dilscoop belong to it. To implement above theory, following techniques or skills are required.

Techniques:

1) Stance: It is the posture of the body of the batsman before hitting the ball. The good stance helps to transfer the momentum of whole body to the ball with good timing. Still and forward leaned head with eyes on the ball with full confidence is the characteristic of a good stance. If the ball is inthe arc of bat, clear the front leg from the line of ball and bend the back leg before giving the impact. Feet can be moved to reach to the pitch of theball. For hook, pull and upper cut, the shape of body should be managed according to line and length of ball and should not be closed.

2) Back-lift: The length ofthe arc of bat before hitting the ball is called back-lift. The high back-lift helps to produce a large velocity of the bat. It can be measured by the back-lift angle which is the anglebetween thehighest (initial) position of bat and the position of bat at time of impact with ball.

3) Timing: To give the impact of bat to the ball at peak speed is more important than the actual speed of the bat. If the timing is perfect, even a small bat speed can produce large force of impact. The timing is determined by 'bat efficiency' which is given by,

$$bat\ efficiency = \frac{speed\ of\ bat\ at\ the\ time\ of\ impact}{peak\ speed\ of\ the\ bat} \times 100\%$$

It is easier to time the ball if the pitch is hard, which gives a true bounce and the ballwill not be swinging. If the pitch is slow and the ball is swinging and stopping, it is better to take single and double by reaching the pitch of ball and playing as late as possible. After spending some time on crease, he can time the ball to hit big shot.

4) Middling: If the ball comes at themiddle of thebat, there will be theleast wastage of force of impact. If the ball is edged; the bat will be recoiled witha large component of total momentum and ball moves in undesired direction witha small component of momentum according to the principle of conservation of linear momentum. The ball neither takes the distance nor gets the direction. In fact, the velocity ofthe ball after impact is given by

$$V = v_0 + (1+E)\ v' \ \ldots\ldots\ldots\ldots(4)$$

Where; v_o = velocity of bounce ball when the bat is at zero speed, E = Ratio of bounce speed (v_0) to incident speed of ball, v' = bat speed at the impact. The value of E nearly changes from 0.1 to 0.3 for edged and middle ball. Timing and middling are the two most important factors to play the big shots. These are obtained by the practice, good form, long spent of time on crease and confidence of the batsman.

5) Angle of projection: If the angle of projection is too high, the ball will get height instead of distance. If the angle is small, the ball drops earlier inside the ground due to the lack of elevation. So, the angle of projection is better around 45 degrees, although, hook, pull and upper cut shots are effective in small angles.

6) Follow through: The momentum of the bat provided by the batsman after striking the ball is called follow through. If the follow through is large, it will provide large speed to the ball in desired direction. It can be measured by the follow through angle which is the angle between final position of bat and thepositionof the bat at the time ofimpact with ball.

7) Making room: To generate the proper speed of bat, some room between ball and body is required. It helps to swing the bat with free hand. If the room is insufficient, the ball strikes the bottom of bat or at the gloves. Also, if there is too much room, the ball strikes at the tip of bat and the body weight remains backside. In both cases; the ball is not in control and momentum becomes low. The requirement room is determined by the line and length of the ball and striking point of the ball and bat.

Data collection

The videos of different cricket matches are the sources of data. The techniques applied by the batsmen are measured mostly qualitatively. In these matches, the batsmen did not use smart bats and quantitative data are unavailable. Also, everything cannot be measured by video analysis. Some details of data are as follows:

SN	Game	Over	Bowler/Batsman	Ball details
1	Austrlia tour of India; Aus Vs Ind; 6th ODI; Nagpur; Oct 14, 2007	43.1	Brett Lee(Aus) to M. S. Dhoni(Ind)	Right arm fast over the wicket and good length slow delivery at off the stump.
2	IPL-2015;RCB vs KXIP Match-40 in Chinnaswamy stadium; Bengaluru on 2015/5/6	2.3	Sandeep Sharma(KXIP) to Chris Gyale (RCB)	Right arm fast over the wicket and full length delivery at off stump.
3	IPL-2017;MI vs KKR Qualifier-2 in Chinnaswamy stadium; Bengaluru on 2017/5/19	1.3	Jasprit Bumrah(MI) to Chris lynn (KKR)	Right arm fast over the wicket and good length delivery at middle stump.
4	IPL-2016;RCB vs GL Match-44 in Chinnaswamy stadium; Bengaluru on 2016/5/14	4.6	Shivil Kaushik (GL) to AB Devilliers(RCB)	Left arm round the wicket and good length slow delivery at fifth off stump.
5	IPL-2016;RCB vs GL Match-44 in Chinnaswamy stadium; Bengaluru on 2016/5/14	15.5	Pravin Kumar (GL) to AB Devilliers(RCB)	Right arm round the wicket and full toss slow (123 kph) delivery at fourth off stump.
6	IPL-2016;RCB vs GL	16.5	Rabindra Jadeja (GL) to	Left arm round the wicket and

	Match-44 in Chinnaswamy stadium; Bengaluru on 2016/5/14		AB Devilliers (RCB)	slightly fast (98kph) orthodox spin in off side.
7	England vs Australia; T20 international at Cardiff in 2015/8/31	3.6	Patt Cummings (Aus) to Jason Roy (Eng)	Right arm over the wicket and fast (148 kph) good length delivery about off stump
8	England vs Australia; T20 international at Cardiff in 2015/8/31	13.4	Boyce (Aus) to Moeen Ali (Eng)	Right arm over the wicket and slow(85kph) legbreak spin at the leg stump
9	England vs Australia; T20 international at Cardiff in 2015/8/31	16.2	Coulter nile (Aus) to Morgan (Eng)	Right arm over the wicket and slow (123 kph) full length delivery at middle and off stump.
10	England vs Australia; T20 international at Cardiff in 2015/8/31	17.3	Starc(Aus) to Butler(Eng)	Left arm over the wicket and fast (142 kph) good length angled delivery off the stumps.
11	India vs Australia; second ODI at MCG on 2015/1/18	22.4	Faulkner (Aus) to Rohit Sharma(Ind)	Left arm over the wicket and slow (117 kph) good length delivery at off stump
12	India vs Australia; second ODI at MCG on 2015/1/18	39.4	Mohammed Shami(Ind) to Smith(Aus)	Right arm over the wicket and slow (122.4kph) short length deliver off the stump.

Data Analysis:

To evaluate the different big shots, the skills or techniques used to make those shots are graded as follows. The number in bracket measures the effectiveness of the skill in the result of the shot. These numbers have been chosen after the observations of a number of shots played in real cricket game.

Result:

If a batsman managed a score greater than fifty from his batting techniques, his shot gone to the air became six.

Discussion:

From the analysis (look at Appendix A and B) it is seen that, if the total mark is greater than fifty, there is a chance of clearing the boundary. But, it is not always true. For example, top edge can be six behind the wicketkeeper. In such case,the total mark becomes very less than fifty. Also, if three factors (timing, middling and angle of projection) are excellent, other become minority factors; however, they enhance the result.

Conclusion:

Transformation of themomentum of bat to the ball to project ball in the airinthe desireddirection is the Physics of hitting sixes. It can be done properly and regularly if the batsman applies the skills of hitting big shots.

Video analysis of data 1

Australia tour of India, 6th ODI: India v Australia at Nagpur, Oct 14, 2007
Data No. 1
Source:https://www.youtube.com/watch?v=zwxR5PMiltY

Video analysis of data 2

RCB vs KXIP, match-40 at Bengluruin May 6, 2015
Data No. 2 Source: https://www.youtube.com/watch?v=FvBnZOnOerk

References:

[1] A. Chopra, *The science of the big hit*. Retrieved from http://www.espncricinfo.com/magazine/content/ story/456798.html (2010).

[2] Cricket.com.au (Publisher) *Highlights: Australia v India*, MCG. Retrieved from https://www.youtube.com/watch?v=EY41X9sfxlA&t=89s (Jan 2015).

[3] Cricket news: (Publisher) BEST - *T20 thriller game ever - AUS vs ENG @ Cardiff 2015*. Retrieved from https://www youtube.com/watch?v=HScHPLkva6Q (Nov.2016).

[4] J. Heruty, *Free real time projectile motion calculator with air drag*. Retrieved from https://www.youtube.com/watch?v=Taj2-XdooiY (Aug. 2012).

[5] IPL 2016 Highlights (Publisher) (2016, June 1). RCB vs GL – Royal Challengers Bangalore vs Gujarat Lions Highlights). Retrieved fromhttps://www.youtube.com/watch?v=67vpusv7Wno&t=47s (2016).

[6] D. S. Mathur, *Mechanics,*New Delhi. S Chand publication (1981).

[7] Physics of cricket, Retrieved from http://www.physics.usyd edu.au/~cross/cricket.htm (2007).

[8] A. Rana (Publisher), *MI vs KKR qualifier 2*. Retrieved from https://www.youtube.com/watch?v= PgavePwcluw (May 2017)

Appendix A: Analysis

Skills	Grades				
Stance	–	**Good (8)** *Head*: still and leant in forward direction. *Eyes*: focused on ball. *Body*: well shaped. *Feet*: moving and properly bent.	**Satisfactory(4)** Any one or two parts are weak	**Poor (0)** More than two parts are weak	–
Back lift	–	**Good (8)** Back lift angle: $130^0$to 160^0	**Satisfactory(4)** Back lift angle: $110^0$to 130^0	**Poor(0)** Back lift angle: $below 110^0$	–
Timing	**Excellent(28)** Bat efficiency: above 90% Sound: sweet	**Good (20)** Bat efficiency: 80% - 90%	**Satisfactory(10)** Bat efficiency: 65% - 80%	**Poor (4)** Bat efficiency: 45% - 65%	**Very poor(-4)** Bat efficiency: below 45%
Middling	**Excellent(24)** Impact in sweet spot of bat; no vibration in bat	**Good (16)** About 1 cm around the sweet spot	**Satisfactory(10)** About 2cm around the sweet spot	**Poor (6)** About 3 cm around the sweet spot	**Very poor(0)** Impact at toe, shoulder and edge of bat
Angle of projection (* for hook, pull and upper cut)	**Excellent(16)** $35^0$to 50^0 degree With horizontal	**Good (13)** 25^0 to 35^0 and 50^0 to 60^0	**Satisfactory(5)** 20^0 to 25^0 and 60^0 to 65^0	**Poor (0)** 15^0 to 20^0 and 65^0 to 75^0	**Very poor(-10)** Below 15^0 Or 10^0 (*) and above 75^0
Follow through	–	**Good (8)** Follow through angle: greater than around 150^0 and in the line of ball	**Satisfactory(4)** Follow through angle: 90^0 to 150^0	**Poor (0)** Follow through angle: below 90^0 ; away from line of ball	–
Making room	–	**Good (8)** Ball comes at sweet spot with comfortably stretched hand	**Satisfactory(4)** Ball comes at sweet spot after a little effort.	**Poor (0)** Ball cannot be got at sweet spot	–

Appendix B: Analysis of data (1) to (12) with help of above grades:

Data no.	Stance	Back lift	Timing	Middling	Angle	Follow through	Room	Total	Result
1	8	8	20	24	5	8	8	81	Huge six over long on
2	8	4	10	6	0	8	4	40	Dropped at deep midwicket
3	4	4	4	10	0	8	4	34	caught at deep mid wicket
4	4	8	20	16	13	4	4	69	Six over the cover
5	8	8	28	24	5	8	8	89	Huge six over the mid wicket
6	4	8	10	10	16	8	4	60	Six over the cover
7	8	8	4	16	-10	8	4	38	caught at mid off
8	4	8	20	6	0	8	4	50	caught at long on just inside the rope
9	8	8	28	16	13	8	8	89	Huge six over the mid wicket
10	8	8	4	0	0	4	8	32	caught at mid on
11	8	8	20	24	13	8	8	89	Huge six over the mid wicket
12	0	4	10	6	0	0	4	24	caught at mid wicket

Cricket-ball Physics

The movement of a cricket ball is unique within the sporting world. When the ball is delivered, a layer of air known as a 'boundary layer' forms over the ball. This is where the physics come into play. By angling the seam – the stitched part in the middle – the bowler can alter the pressure of the forces on the ball and choose which way the delivery will go. The aerodynamics can be varied further by the bowler changing the pace of the ball and where the ball bounces. These deliveries are known as 'cutters' to cricket fans and the practice is called seam bowling. Spin is another weapon in the bowler's armoury. Spin bowlers use their wrist or fingers to put revolutions on the ball to allow it to spin fiercely once it has pitched. Slow spin works better on dry and dusty pitches where the ball can skip off the pitch. Side forces also act on the ball in swing bowling. When one side of the ball becomes rougher than the other, that half becomes less streamlined. Bowlers frequently use this to their advantage to move the ball sideways in the air in order to confuse batsmen into playing false and poorly timed shots. The effect of swing can be exaggerated even further by shining one side of the ball, although using anything other than your cricket whites to rough the ball up is considered unsporting.

Source: https://www.howitworksdaily.com/cricket-ball-physics/

Different Aspects of Quantum Computing with Classical Interpretation of Shor's Algorithm

Prashrit Baruwal[1] and Prashant Baruwal[2]
[1]Central Department of Physics & [2]Amrit Campus, TU, Kathmandu

ABSTRACT

The basic fundamental unit to operate the Quantum phenomena is Qubit. Quantum reality is profoundly rich over classical one. Everything acts differently and shows bizarre characteristics when Quantum effect comes into account. Among various Algorithms on Quantum Computing, Shor's Algorithm helps to simplify the complexities related to prime factorization. In this paper, we have reviewed different aspects of Quantum Computing: Logic Gates, Qubits, Entanglement, and Decoherence which play crucial role in Quantum Computing. The possible classical analogue has been attempted for Shor's Algorithm.

Introduction

The onset of quantum mechanics encompassing the familiar classical concept and broadening the window towards the hitherto unknown reality that seems classically implausible is in fact the experimental reality of the nature. The non-intuitive nature of the quantum reality bewildered and still puzzles even the experts in the fields. In essence, Quantum mechanics is a theory in a mathematical sense which is governed by a set of axioms. The behavior of quantum system is described by the consequences of the axioms [1,4].

In 1982, the Nobel Laureate theoretical physicist Richard Feynman dreamt the idea of a 'quantum computer', which is based entirely on principles of quantum mechanics. Unprecedentedly, the idea of a quantum computer was only of theoretical and was circumscribed within the few scientists, but as the time evolved, new ideas were generated and added into account making the idea more robust and enticing the wide researchers [1,6].

Earlier Feynman tried to solve the quantum problems by computers, but till this day we only have is classically based designed computers whose working principles are based on the classical algorithm. He envisioned of machines capable of figuring out the untraveled issues, problems, and mysteries of quantum phenomena thereby necessitating new algorithm surpassing the familiar classical one[1].

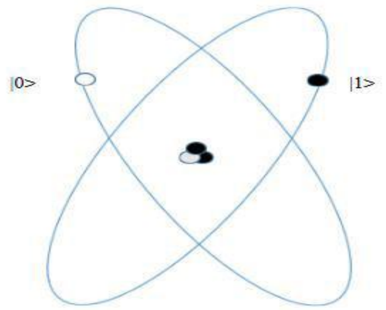


Figure 1: *Qubit represented by two electronic levels in an atom.*

Quantum Computing

It is a most powerful and advanced device to perform operations on data, highly based on the principle of quantum physics. Different aspects of quantum computer are: Logic Gates, Qubits, Entanglement and Decoherence [1].

Quantum Logic Gates

Basically logic gates are the building blocks of quantum circuits performing on small number of qubits. Some common types includes:

- NOT Gate
- One- Qubit Hadamard Gate
- Multi- Qubit Hadamard Gate
- Control-NOT Gate

Qubits

Literally, Building work of quantum computer implies the building of qubits. Basic fundamental unit used for the measurement of quantum information is Qubit. Here the term Q-refers to quantum i.e. (quantum bit). Single qubit in reality is a two dimensional state comprising of dichotomous variables like: true, false; real, unreal; spin-up, spin-down, Mathematically, we represent qubits as a '0' and/or a '1', while electronically it can be considered as 'switch on' and 'switch-off'. Basically, results of quantum problems are themselves unpredictable. Also we can represent '0' as ground energy state while '1' as excitation state [5, 11, 12]. Qubits can be measured as the basic vectors using Dirac notation as |0> and |1> and read as ket '0' and ket '1'. For more concise manner |0> is said to be up-spin while |1> as down-spin. The complete wavefunction $|\Psi\rangle$, can be expressed using linear combination of both as, $|\Psi\rangle = \alpha|0\rangle + \beta|1\rangle$.

The computers, and any advance electronic devices that we are using right now stores each single code or data of information in the form of binary digits which contains only '0' and '1'. Each data such as text, videos, images are just the 0's and 1's, the method of retrieving in suitable form is another matter however. Instead of binary digits, quantum computer uses quantum binary digits (qubits) in which information is stored by the manipulation of particles such as atoms, protons or ions. The underlying mechanism now thus differs drastically from usual classical algorithm and the concept of superposition and the entanglement becomes inevitable.

Entanglement

It is one of the weird and contemporary topics in the field of quantum mechanics. Once there is an inextricable link between the particles then the action of behavior of one can affect the other. For instance, the two entangled change their state accordingly regardless how far they exist in this known universe and the information about the change of the state of the either of the particles is propagated even faster than the speed of light. Furthermore, it gets even amazing when we observe the distance between two entangled particles, that can be in the opposite sides of the universe and still be in opposite state. Till now, Scientists have been successful in performing the entanglement in very sub-atomic level between photons, and atomic gases inside atom. Similarly in future, if possible, we may entangle things within interstellar [5, 6, 7, 8].

Figure 2: *D-Wave's 16-qubit quantum computer [2].*

Since, the entanglement can build the permanent link between particles and by observing the behavior of the particles, we can encode the message we receive, which might help in identifying the state of the particle [7]. Today, most of the researches in labs are trying to achieve the unique and unseen feat by creating high powered magnetic fields and adjusting super-low temperature to produce entanglement between electron and the nucleus of an atom. The phosphorous atom so being used and is embedded in a silicon crystal because silicon crystal is the most stable one [1].

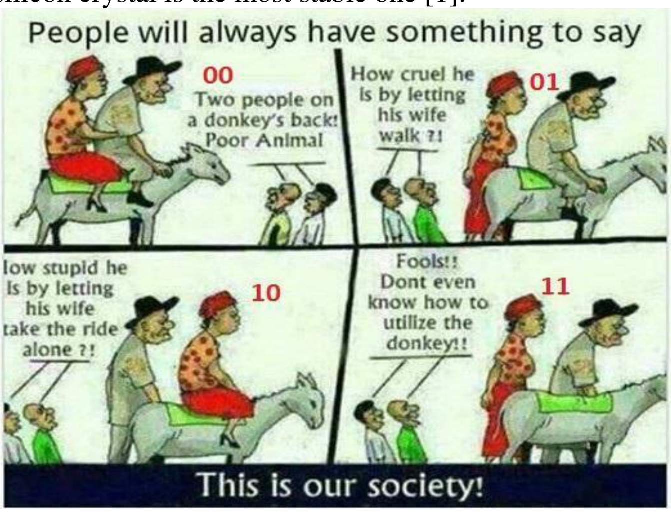


Figure 3: *Physical representation of nature of Qubits [3].*

Decoherence

The main problem of quantum computation which uses matter degrees of freedom to encode the qubits is decoherence. The term decoherence in physics became more popular in the last decade because due to the advancement in technology. In real world we can find the real physical meaning of term decoherence. The interaction of the system with whatsoever system cannot be avoided and this can lead to the loss of the quantum behaviors [5, 7, 8].

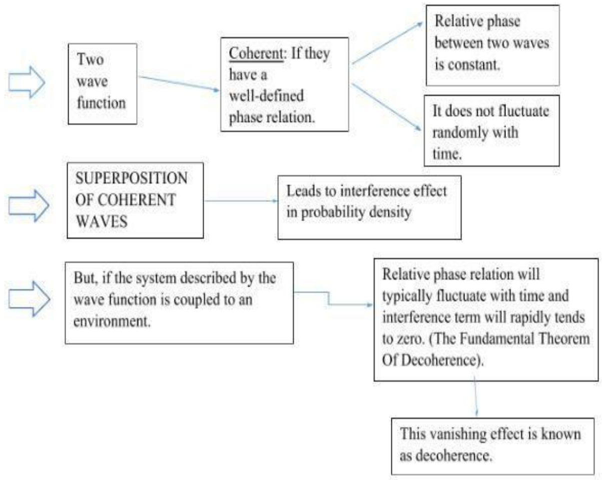


Figure 4: *Interpretation of Decoherence.*

This interaction constitute the information transfer from the system to the surrounding environment. To acknowledge more about decoherence phenomenon we have many popular statements [5, 7, 8]. It can be much faster as compared to other pertinent facts e.g.(time scales). It can be taken as the indirect measurement process which seemingly does not obey the superposition principle. It helps to understand the emergence of classicality in quantum mechanical frame work.

Shor's Algorithm

Shor's integer factoring is the most striking and first quantum algorithm for quantum computation which provides the result of any important task in very short period of time. For decades, no such algorithm had emerged. Shor's work got the greatest success as he developed exponentially faster quantum algorithms which are discrete compared to classically designed algorithms.[9,10].

In 2001: Shor's algorithm was first demonstrated and successfully tested by the scientists from IBM and Stanford University. To obtain the factor of number 15, a 7-qubit computer was used which correctly showed that the prime factors were 3 and 5. [11,12]. Shor's algorithm which fits on quantum computer system would be able to crack any kind of (no matter how hard it is for human intellect) cryptography techniques in matter of no time. Due to this kind of future prospectus most of the world's top ranked countries and intelligence are paying more attention to be the first inventor of practical quantum computer. After many years, in 1994 a mathematician Peter shor's (bell laboratory), came up with the new algorithm named after him, Shor's algorithm which draws the attention to a wide scientific community. His algorithm can do the factorization of large number to the range of 2^n (where n= any integer number). It is very much difficult and time consuming to get the expected result using classically based computers. Shor's algorithm is also called the quantum algorithm. Quantum computer can do every task that the classical computer can perform. Quantum computer are very convenient to get optimal result of the unsolved quantum problems [12, 13, 14].

Shor's algorithm consists of two parts:
1. A reduction of the factoring problem to the problem of order-finding which can be done on a classical computer.
2. A quantum algorithm to solve the order-finding problem.

Classical part of shor's algorithm: [12,13,14].

Steps:
1. Pick a pseudo-random number a < N
2. Compute greatest common denominator (GCD) (a,N). This may be done using the Euclidean Algorithm.
3. If GCD (a,N) ≠1, then there is a non-trivial factor of N, so we are done.
4. Otherwise, use the period-finding subroutine (below) to find r, the period of the following function: F(x)=a^x mod N, i.e. the smallest integer r for which f(x+r) = f(x)
5. If r is odd, go back to step 1.
6. If ar/2 ≡ -1 (mod N), go back to step 1.
7. The factors of N are GCD (ar/2±1,N), we are done.

Interpretation:

Table 1: *Mathematically solved the factor of number 15 based on classical algorithm.*

x	$\frac{(a^x)}{N}$	Remainder (mod)
1	$\frac{(7^1)}{15}$	7 (start)
2	$\frac{(7^2)}{15}$	4
3	$\frac{(7^3)}{15}$	13
4	$\frac{(7^4)}{15}$	1
5	$\frac{(7^5)}{15}$	7 (repeated)

For N=15; where N is any random number whose factor is to be identified. Let us pick any random number a = 7, say;

If we proceed further by increasing the value of x, we can get amazing patterns of these (7,4,13,1) numbers repeating alternatively with the period(r) of 4. If period is odd then go back to step 1, but here, the period is even (4). So,

$a^{period/2} = 7^{4/2} = 7^2 = 49.$

Again, add (49+1) = 50, and Subtract (49-1) = 48.

$GCD\ (50, 15) = 5 \,|\frac{50,\ 15}{10,\ 3}$; and $GCD\ (48, 15) = 3 \,|\frac{48,\ 15}{16,\ 5}$.

Hence, 3 and 5 are the prime factors of 15.

Conclusion

Classical concept is not sufficient enough for dealing with a wide variety of physical problems as the bizarre quantum world is the undeniable reality of nature. The basic fundamental aspect of Quantum Computing is realized through qubits. Shor's Algorithm plays crucial role in development of Quantum Computing. Our future perspective is to find fundamental link: Quantum part of Shor's Algorithm and corresponding hardware need to be developed to run that program.

References

[1] https://en.wikipedia.org/wiki/Quantum_computer (Feb 2019).
[2] https://www.dwavesys.com/ (Feb 2019).
[3] https://www.google.ca/ "*people will always have to say*".
[4] C. Cohen-Tannoudji, B. Diu, and F. Laloë, Quantum Mechanics,Wiley, New York (1977).
[5] E. Rieffel, and W. Polak, *Quantum computing: A gentle introduction*, MIT Press (2011).
[6] E. Rieffel, and W. Polak, *An introduction to quantum computing for non-physicists*. ACM Computing surveys, **32**(3), 300 (2000).
[7] A. Buchleitner, C. Viviescas, and M. Tiersch, eds, *Entanglement and decoherence: foundations and modern trends*, Springer Science & Business Media, 768 (2008).
[8] M. Rahmi, D. Shamanta, and A. Tasnim, *Basic Quantum Algorithms and Applications*, International Journal of Computer Applications, **56**(4), 412 (2012).
[9] M. Hayward, *Quantum computing and shor's algorithm*,Illinois Mathematics and Science Academy, **1**, 1 (2005).
[10] A. Steane, *Quantum computing*, Reports on Progress in Physics, **61**(2), 117 (1998).
[11] M. A. Nielsen, and I. Chuang, *Quantum computation and quantum information* McGraw Hill (2002)
[12] L. Merciadri, *Quantum Computers: A Brief Overview*, Narosa (2009).
[13] P.W. Shor, *Introduction to quantum algorithms*, In Proceedings of Symposia in Applied Mathematics, **58**, 143 (2002).
[14] S. J. Lomonaco, *Shor's quantum factoring algorithm*, In Proceedings of Symposia in Applied Mathematics, **58**, 161 (2002).

Lagrangian Points: The Parking Spots in Space

Niraj Kumar Shah
M.Sc. (Physics), Fourth Semester, CDP, TU, Kirtipur

ABSTRACT
The solution of three body problem where the effects of gravitational forces of two massive bodies on a small third object cancel each other gives rise to the notion of Lagrangian points. These points are of great interest for physicists and engineers. Various satellites and telescopes are launched at these points, and many satellites and telescopes (including JWST) are scheduled to launch around these points. In this article, I have primarily focused in the nature of Lagrangian points for the Sun-Earth system and their significances.

Lagrangian points or L- points are locations in space where the combined gravitational effects of two massive bodies such as the Earth and the Sun or the Earth and the Moon perfectly balance the centrifugal force felt by a small third body such as satellite, telescope, orbital space colony etc. maintaining their relative positions. The Lagrangian points between the Sun and the Earth are at different spots than the Lagrangian points between the Earth and the Moon, and at different spots between the Sun and the Jupiter etc. There are five such points, labeled L_1 to L_5, all in the orbital plane of the two massive bodies. Scientists are currently using Lagrangian points as parking spots for certain satellites and telescopes.

Lagrangian points (also Lagrange points, libration points or L- points) are named after the French mathematician and astronomer Joseph-Louis Lagrange, who wrote an "Essay on the Three Body Problems" in 1722 extending the mathematics of Leonhard Euler. The first three L-points (L_1,L_2 and L_3) arranged in a straight line were discovered by Leonhard Euler few years before Joseph-Louis Lagrange discovered the remaining two L-points (L_4 andL_5)[1] which form two equilateral triangles with common base.

Nature of L-points

Lagrangian points exist between any two massive objects in orbit around each other. But here I have primarily focused at the Sun-Earth system. Each of the five L-points around the Sun-Earth system has its own quirks.

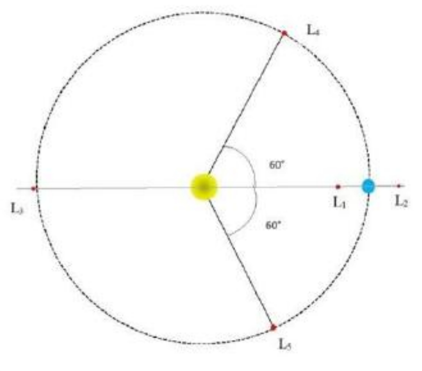


Figure1: *Representation of L-points in the Sun-Earth system.*

L_1-point: The position of L_1-point is shown in figure 1. It lies between the Sun and the Earth on the line connecting their centers. An object placed at L_1 position will be pulled left by the Sun and right by the Earth. Since the gravitational influence of the Sun is more than the gravitational influence of the Earth, the L_1-point is at much closer to the Earth than the Sun, so that the pull of gravity from each body would balance at L_1-point. L_1-point lies about 1.5 million kilometers from the Earth, or 1% of the distance to the Sun.

This spot is very convenient spot for placing satellites because the satellites placed here will never fall into the Earth shadow or travel behind the Sun with relative to the Earth. Satellites placed at L_1 will have continuous uninterrupted view of the fully illuminated Earth and the Sun. The ESA/NASA solar watchdog spacecraft, the Solar and Heliospheric Observatory (SOHO), remains at the L_1 point, orbiting the Sun at the same rate as the Earth. From this position, SOHO constantly monitors the Sun and, as well as conducts scientific studies, SOHO is also an early warning spacecraft. It can report violent solar storms that could damage communications and navigation satellites in orbit around our planet. [2]Other satellites positioned at L_1 are ACE, WIND, and DSCOVR (formerly known as Triana)by NASA.

L_2-point: The L_2-point is also a great location for satellite placement. The L_2-point lies on the line through the Sun and the Earth, beyond the Earth as shown in figure 2. The L_2-point is particularly well-suited for space telescopes. Since the Sun and the Earth always lies behind the L_2-point, a telescope placed at this location will have better view of deep space. An object placed at L_2-point, higher orbit around the Sun, will maintain its position and its orbital speed equals to the Earth by the extra pull of Earth's gravity. LikeL_1, L_2 is also about 1.5 million kilometers from the Earth or 0.01 AU from the Earth but in the opposite direction of the Sun.

The European Space Agency's (ESA) Gaia telescope is currently placed at L_2 and the James Webb Space Telescope (JWST) is scheduled to place there in 2021 by NASA, ESA and CSA and will be the successor to the Hubble Space Telescope and Spitzer Space Telescope. [3] Euclid Space Telescope, Wide Field Infrared Survey Telescope (WFIRST) and Advanced Telescope for High Energy Astrophysics (ATHENA) will use halo orbit nearL_2. This L_2 point was also used for the Planck satellite for the study of the Cosmic Microwave Background.

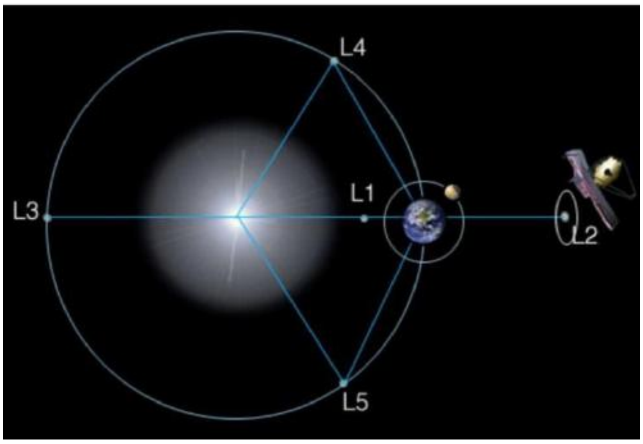


Figure 2: *The James Webb Space Telescope will orbit the L_2 point. [Source: jwst.nasa.gov]*

L_3-point: The third Lagrange point L_3 exists on the opposite side of the solar system, a little outside Earth's orbit but slightly closer to the Sun than the Earth is. At the L_3 point, the combined pull of Earth and Sun causes the object to orbit with the same orbital speed as the Earth. The Sun's and the Earth's gravities line up at L_3 with similar physics as L_2 but in the opposite direction and on the opposite side. An object placed at L_3-point would not be visible from the Earth because the Sun will always block the line of sight. This point is perfect candidate for aliens to hide from us. As this point remains hidden by the Sun it is quite difficult to communicate from the Earth, and hence this point remains yet to be utilized as a parking spot for satellites. This point is mostly famous in science-fiction movies.

The **L_4** and **L_5** points can be found by constructing equilateral triangles taking the line joining the centers of the Sun and the Earth as the common base, L_4 and L_5 as the third vertex as shown in figure 2. These $L_4$and L_5 are stable equilibrium points, so it is common to find natural objects at or orbiting the $L_4$and L_5 points of natural orbital systems. The reason these points are in balance is that, at L_4 and L_5, the distances to the two masses are equal. Accordingly, the gravitational forces from the two massive bodies are in the same ratio as the masses of the two bodies, and so the resultant force acts through the barycenter of the system; additionally, the geometry of the triangle ensures that the resultant acceleration to the distance from the barycenter is in the same ratio as for the two massive bodies. The barycenter being both the center of mass and center of rotation of the three-body system, this resultant force is exactly the same required to keep the smaller body at the Lagrange point in orbital equilibrium with the other two larger bodies of system.[4] The L_1, L_2 and L_3 points are unstable equilibria, any object placed at these positions orbiting the Sun tend to fall out of orbit, and therefore it is rare to find natural objects at these points.

The positions of five Lagrange points are as follows:

(Assuming that $\alpha = \frac{M_e}{M_e+M_s}$)

Point	Location
L_1	$(R[1-(\frac{\alpha}{3})^{\frac{1}{3}}],0)$
L_2	$(R[1+(\frac{\alpha}{3})^{\frac{1}{3}}],0)$
L_3	$(-R[1-(\frac{5\alpha}{12})^{\frac{1}{3}}],0)$
L_4	$(\frac{R}{2}[\frac{M_s-M_e}{M_s+M_e}],\frac{\sqrt{3}}{2}R)$
L_5	$(\frac{R}{2}[\frac{M_s-M_e}{M_s+M_e}],-\frac{\sqrt{3}}{2}R)$

Besides the Sun-Earth system similar types of L-points are found in the case of the Sun-Jupiter system, Sun-Venus system, Earth-Moon system etc.

Summary

The Lagrangian points are extensively useful for parking satellites, telescope and for placing orbital space colony with very small or zero energy to maintain its position. These points will be extremely important for interplanetary travel, and for further space exploration in the future. The L_1 point is better for parking the satellites whereas L_2 point is better for telescope for better view of deep space for the Sun-Earth system. The L_3 point remains hidden from the Earth and is famous in science-fiction movies. The L_4 and L_5 points are stable equilibria and many natural objects are found near it.

References

[1] W. S. Koon, M. W. Lo, J. E. Marsden, S. D. Ross, *Dynamical Systems, the Three-Body Problem, and Space Mission Design*. Cambridge Univ Press, p.6 (2006).
[2] https://www.esa.int/Our_Activities/Space_Science/L1_the_first_Lagrangian_Point (Feb 2019)
[3] https://jwst.nasa.gov/news_archive.html (March 2019)
[4] https://en.wikipedia.org/wiki/Lagrangian_point (24 May, 2017).

Water detected on an Exoplanet located in its star's Habitable Zone

Astronomers have detected water vapor on the exoplanet K2-18b -- a major discovery in the search of alien life. Ever since the discovery of the first exoplanet in the 1990s, astronomers have made steady progress towards finding and probing planets located in the habitable zone of their stars, where conditions can lead to the formation of liquid water and the proliferation of life. Results from the Kepler satellite mission, which discovered nearly 2/3 of all known exoplanets to date, indicate that 5 to 20% of Earths and super-Earths are located in the habitable zone of their stars. However, despite this abundance, probing the conditions and atmospheric properties on any of these habitable zone planets is extremely difficult and has remained elusive... until now.

Source: https://www.sciencedaily.com/releases/2019/09/190911121950.htm

Implications of Shape-Shifting Neutrinos

Sagar Adhikari
M.Sc. (Physics), Central Department of Physics, TU

ABSTRACT
The standard model of particle physics does not embrace neutrino mass.Experiments have shown neutrinos actually behave as if they have mass eigenstates between which they can oscillate.I discuss about these "oscillations", how these oscillations allow neutrinos to have mass and the possible implications of this property.

Introduction

Neutrinos are fundamental particles that were first formed in the first second of the early universe, before even atoms could form. They are also continually being produced in the nuclear reactions of stars, like our sun, and nuclear reactions here on earth. Much is still unknown about these particles, they have an undetermined mass and travel at near the speed of light.Neutrino actually means "little neutral one." There are three types (flavors) of neutrinos: electron neutrino, muon neutrino, and tau neutrino. Each "flavor" of neutrino has a corresponding charged particle from which it gets its name (see Figure 1) [1]. Neutrinos interact with other particles only via weak and gravitational force. Weak force is extremely short range and gravitational force is negligible in subatomic scale so they can pass through massive objects without interacting. Thus, their detection is extremely hard. [2]

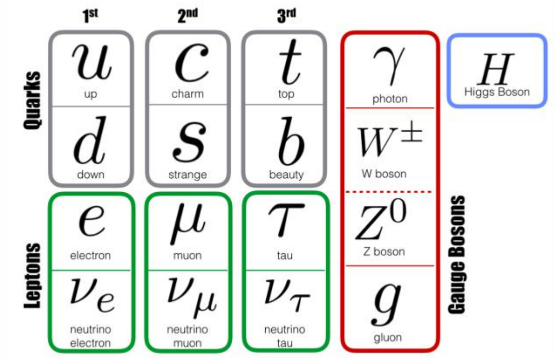


Figure 1: *Standard Model: The Standard Model consists of matter particles (with spin 1/2), gauge bosons (with spin 1) and the Higgs boson (with spin 0). The gauge bosons are associated with the three fundamental forces (electromagnetic, strong and weak) which are responsible for interactions between the elementary particles.[1]*

Atmospheric and Solar neutrino problem and Solution:

Hydrogen fusion in the sun produces huge number electron neutrinos (mainly by means of reaction (1)) and energetic cosmic rays react with molecules in the atmosphere producing muon and electron neutrinos (see figure 2)[3].

$$^{1}H + {}^{1}H \rightarrow {}^{2}H + e^{+} + \nu_e \qquad (1)$$

But the observations of atmospheric and solar neutrinos detected only about a third of the estimated neutrino flavors whichwas absurd. This problem is believed to be solved withthe discovery of the shape-shifting neutrinos (Neutrino oscillation). In 1957 Bruno Pontecorvo first proposed the idea of neutrino oscillation; neutrino changing flavor during their travel. Neutrino oscillation was discovered by the Super-Kamiokande experiment in 1998. The atmospheric muon neutrinos generated by the collision between cosmic rays and the atmosphere on the earth were observed, the number of the upward going neutrinos was only half of the number of the down going neutrinos.This is because the muon neutrinos passing through the earth turn into tau neutrinos. The 2015 Nobel Prize in Physics was awarded to Takaaki Kajita and Arthur B. McDonald "for the discovery of neutrino oscillations, which shows that neutrinos have mass".

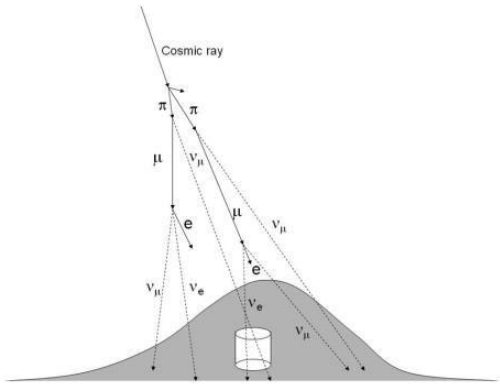


Figure 2: *Production of neutrinos by cosmic-ray interactions with the air nucleus in the atmosphere. The typical height of the neutrino production is 15 km above the ground. [3]*

Neutrino oscillation is a phenomenon that a neutrino produced in a definite type (flavor)is to be observed in a different type (flavor) after traveling some distances. It is possible that a type of neutrino does not have a unique mass. Instead, it is generally possible that a type of neutrino is a mixture of several (probably three) mass states with definite masses.

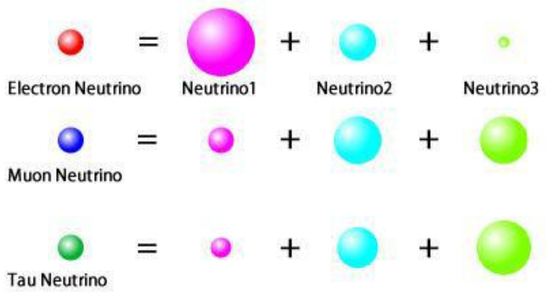


Figure 3: *Neutrinos are also classified in terms of "mass." Neutrino1, neutrino2 and neutrino3 have a mass of: m1, m2, and m3, respectively. These classifications, in terms of flavor and mass, are mixed with each other. Flavor eigenstates and mass eigenstates cannot be determined at the same time. [4]*

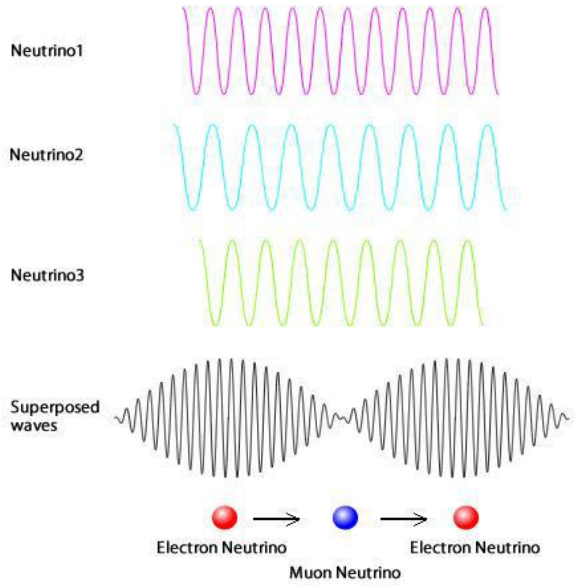


Figure 4: *Neutrino as superposition of different mass Eigen functions: [4]*

Figure 4 is the representation of neutrinos being in the superposition of mass eigen-functions. Neutrinos exhibit the properties of a particle as well as a wave. Therefore, neutrino1, neutrino2 and neutrino3, each with different mass eigenstates, travel through space as waves that have a different frequency. The flavor of a neutrino is determined as a superposition of the mass eigenstates. The type of the flavor oscillates, because the phase of the wave changes. For simplicity, let us discuss neutrino oscillations between two types of neutrinos. In neutrino oscillations, the original type of neutrino (for example, ν_μ) changes to a different neutrino type (for example, ν_τ) after traveling some distances. After further traveling, the type of the neutrino becomes the original one (in this example, ν_μ). This is a way by which neutrino oscillations take place. The probability that a neutrino of an original type to be observed in a different type after traveling a distance of L with the energy of E_ν is a function of the neutrino mass, or more exactly the difference of the neutrino masses squared (Δm^2), namely $m_{\nu j}^2$ - $m_{\nu i}^2$, where $m_{\nu i}$ and $m_{\nu j}$ are masses of i-th and j-th mass states of definite masses. Therefore, by measuring the neutrino oscillation probability as a function of the neutrino flight length or the neutrino energy, it is possible to get information on the neutrino masses. The fraction of the ν_2 and ν_3 components in ν_μ is expressed by introducing a "mixing angle θ". If ν_μ is composed of ν_2 only, the mixing angle θ is 0 degree. If ν_μ is composed of ν_2 and ν_3 with an equal fraction, the mixing angle θ is 45 degrees. Assuming the neutrino oscillation is purely between ν_μ and ν_τ , the probability of a ν_μ survived as ν_μ after traveling some distance L is expressed as;

$$P(\nu_\mu \to \nu_\mu) = 1 - sin^2(2\theta) \cdot sin^2\left(\frac{1.27\Delta m^2 L}{E_\nu}\right) \quad (2)$$

The disappeared ν_μ is oscillated to ν_τ.

Mass difference and absolute mass:

The oscillation of neutrinos means that neutrinos can experience time, so they have to travel with speeds less than that of light, which in turn implies that they must have masses. To determine these masses remains one of the most challenging tasks of contemporary physics, bearing fundamental implications to particle physics, astrophysics and cosmology.

Here I present a work in which one of the possible techniques to find absolute mass of neutrinos using mass difference is discussed. Used mass difference is obtained by experiments on solar neutrinos and atmospheric neutrinos.

Let's consider the case when there are three neutrino flavor eigenstates (ν_e, ν_μ, ν_τ) and three neutrino mass eigenstates (ν_1, ν_2, ν_3) with corresponding masses (m_1, m_2, m_3). The neutrino oscillations probabilities depend on mass squared differences, $\Delta m_{ij}^2 \equiv (m_i^2 - m_j^2)$, which can be determined experimentally. In the case of 3-neutrino mixing there are only two independent neutrino mass squared differences, say Δm_{21}^2 and Δm_{32}^2. The Δm_{21}^2 (needed to explain solar data) and the Δm_{32}^2(needed to explain atmospheric data) are often referred as the "solar" and "atmospheric" neutrino squared differences and denoted as $\Delta m_{21}^2 \equiv \Delta m_{Sun}^2$ and $\Delta m_{32}^2 \equiv \Delta m_{atm}^2$.

From the recent experiments, we have:

$$\Delta m_{Sun}^2 \equiv \Delta m_{21}^2 = (m_2^2 - m_1^2) \approx 7.59 \times 10^{-5}\ eV^2 \quad (3)$$

$$\Delta m_{atm}^2 \equiv \Delta m_{32}^2 = (m_3^2 - m_2^2) \approx 2.43 \times 10^{-3}\ eV^2 \quad (4)$$

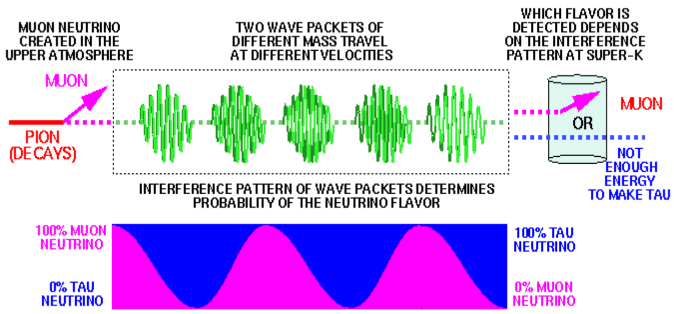


Figure 5: *Neutrino oscillating between two flavors. [5]. Quantum mechanics tells us that if two (or more) neutrinos are composed of the same mass states but in different combinations, then the neutrino can oscillate from one flavor to another while it travels through space.*

Hence, neutrino spectrum contains a doublet of two mass eigenstates (m_1 and m_2) separated by the splitting Δm_{Sun}^2, and a third eigenstate m_3 , separated from the first two by a much larger splitting Δm_{atm}^2 ($\Delta m_{atm}^2 \approx 32\ \Delta m_{Sun}^2$). The two equations (3) and (4) are obviously not sufficient to determine three masses m_1, m_2, m_3. A third relation between masses is needed. For instance, a recent proposal is to use, as a third equation, geometric mean neutrino mass relation m_2 = sqrt (m_1* m_3) for normal spectrum and m_1 = sqrt(m_2 *m_3) for the inverted spectrum. This proposal is inspired by the geometric mean mass relation used previously for quarks. A weak point of the proposal lies in the well-known fact that Lepontic mixing (characterized with large mixing angles) is very different from its quark counterpart, where all the mixing angles are small. Our second objection is that geometric mean mass relation has a form which is quite different from Equations (3) and (4) while it is desirable to have a third equation with similar form. The equations (3) and (4) are about mass squared differences; hence the most natural third equation is in the form of a mass squared sum. After some rigorous calculations [6], which is beyond the scope of this article, author found the absolute masses as:

m_3 = 0. 070 eV

$m_2 = m_2'$ = 0. 050 eV

$m_1 = m_1'$ = 0. 049 eV

m_3' = 0. 0087 eV

Where, m_1, m_2& m_3 are for neutrino mass spectrum with normal hierarchy ($m_1 < m_2 < m_3$), and m_1', m_2'& m_3' are for neutrino mass spectrum with inverted hierarchy ($m_3 < m_1 < m_2$).[6]

Note that these absolute values are not widely accepted and much of new research is to be done to understand neutrinos comprehensively.

Why it matters:

The mechanism which generates neutrino masses is still unknown, and the Standard Model must be extended to include this new physical reality. Although mass differences between neutrino flavors have been determined with precision, no one has yet succeeded in actually measuring the neutrino mass itself. The best upper limits derived from laboratory experiments give $m_{\nu,\ e} < 2$ eV (from tritium decay), while limits on the mass of the muon-neutrino and the tau-neutrino (from pion and tauon decays) are considerably higher. [7]

Closing Remarks/Conclusions:

The standard model of particle physics does not embrace neutrino mass but various experiments such as Super-Kamiokande and SNO's have shown neutrinos actually behave as if they have mass eigenstates between which they oscillate. Since we know that neutrinos must be massive in for their mass eigenstates to oscillate. We also know that our standard model view of neutrinos is flawed. This disagreement indicates a need for explanation beyond the standard model to realize neutrinos. Many complex and beautiful theories have emerged to explain how neutrinos get their mass, such as the Higgs mechanism.

There have been many experiments attempting to determine the neutrino mass ordering. Also there is search for sterile neutrinos (some argue they may lead us to the discovery of dark energy) or measure the CP violating effects in the neutrino sector (The leptonic CP violation effects might have played a role for the baryon-antibaryon asymmetry in the universe through a mechanism called leptogenesis). Hence, the discovery of neutrino oscillations has opened a door towards a more comprehensive understanding of the universe we live in.

References:

[1] http://www.physik.uzh.ch/en/researcharea/lhcb/outreach/StandardModel.html (Jan 2019).

[2] http://www.astro.wisc.edu/~larson/Webpage/neutrinos.html (Jan 2019).

[3] T. Kajita, *Atmospheric neutrinos and discovery of neutrino oscillations,* Proceedings of the Japan Academy. Series B, **86**, 303 (2010).

[4] http://www.hyper-k.org/en/neutrino.html (Jan 2019).

[5] http://hep.bu.edu/~superk/osc.html (Jan 2019).

[6] D. S. Hajdukovic, *On the absolute value of the neutrino mass,* Modern Physics Letters A, **26**, 1555 (2011).

[7] Scientific Background on the Nobel Prize in Physics 2015, Neutrino Oscillation, compiled by the Class for Physics of the Royal Swedish Academy of Sciences (Jan 2019).

Renewable energy generation with kites and drones

A group of researchers has recently developed a new software aimed at the analysis of energy generation systems based on kites and drones. They used the software to study the behavior of these systems while transforming the kinetic energy of the wind into useful electrical energy. Airborne Wind Energy Systems (AWES) are a new kind of technology to harvest wind energy. The expensive and heavy tower and rotor of a conventional wind turbine are here substituted by a light tether and an aircraft (flexible giant kites or large drones), respectively. In the so-called ground generation scheme, AWES use the tension force of the tether to move an electrical generator on the ground whereas, in fly generation scenarios, the electrical energy is produced by wind turbines onboard the aircraft and transmitted to the ground by a conductive tether. In both cases, AWES present low installation and material costs and operate at high altitude (over 500 metres) where winds are more intense and less intermittent. They also present a low visual impact and their easier transportation make them suitable for producing energy in remote and difficult access areas. "They combine well-known disciplines from electrical engineering and aeronautics, such as the design of electric machines, aeroelasticity and control, with novel and non-conventional disciplines related to drones and tether dynamics," he adds.

Sources: https://www.sciencedaily.com/releases/2019/02/190219132700.htm

Integrated Circuit Fabrication

Bharat Sunar
M.Sc.(Physics), Fourth Semester, Central Department of Physics, T.U., Kirtipur

ABSTRACT
The Integrated circuit (IC) technology which made electronic world possible to reach the micro-level, has revolutionized the technology. One of the processes of fabricating IC is called planar technology. It is successful to include all the circuit components into a small crystal chip of silicon, as a single entity.

Introduction

Integrated circuit (IC), also called microelectronic circuit, microchip, **or** chip, is a semiconductor-based electronic device in which thousands or millions of tiny circuit components – transistors, diodes, resistors, capacitors, and their interconnections- are fabricated as a single entity. Actually, it is really interesting to be acquainted with how such a large number of components are built up on a thin substrate of semiconductor material (typically silicon).The integration of large numbers of tiny circuit components into a small chip results from the process called *planar technology*. This technology revolutionized the world of electronics, offering the advantages of low cost, small size, high reliability, improved performance, and high speed. The processes used to fabricate ICs by planar technology are discussed in this article.

Figure 1*: Integrated Circuits (ICs)*

Planar Process:

The planar processes for IC fabrication consist of six or seven independent processes: (1) crystal growth of substrate, (2) epitaxial growth, (3) oxidation, (4) photolithography and chemical etching, (5) diffusion, (6) ion implantation and (7) metallization. Using these processes step-by-step, many circuits are fabricated simultaneously on a single small flat of silicon.Examiningeach of these processes in more detailwillelucidate us about how IC fabrication became really possible.

1) Crystal Growth

At first, a rod of silicon, called ingot, of the order of 10 cm in diameter and 50 cm long is grown by Czochralski process. The ingot is subsequently sliced into round wafers to form the substrate on which all integrated components will be fabricated. One side of each wafer is lapped and polished to eliminate surface imperfections before proceeding with next process.

2) Epitaxial Growth

The epitaxial process is used to grow a layer of single-crystal silicon as an extension of an existing crystal wafer of the same material. Epitaxial growth is performed in a special furnace called a reactor into which the silicon wafers are inserted and heated to about 1200º C. An epitaxial layer is grown on a substrate, typically 5 to 25 μm thick, a silicon surface.Current technology uses the gases silane (SiH_4) or tetrachloride ($SiCl_4$) as the source of silicon to be grown.

3) Oxidation

An oxide layer of silicon is then grown on the silicon surface. Most often, this SiO_2 layer is achieved by thermal oxidation of silicon in the presence of water vapor. Using the feature of SiO_2 as a passivating layer, selective doping of specific regions of the chip is accomplished, as described later. The thickness of the oxide layers is generally in the order of 0.02 to 2 μm. Process temperature, impurity concentration, and processing time are main factors that influence the thickness of SiO_2 layer.

4) Photolithography

The planar process requires the selective removal of SiO_2 to form openings through which impurities may be diffused.During the photolithographic process the wafer is coated with a uniform film of a photosensitive emulsion, a photoresist. A large black-and-white layout of the desired pattern of openings is made and then reduced photographically. This negative of the required dimension is placed as a mask over the photoresist. By exposure of the emulsion to ultraviolet light through the mask, the photoresist becomes polymerized under the transparent regions of the mask. The mask is now removed, and the wafer is developed by using a chemical which dissolves the unexposed portions of the photoresist film. The chip is immersed in an etching solution of hydrofluoric acid, which removes the oxide from the areas through which dopants are to be diffused. Those portions of SiO_2 which are protected by the photoresist are unaffected by the acid. After diffusion of impurities, the resist mask is removed with a chemical solvent coupled with a mechanical abrasion process.

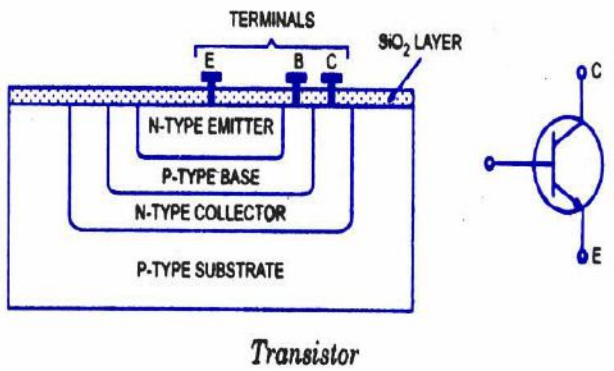


Figure 2: *Planar IC realization of a Transistor*

5) Diffusion

The diffusion of impurities into silicon is the basic step in the planar process. Even before the introduction of integrated circuits, diffusion method was used to fabricate discrete transistors. The introduction of controlled impurity concentrations is performed in a diffusion furnace at a temperature of about 1000 ° C over 1 to 2 hours period. The temperature must be carefully controlled so that it is uniform over the entire hot zone of the furnace. Impurity sources can be gases, liquids, or solids and are brought into contact with theexposed silicon surface in the furnace.

6) Ion Implantation

This is a second method of introducing impurities into silicon. A beam of appropriate ions is accelerated in a vacuum by energies between 30 and 200 Kev to fall on silicon surface. The depth of penetration of these ions is determined by the accelerating energy and the beam current. This process is frequently used where thin layers of doped silicon are required such as the emitter region of a transistor. For such narrow regions, ion implantation permits the doping concentrations to be more readily controlled than does diffusion. The advantage of ion implantationover diffusion is that, it can be performed at low temperature.

7) Metallization

Metallization is the final process of IC fabrication. This process is used to form the interconnections of the components on the chip. These are formed by the deposition of a thin layer of aluminum over the entire surface of the chip. Deposition is achieved by high-vacuum evaporation inside a bell jar. The aluminum is heated until it vaporizes; the gaseous molecules formed uniformly radiate in all directions and completely cover the wafer surface. A mask is used to define the connection pattern between components and the unwanted aluminum is etched and removed after which IC is finally ready.

Hence, these processes of IC fabrication are of extreme importance due to which hundreds and thousands of circuit components are contained within a single chip. This results into *technological* revolutions with the inventions of portable devices like mobile phones and laptops.

References:

[1] J. Millman, and A. Grabel, *Microelectronics,* New York: McGraw-Hill (1987).

[2] P. Horowitz, *W.* Hill, S. Winfield, *The Art of Electronics (2nd ed.),* Cambridge University Press (1989).

List of M.Sc. Dissertation 2018-19 (3)

Central Department of Physics

Name of Student	M.Sc. Dissertation Title	Supervisor
Prakash Chalise	A STUDY OF FAR INFRARED CAVITY NEARBY KK LOOP G150+01	Prof. Dr. Binil Aryal
Prakash Chandra Adhikari	A STUDY OF A FAR-INFRARED CAVITY NEARBY KK-LOOP G117+00	Prof. Dr. Binil Aryal
Pramod Ghimire	TRANSPORT PROPERTIES OF CARBON DIOXIDE IN WATER, A MOLECULAR DYNAMICS STUDY	Prof. Dr. Narayan Pd Adhikari
Raj Kumar Pradhan	THE AGE AND KINEMATIC DISTRIBUTIONS OF THE MILKY WAY STELLAR HALO	Dr. Prajwal R. Kafle & Dr. Ajay Kumar Jha
Ramesh Dhakal	EFFECT OF Fe DOPING ON SPIN GAPLESS PROPERTY OF INVERSE HEUSLER ALLOY Mn2CoAl	Dr. Gopi Chandra Kaphle
Reason Shakya	MESO-SCALE METEOROLOGICAL FLOWS AND AIR POLLUTION DISPERSION MODELING OF UDAYAPUR CEMENT INDUSTRY, UDAYAPUR NEPAL	Prof. Dr. Ram Pd Regmi
Reg Bd Dangi	TO STUDY OF STRUCTURAL, ELECTRONIC AND MAGNETIC BEHAVIOR OF Fe DOPED CeCrO3 PEROVSKITE: A FIRST-PRINCIPLES CALCULATION	Dr. Gopi Chandra Kaphle
Rima G.C.	MESO-SCALE METEOROLOGICAL FLOWS AND AIR POLLUTION DISPERSION MODELING OF ARGHAKHACHHI CEMENT FACTORY, RUPANDEHI, NEPAL	Prof. Dr. Ram Pd Regmi
Roshan K Thakur	EFFECTS OF ION TEMPERATURE ON MAGNETIZED HELIUM PLASMA SHEATH	Prof. Dr. Raju Khanal

A Versatile, source of High Quality Microwave Signal, Oscillator

Nabin K. Raut
MS Student, University of California, Merced, USA

ABSTRACT

In modern time, Area like communication, radar, and navigation demands very precise timing oscillator immunity to extreme environments.An optoelectronic oscillator uses loss low, low dispersion and high efficiency optical fiber as an additional energy storing component unlike traditional mechanical, quantum mechanical and electromagnetic oscillator by producing low phase noise microwave signal.Such highly stable and ultra-pure signal can be used for sensing, detection and measurement.

Introduction

In traditional oscillator tenability and purity of signal is compromise due to limited energy storagecapacity and inherent high loss components.But after invention of a hybrid, optoelectronic, and oscillator takes quality of signal to new height. It uses loss low, low dispersion and high efficiency optical fiber as an energy storing component. Use of this additional energy storing component brings stability in the signal by increasing its purity. Moreover, it has dual, electrical and optical, outputs. The electrical signal can be used in ultra-low phase noise demanding applicationslike Doppler radar, whereas optical output has applications in high speed telecommunication, clock-recovery, and ship navigation. In addition, this oscillator can be used as a transporter of microwave signal to long distance [1-4].

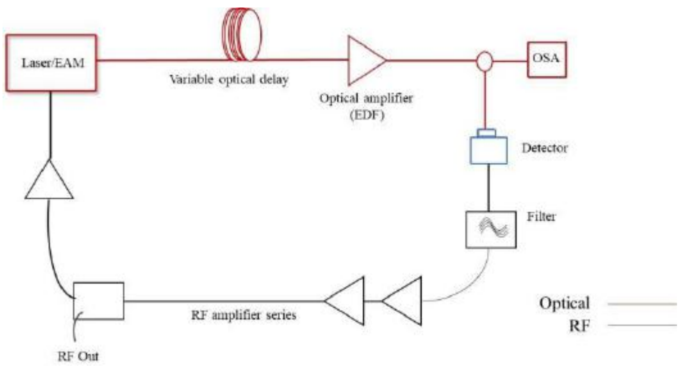


Figure 1: *Optoelectronic oscillator.*

Figure 1 shows diagram of an optoelectronic oscillator (OEO). The red and black colors respectively show optical and electrical region. The optical region includes laser, modulator, fiber and optical amplifier whereas the electrical part has filter and various amplifiers. Here, a continuous laser lightis pass through a modulator. The modulated nonlinear signal is then carries onby optical fiber,after optical amplification, to thephotodetector. The photo detector converts optical signal into electrical signal. The multimode signal is now pass through a filter, which suppress all other modes except a mode inside its bandwidth. This filtered linear microwave signal then go through various stages of amplification before fed into the electrical port of the modulator. The system starts to oscillate when overall gain of the oscillator is greater than loss and phase is integer multiple of 2Π. In this process, a continuous laser light is converting into discrete microwave signal. The oscillation frequency, as shown in equation below [3], depends onthe gain of the system.

$$f_{osc} = f_k = \frac{\left(k + \frac{1}{2}\right)}{\tau} \text{ for } G(V_{osc}) < 0$$

$$f_{osc} = f_k = \frac{k}{\tau} \text{ for } G(V_{osc}) > 0$$

Where, k = mode selected by the filter and τ = time delay introduced by the fiber. Furthermore, in this oscillator optical fiber and filter plays very important role. In fact, use of the optical fiber in optoelectronic oscillator puts it on topof thelist, in terms of purity, among all other oscillators. It is cheap and easily available.The fiber does various contributions in the oscillation. First, it helps transportation of encoded information in speed of light, which is way faster than its counterpart oscillators. Most importantly, it works as an energy storing components. As shown in figure 2, separation between modes and hence delay time is determines by the length of fiber as $\Delta f = \frac{1}{\tau} = \frac{c}{nl}$. Where n= refractive index of material, c = velocity of light, l= delay length. As shown in the equation, longer fiber introduces more delay time in the system. Interestingly, there is advantage of having longer delay time because it relates directly with the quality factor. The longer fiber corresponds to the higher quality factor (Q). For example, a 4 km fiber corresponds to Q of an order 10^6 [5]. In addition, timing jitter, phase noise in frequency region, is inversely proportional to the square root of length of the fiber delay. Hence, for high quality microwave signal length of fiber is crucial. However, length of the fiber is limited by environmental effects [6].The longer fiber increases thermal vibration, which changes its refractive index. Due to which instability on output frequency can observe. Relation between change in temperature, refractive index and frequency is $\frac{\Delta f}{\Delta T} = -\frac{f}{n} \cdot \frac{\Delta n}{\Delta T}$, where, Δn = change in refractive index, ΔT= change in temperature, Δf= change in frequency [7]. Moreover, filter is another important component in the OEO. Different types of filters were invented over the years. Some of them are dielectric, whispering gallery mode, and superconducting cavity. The main works of almost all filters is to choose single mode out of many competing input modes. Let us suppose an OEO with filter of Q in order of ten thousand and 3km fiber spool then there willbe 149 input modes inside the filter fighting for selection. Out of 149, only one modegets filtered and remaining 148 modes suppress due todestructive interference. In this way every time filter will allow only a mode in output. Along with mode selectionfilteralso helps to reduce noise originate from optical region and photodetector. The development of filter was based on how well it can suppress all these different sources of noise. This unique quality of the filter is identified by its quality factor (Q). During beginning years of the OEO, filter with quality factor in order of ten thousand and less were used. In recently years, use of whispering gallery mode and superconducting cavity increase quality factor in order of billion and more.

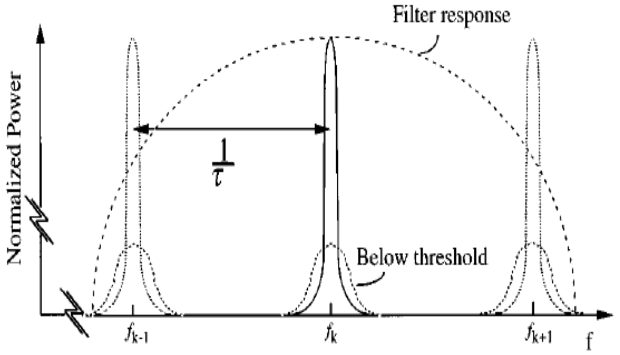


Figure 2: *Multi modes inside a filter bandwidth [3].*

An important question about OEO is what measures its quality? The phase noise measurement is key test for performance evaluation of an OEO. Lower the phase noise better the OEO is. Commonly, single side band (SSB) phase noise is characterized by one sided spectral density, which describes the energy distribution as a continuous function per unit bandwidth,L(f)=Area of 1 HZ bandwidth/Total area under the curve. Its unit is dBC/Hz. Figure 3 and Table 1 shows unique characteristic of SSB phase noise in different frequency region. First 10Hz offset frequency is dominat by environment fluctuation cause by thermal and acoustic vibration and has 1/f^4 slope. Similarly, in the region of 10Hz-1KHz, 1KHz-30KHz and >30KHz offset frequency main source of noise are respectively flicker noise, white noise and noise due to non-oscillating and parasite modesand have slope of $1/f^3$, $1/f^2$and $1/f^0$[4].

Over the years different modifications has been done to improve phase noise performance of OEO.All these modifications were achieved by modifying either fiber, filter, or both. Some of them are multi-loop OEO [8-11], injection locking OEO [12, 13], coupled OEO [14, 15], whispering gallery mode OEO[16,17].In multi-loop OEO two or more fibers are connected in series. Whereas in injection locking OEO, setting of OEO is such that the fibers areparallel to each other. In coupled OEO laser oscillation is isolated from optoelectronic oscillation.

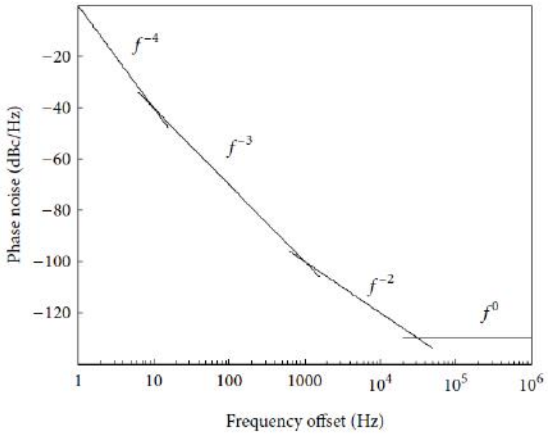


Figure 3: *Different types of phase noise in certain frequency region [4].*

Furthermore, as name suggest whispering gallery mode oscillator is use in whispering gallery mode OEO.

Table 1: Sources of different phase noise.

Frequency range	Cause of phase noise
1Hz-10Hz	Environment fluctuations cause by thermal and acoustic vibrations.
10Hz-1KHz	Flicker noise from RF amplification stage.
1KHz-30KHz	White noise.
>30KHz	Non-oscillating side modes.
1Hz-10Hz	Environment fluctuations cause by thermal and acoustic vibrations.

Conclusion:

An optoelectric oscillator is a versatile oscillator. It uses optical fiber as an additional energy storing component, which increases stability and purity of microwave signal significantly. Use of photonic signal makes data transportation very fast in this oscillator. In addition, it has electrical and optical output, which can be usedin various applications related to respectiveoutputs.

Acknowledgement

I would like to acknowledge Central Department of Physics for this opportunity, especially Prof. Binil Aryal for making Symmetry accessible for everyone and Dr. Hari Prasad Lamichhane for his inspiration and motivation. I also want to acknowledge Prof. Jay Sharping and my friend Jeffery Miller for all help and support.

References

[1] A. Neyer& E. Voges, "*Nonlinear electrooptic oscillator using an integrated interferometer*",Optics Communications **37**, 169-174 (1981).

[2] X. Zouet. al., "*Optoelectronic Oscillators (OEOs) to Sensing, Measurement, and Detection*", IEEE Journal OF Quantum Electronics **52**, 1 (2016).

[3] X. S. Yao & L. Maleki, "*Optoelectronic microwave oscillator*", Opt. Soc. Am. B **13**, 1725- 1735 (1996).

[4] P. Devgan, "*A Review of Optoelectronic Oscillators for High Speed Signal Processing applications*", Hindawi Publishing Corporation, 1-16, (2013).

[5] P.H. Merrer, H. Brahimi & O. Llopis, "*Optical techniques for microwave frequency stabilization: resonant versus delay line approaches and related modelling problems*", Conference Paper, (2008).

[6] J. Lasri, P. Devgan, R. Tang& P. Kumar, "*Self-starting optoelectronic oscillator for generating ultra-low-jitter high-rate (10GHz or higher) optical pulses*", Opt. Soc. Am.**11**,1430-35(2003).

[7] D. Eliyahu, K. Sariri, J. Taylor & L. Maleki, "*Optoelectronic oscillator with improved phase noise and frequency stability*", SPIE **4998**, 139-147 (2003).

[8] X. S. Yao, L. Maleki, Y. Ji, G. Lutes& M. Tu, "*Dual-loop opto-electronic oscillator*", Jet Propulsion Laboratory (2005).

[9] T. Banky, B. Horváth& T. Berceli, "*Optimum configuration of multiloop optoelectronic oscillators*", J. Opt. Soc. Am. B **23**, 7, 1371-80 (2006).

[10] E. Shumakher, "*A Novel multiloop optoelectronic oscillator*", IEEE Photonics Tech Lett., **22**, 1881-83 (2008).

[11] J. Yang, Y. Jin-Long, W. Yao-Tian, Z. Li-Tai &Y. En-Ze, "*An Optical Domain Combined Dual-Loop Optoelectronic Oscillator*", IEEE Photonics Tech Lett., **19**, 11 (2007).

[12] W. Zhou & G. Blasche, "*Injection-Locked Dual Opto-Electronic Oscillator with Ultra-Low Phase Noise and Ultra-Low Spurious Level*", IEEE TRANSACTIONS ON MICROWAVE THEORY AND TECHNIQUES, **53**, 3 (2005).

[13] O. Okusaga, E. J. Adles, E. C. Levy, W. Zhou, G. M. Carter, C. R. Menyuk& M. Horowitz, *Spurious mode reduction in dual injection-locked optoelectronic oscillators*, Optical Society of America **19**, 7 (2011).

[14] X. S Yao & L. Maleki, "*Dual microwave and optical oscillator*", Optical Letters **22**, 1867-1869 (1997).

[15] X. S Yao, Larry Davis & L. Maleki, "*Coupled optoelectronic oscillator for generating both RF signal and optical pulses*", Journal of Lightwave Technology, **18**, 1, 73-78 (2000).

[16] Y. Ji, X. S. Yao & L. Maleki, "*A high-Q millimeter-wave dielectric-resonator bandpass filter using whispering-gallery modes*", TMO Progress Report, **42**, 1-11 (2000).

[17] A. B. Matsko, L. Maleki, A. A. Savchenkov& V. S. Ilchenko, "*Whispering gallery mode based optoelectronic microwave oscillator*", Journal of Modern Optics, **50**, 2523-2542 (2003).

TERM PAPER TITLES & SUPERVISORS OF FIRST BATCH STUDENTS, 2019, CDP, TU (1)

Name of Student	TERM PAPER TITLE	Advisors
Ajay Sakya	A STUDY OF VERTICAL TEMPERATURE PROFILE AND ATMOSPHERIC STABILITY OVER KIRTIPUR AREA	Prof. Dr. Ram Prasad Regmi
Alisha Budhathoki	A STUDY OF SOLAR A RENEWABLE SOURCE OF ENERGY	Dr. Madhav Pd Ghimire
Amit Kumar Sah	ERRORS IN NUMERICAL INTEGRATION METHODS	Prof. Dr. N. P Adhikari
Anil Yadav	STUDY THE BACKGROUND RADIATION AT THE DIFFERENT PLACES OF KIRTIPUR MUNICIPALITY	Prof. Dr. Binil Aryal
Arun Kumar Sah	A STUDY OF WIND ROSE PLOT AND STATISTICAL DISTRIBUTION OF WIND OVER KIRTIPUR AREA	Prof. Dr. Ram Prasad Regmi
Babita Gyawali	SEISMIC SITE CHARACTERIZATION OF KATHMANDU VALLEY (TILGANGA SITE) USING GROUND RESPONSE ANALYSIS	Dr. Gopi C. Kaphle
Baburam Sapkota	THE STUDY OF NOISE LEVEL IN KATHMANDU CITY	Prof. Dr. Ishwar Koirala
Balram Regmi	THE STUDY OF ELECTRICAL SAFETY PRACTICES IN KATHMANDU	Dr. Gopi C. Kaphle
Bandana Shrestha	FOOD ADULTERATION STUDY ON MILK ADULTERATION	Dr. Balram Ghimire
Basanta Acharya	ELECTRICITY RELATED SAFETY KNOWLEDGES AND PRACTICES: A CASE STUDY	Dr. Gopi C. Kaphle
Basdev Yadav	FLUXONS IN THIN – FILM SUPERCONDUCTOR-INSULATOR SUPERLATTICES: A REVIEW	Dr. Balram Ghimire
Bhisma S. Joshi	POSSIBILITY OF SOLAR WATER PUMPING SYSTEM IN MALIKARJUN-7 SHREEPUR	Dr. Madhav Pd Ghimire
Bhuwan Poudel	STABILITY ANALYSIS OF THE REALWORLD PROBLEM: UNEMPLOYMENT	Prof. Dr. N. P Adhikari
Bibek Subedi	CRITICAL EXPONENTS OF SUPERCONDUCTIVITY: REVISITED	Prof. Dr. N. P Adhikari
Bidya Wagle	SEISMIC SITE CHARACTERIZATION INSIDE KATHMANDU VALLEY USING GROUND RESPONSE ANALYSIS	Dr. G. C. Kaphle
Bikalpa Lamsal	STUDY OF ENROLLMENT OF PHYSICS STUDENTS IN CENTRAL DEPARTMENT OF PHYSICS (CDP) FROM COLLEGES OF KATHMANDU VALLEY	Dr. Gopi C. Kaphle
Bikash Sapkota	VAN DER WAALS INTERACTION IN INERT GASES: A REVIEW	Dr. Nurapati Pantha
Binay K Mahato	A STUDY OF WIND ROSE PLOT AND STATISTICAL DISTRIBUTION OF WIND OVER KIRTIPUR AREA	Dr. Ram Prasad Regmi
Bishnu Karki	ANALYSIS OF DOSIMETRIC DATA OF B.P. KOIRALA MEMORIAL CANCER HOSPITAL BETWEEN 2013-2015	Dr. Madhav Pd Ghimire
Bishnu Pd Belbase	ANALYSIS OF DOSIMETRIC DATA OF B.P. KOIRALA MEMORIAL CANCER HOSPITAL BETWEEN 2013-2017	Dr. Madhav Pd Ghimire
Chianjibi Shrestha	TO STUDY BOUNDARY LAYER HEIGHT ESTIMATION OVER KIRTIPUR, KATHMANDU	Prof. Dr. Ram Prasad Regmi
Devraj KC	A STUDY OF VERTICAL WIND SHEAR-TURBULENCE OVER KIR-TIPUR AREA	Prof. Dr. Ram Prasad Regmi
Dhruba Raj Jaishi	POSSIBILITY OF SOLAR WATER PUMPING SYSTEM IN BAJURA	Dr. Madhav Pd Ghimire
Dipendra K Raut	STUDY OF ENROLLMENT OF PHYSICS STUDENTS IN CENTRAL DEPARTMENT OF PHYSICS FROM DIFFERENT PARTS AND DISTRICTS OF NEPAL	Dr. Gopi C. Kaphle
Ependra Tamang	STUDENTS' ENROLLMENT IN CENTRAL DEPARTMENT OF PHYSICS (CDP) FROM DIFFERENT PARTS AND COLLEGES OF NEPAL	Dr. Gopi C. Kaphle

Is Life Possible on Mars?

Manoj Kumar Shrestha
Third Semester, M.Sc. (Physics), CDP, TU, Kirtipur

ABSTRACT

After the Earth, the Red Planet, Mars is the most studied planetof the solar system. This planet is said to be similar as earth in many aspects, made everyone more curious about Mars. The most important facts on the Earth for living beings are liquid water, warm temperature, oxygen, carbon dioxide, the sunlight and the Earth's gravity etc. We believe that no living beings, including us, can exist on Earth without these things. The research and observations over the decades show that there is the possibility of life on Mars. There are many signsand signals sent back by spacecraft from the surface of Mars. These signs make everyone believe that once there were human civilizations on Mars. The channels on the surface of Mars show that there were rivers and seas on Mars.

What is the truth?

This article is prepared for providing the truth.

1. How the surface of Mars actually looks like?
2. How are the surface temperature and atmosphere of Mars?
3. Is the climate on Mars surface suitable for living beings?
4. Is there exist liquid water on Mars surface?
5. If Mars surface is not habitable for living beings, then what are the reasons behind being inhabitable?

All these questions are answered in a precise way through this article. It is hoped that this article will be useful to gain additional knowledge of the Mars and evidencesfor possibility of life.

Introduction

Mars is the 4th planet of the solar system. It is small and rocky body once thought to be asearthlike. The red planet is named by Romans after their god of war. There are three landers and rovers on the surface of Mars i.e. Phoenix, Opportunity and Curiosity and functional spacecraft in the orbit i.e. Mars Odyssey, Mars Express, Mars Reconnaissance Orbiter. The spacecraft has sent back incredible detailed images of the surface of Mars and helped to discover that there was once liquid water on Mars surface.

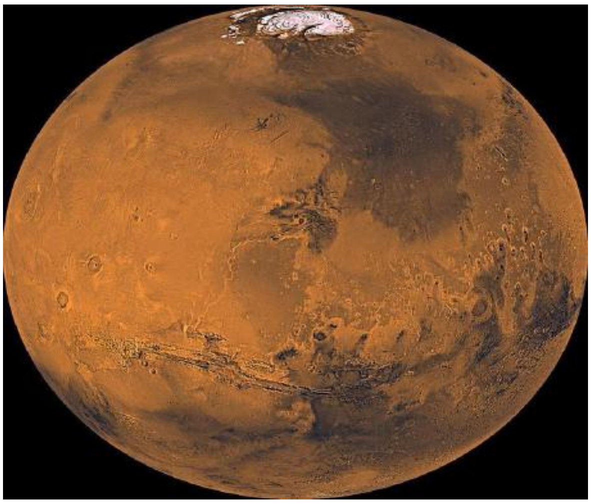


Figure1:*Mars picture by taken Viking 9 Mission.*

Among eight planets in the solar system, Mars is the second smallest planet after Mercury. Due to its reddish appearance, Mars is most visible in the night sky every couple of years, when it is the planet closest to us. The bright rust color of Mars is known for its iron-rich minerals, the loose rock and dust covering its surface. According to NASA, the iron minerals oxidizes or rust causing soil to look red.

Surface Structure:-

Mars has many geological features on its surface, that first became apparent with Mariner 9, were subsequently studied by the Viking missions and many of which now are visible from the Hubble Space Telescope. The red planet is home for both highest mountains and deepest and longest valleys. Olympus Mons is roughly 27 km high, about three times taller than the Mount Everest of the Earth. In solar system, Mars has the largest volcanoes, including Olympus Mons which is 600 km in diameter and wide enough to cover the entire State of New Mexico. It is a shield volcano created by eruption of lavas that flowed for long distance before solidifying. Mars also has many other kind of volcanic landforms from small steep sided cones to enormous plains coated in hardened lava. Some minor eruptions still occur on the planet.

The Valles Mariner is formed mostly by rifting of the crust as it got stretched. Individual canyons within the system are as much as 100 km wide. They merge in the central region of the Valles Mariner in a region as much wider as 600 km. large channels emerging from the ends of some canyons and layered sediments suggest that the canyons might once have been filled with liquid water. Such channels and Valles are found all over the surface of Mars. Many regions of Mars are flat and low-lying plains.The lowest of the northern plains are among the flattest and smoothest places in the solar system, potentially created by water that believed to once flow across the Martian surface.

Orbital Characteristics

The axis of Marsis tilted at 25o angle relative to the Sun. This means the amount of sunlight falling on certain parts of the planet can vary widely during the year, giving Mars seasons. However, the seasons that Mars experiences are more extreme than earth's because the red planet's elliptical and oval shaped orbit around the Sun is more elongated then that of any other major planets. When Mars is closest to the Sun, its southern hemisphere is tilted towards the Sun giving it a short and very hot summer while the northern hemisphere experiences a short and cold winter. When Mars is farthest from the Sun, the northern hemisphere is tilted towards the Sun giving it a long and mild summer while the southern hemisphere experiences a long and cold winter. These are the facts how the seasons change on the surface of Mars. Just like the Earth, Mars has four seasons. The seasons vary in length because of Mars's eccentric orbit around the Sun. In northern hemisphere, spring is the longest season at seven months, summer and fall are both about six months long while winter is only four months long.

Polar Caps

The vast deposits of finely layered stacks of frozen carbon dioxide, trace of water vapor and dusts extend from the poles to latitudes of about 80 degrees in both hemispheres are called polar caps. On the top of this, much of the layered deposits in both hemispheres are caps of water ice that remain frozen all year around.

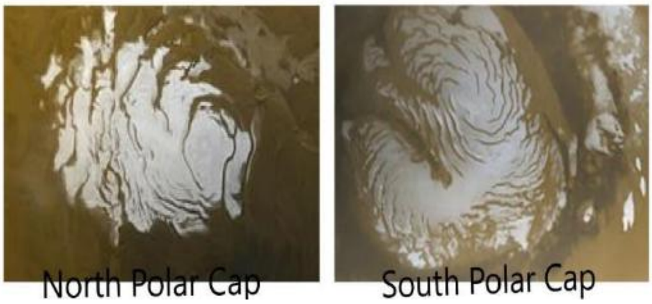


Figure2: *Polar Caps of Martian surface*

Additional seasonal caps of frost appear in the winter time. These are made up of solid carbon dioxide (CO2), also known as dry ice which is the condensed form of CO2 gas in the atmosphere and in the deepest part of winter. The dry ice layer appears to have fluffy features such as freshly fallen snow (according to the report in the Journal of Geographical Research- planets). Polar caps on both hemisphere look like white and bright layers covering the poles.

Mars Atmosphere and its Composition

Atmosphere of Mars is the layer of gases surrounding the planets. It is mostly composed of carbon dioxide gas at about 95.97%. The atmospheric pressure of Mars surface averages 600 Pascal (about 0.6 % of Earth's mean sea level atmospheric pressure of 1.013*105Pascal). The Mars atmosphere mainly consists of the following gases:
Each pole is in continual darkness during its hemispheres' winter and the surface gets cold that as much of 25% of the atmospheric CO2 condenses at the polar caps into solid CO2 ice i.e. dry ice. When the poles are again exposed to sunlight during summer, the CO2 ice sublimes back into the atmosphere.

Gases	% compositions
1. Carbon dioxide (CO2)	95.9700
2. Argon (Ar)	1.9300
3. Nitrogen (N2)	1.8900
4. Oxygen (O2)	1.1460
5. Carbon monoxide (CO)	0.0557

This process leads to a significant annual variation in the atmospheric pressure and atmospheric composition around the poles. The atmospheric layer on surface of Mars is very thin and dry.

Surface Temperature and Climate

- The temperature measuredby two Viking Landers at 1.5 m above the surface of Mars ranges from -107o C to -17.2o C. However, the temperature of the surface at winter polar caps drop to -143o C while the warmest soil occasionally reaches to 27o C as estimated from Viking Orbiter Infrared Thermal Mapper.

- The Martian climate is regulated by seasonal changes that affect the release of Carbon dioxide from Polar ice caps. Wind patterns that stir up from the planetary surface also produce widespread cooling. Martian dust storms play a large role in regulating the climate and grow in size until they encompass the entire planet. Colder regions of Mars even experience snow, although the flakes are composed of frozen carbon dioxide rather than water.

- Mars is smaller than Earth, and lacks the planetary magnetosphere needed to protect its atmosphere from the solar winds that strip away atoms and lowers atmospheric densities. With such an atmosphere only 1% as dense as Earth's, Mars is unable to retain much heat at the planetary surface. Although its distance from the Sun creates a much colder global climate than Earth's, temperature at equator can still reach as high as 13.57^{o} C.

Evidence and Possibility of Water

Before about 3.8 billion years, Mars had a denser atmosphere, higher surface temperature allowing vast amounts of liquid water on the surface, possibly including a large oceans that might have covered one-third of the planet. After that, it was found that the surface of Mars periodically wet and could have been hospitable to microbial life billions of years ago.

Early telescopic observations correctly assumed that the white polar caps and clouds were indications of water's presence. For many years, the dark regions visible on the surface were interpreted as oceans. By the start of 20th century, most of the astronomers recognized that Mars was far drier and colder than Earth. Thus, the presence of water was no longer accepted. In 1971, Mariner 9 spacecraft caused a revolution in our idea about the presence of water on Mars. Images showed that the floods of water broke through dams, carved deep valleys, eroded grooves into bedrocks and travelled thousands of kilometers on the surface. Areas of branched streams in the southern hemisphere suggested that rain once fall.

Figure 3: *Predictions about water in different times (b.y.a- billions years ago).*

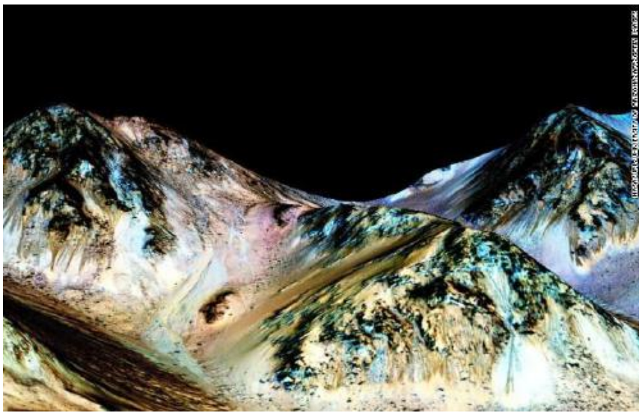


Figure 4: *Evidence of water on Mars/NASA*

A variety of lake basins have been discovered on Mars, some are comparable in size to largest lakes on Earth such as the Caspian Sea, Black Sea and the Lake Baikal. Research in 2010 suggested that Mars also had lakes along parts of its equator. Using detailed images from NASA's Mars Reconnaissance Orbiter, researchers speculate that there may have been increased volcanic activity, meteorites impacts or shift in Mars orbit which warms atmosphere enough to melt the ice present in the ground.

When Phoenix landed on Martian surface, the astronomers observed that the retrorockets splashed soil and melted ice into the vehicle. It confirmed the existence of large amounts of water ice in the northern region of Mars. Although having all these evidences of existence of water on Mars surface today. Due to the low temperature, thin atmosphere and low pressure, water on the surface of Mars exist in the form of ice. Small amount of water also exist in the form of vapor in the Martian atmosphere. Some liquid water transiently occurs on the Martian surface today, but only under certain conditions. No large standing bodies of liquid water exist because the atmospheric pressures at the surface averages just 600 Pascal (about 0.6% of Earth's mean sea level pressure) and average temperature is too low i.e. about -62^o C leading to rapid freezing of water.

Comparison between Earth and Mars

Figure 5: *Size of Earth & Mars/NASA*

Compared to the Earth, Mars is a pretty small, dry, cold and dusty planet. Mars has comparatively low gravity and thin atmosphere. When it comes to the surfaces of Earth and Mars, things again become a case of contrasts. As Earth seems to be Blue planet and Mars seems to be Red planet as their names suggest. Though Mars appears red, it is very cold planet rather than being hot one. About 75% of Earth's surface is covered by water whereas same area of Mars is covered by ice, dust and iron oxide-rich materials. Ice water exist beneath the Martian surface. The surface temperature of Mars ranges from -143^o C during winter at the poles to 35^o C during summer at the equator. Average surface temperature on Earth is 14^o C while that on Mars surface is -62^o C. These information shows that Mars surface is much colder than Earth surface. Percentage composition of gases in Earth's and Mars's atmospheres is given in the following table.

Gases / Planets	N_2 %	Ar %	O_2 %	CO_2 %	CO %
Earth	98.08	1.93	20.95	0.038	0.040
Mars	1.89	0.93	.146	95.97	0.0557

Other differences between Earth and Mars are shown in following table:

Table 2: Table showing differences between Earth & Mars

Differences		
Aspects	**Earth**	**Mars**
1. Mean radius	6.371 x 10^3 km	3.389 x 10^3 km
2. Mass	5.97x10^{24} kg	6.417 x 10^{23} kg
3. Surface area	5.101 x10^8 km^2	1.448 x 10^8 km^2
4. Mean Density	5.514 g/cm^3	3.933 g/cm^3
5. Surface gravity	9.89 m/s^2	3.711 m/s^2
6. Escape velocity	11.2 km/s	5.27 km/s
7. State of water	Mostly in liquid	Mostly in ice
8. Atmospheric gas components	N_2, O_2, Ar, CO_2, H_2O vapor.	CO_2, Ar, N_2, O_2, CO & trace of H_2O vapor.
9. Satellites	The moon	Phobos& Deimos

Habitability and Possibility of Life

In many aspects, Mars is comparable to Earth. Mars could have once harbored life. By 1996, some complex organic molecules, grains of minerals called magnetite (that can be formed within some kind of bacteria) and tiny structures that resembled fossilized microbes were claimed to be found. Also, recently it is believed that there is possibility of Methane gas. However, these claims became controversial and there is no consensus as to whether they are signs of life. Mars has possessed oceans on its surface in the past providing an environment for life to develop. Although the red planet is cold desert today, it is assumed that liquid water may present underground providing a potential for any life that light still exist there. Above table also suggests that life on Mars is not possible with respective to its atmosphere. For life to exist on Mars, its temperature, atmospheric composition and light energy are expected to be similar as those on Earth. There is no liquid water on the surface of Mars. There is no sufficient oxygen gas necessary for breathing. The surface is so dry and cold that no living beings can adjust themselves on the planet.

Future Mars Missions

Roberts are not only the one looking to buy tickets to Mars. A workshop group of government, academic and industrial scientists have found that NASA led manned mission to Mars should be possible by the 2030. But NASA is not the only one with Martian Astronaut hopefuls.

Figure 6: *Rover Curiosity on Mars surface/NASA*

The Mars One Colony project is preparing to send private citizen on a one way trip to red planet. Today, two NASA's spacecraft Opportunity and Curiosity missions are on the surface of Mars. They are investigating the new facts about life on Mars. The spacecraft are sending clear images of Mars surface.After the successful landing of Curiosity on Mars surface in 2012, NASA has announced plans for a new robotic science rover set to launch on 2020. The proposed 2020 rover mission is parts of NASA's Mars Exploration Program, a long-term effort of robotic exploration of the red planet. Designed for advance high-priority science goals Mars exploration, the mission would address the key questions about the potential for life on Mars.

Mars Oneis a non-profit foundation with the goals of establishing a permanent human settlement on Mars. To prepare for this settlement, the first unmanned mission is scheduled to depart 2020. Crews will depart for the one-way journey to Mars starting 2026; subsequent screws will depart 26 months after the initial crew has left for Mars. Mars One is a global initiative aiming to make this everyone's mission to Mars.

Figure 7: *Mars One*

Conclusion:

On the surface of Earth, there are many places such as Antarctica continent near South Pole, Arctic region near North Pole and different desert lands which are not habitable due to inappropriate pressure, temperature and unavailability of liquid water. The research and observations show same problems in case of Mars surface. Due to low gravity the atmosphere is very thin. Due to thin atmosphere and far distant from sun, surface temperature is very low. Due to low temperature, there is no liquid water available on surface Mars. For existence of living beings on Mars, the planet must have liquid water, suitable temperature and breathable air on atmospheres as in the Earth. These lacks of liquid water, breathable air and adjustable temperature on Mars surface are showing that there is no possibility of life on Mars today. Different space agencies, such as Canadian Space Agency Canada; Arno Wielders- Mission Mars One and National Aeronautics & Space Administrations-NASA's Mars mission rovers Opportunity and Curiosity are still investigating to find out detailed information about life on Mars. Right now, we can just hope that these investigations will bring the real truth of life on Mars very soon.

References

[1] https://en.wikipedia.org/wiki/Life_on_Mars (Dec 2018).
[2] T. Sharp, "*Mars, Atmosphere: Composition, Climate & Weather*" Springer (2017).
[3] E. Howell; "*Mars Curiosity: Facts and Information*", Space.com, July-17 (2018).
[4] https://space-facts.com/mars/(Dec 2018).
[5] Redd, Nola Taylor, "*Water on Mars: Exploration & Evidence*", Space.com, November-18 (2018).
[6] https://en.wikipedia.org/wiki/Water_on_Mars (Dec 2018).
[7] Brady, Hillary, "*Today, Mars is warmer than Earth. See how we compare.*", Digital Experience, January-5 (2018).
[8] https://www.space.com/17135-life-on-mars.html (Dec 2018).
[9] L. W. Lee, "*Similarities & Differences in Mars & Earth.*", April-21 (2018).

[10] https://sciencing.com/similarities-differences-mars-earth-8425570.html (Dec 2018).
[11] https://www.nasa.gov/mission_pages/mars/images/index.html (Dec 2018).
[12] https://www.shutterstock.com/search/mars (Dec 2018).
[13] http://www.differencebetween.info/difference-between-earth-and-mars (Dec 2018).
[14] https://www.space.com/16907-what-is-the-temperature-of-mars.html (Dec 2018).
[15] www.nasa.gov/press/release (Dec 2018).
[16] www.universetoday.com/2263/mars (Dec 2018).
[17] www.space.com (Dec 2018).

TERM PAPER TITLES & SUPERVISORS OF FIRST BATCH STUDENTS, 2019, CDP, TU (2)

Name of Student	TERM PAPER TITLE	Advisors
Ganesh Shrestha	COMPARISON BETWEEN ELECTRIC INDUCTION & HEATER	Prof. Dr. Ishwar Koirala
Ganesh Subedi	COMPARATIVE STUDY OF ENERGY CONSUMPTION BY VARIOUS COOKTOPS IN THE KITCHEN	Prof. Dr. Ishwar Koirala
Gopi Mahato	TO STUDY THE NOISE LEVEL IN BHAKTAPUR DISTRICT	Prof. Dr. Ishwar Koirala
Hari Pokharel	REVIEW OF SECOND QUANTIZATION AND IT'S APPLICATION IN WEAK INTERACTING FERMION SYSTEM	Dr. Gopi C. Kaphle
Janak Basel	STUDY OF THE PRESSURE-TUNED MOTT INSULATOR TO METAL TRANSITION	Dr. Nurapati Pantha
Jeevan Shrestha	APPLICATIONS OF COMPUTATION PHYSICS IN SPHERICAL BESSEL FUNCTION	Dr. G. C. Kaphle
Kamal Khanal	A REVIEW STUDY OF MOTT_METAL INSULATOR PHASE TRANSITION UNDER VARYING TEMPERATURE	Dr. Nurapati Pantha
Kamal Khatiwada	AN OVERVIEW OF VAN DER WAALS INTERACTION IN HYDROGEN AND INERT GASES	Dr. Nurapati Pantha
Keshab Subedi	APPLICATION OF COMPUTATIONAL PHYSICS IN BASSEL FUNCTION	Dr. Gopi C. Kaphle
Kisan Khatri	TO ESTIMATE THE GLOBAL SOLAR RADIATION AT POKHARA VALLEY, NEPAL	Prof. Dr. K. N. Poudel & Dr. Nurapati Pantha
Kishor Sijapati	WIND POWER POTENTIAL AT DIFFERENT COMMERCIAL HEIGHT OVER KIRTIPUR	Prof. Dr. Ram Prasad Regmi
Krishna Bd Khadka	WIND POWER POTENTIAL AT DIFFERENT COMMERCIAL HEIGHT OVER KIRTIPUR AREA	Prof. Dr. Ram Prasad Regmi
Laxmi Bhurtal	DISTRIBUTION OF RADIUM-226 IN SOIL AT VARYING DEPTH USING GAMMA SPECTROSCOPY	Prof. Dr. Raju Khanal
Madan Somai	EGGS LAYING PATTERN BY LAYERS HEN USING DIFFERENT GENERA MUSIC	Prof. Dr. Ishwar Koirala
Madhav Pokharel	THE STUDY OF NOISE LEVEL IN LALITPUR CITY	Prof. Dr. Ishwar Koirala
Mahesh Aryal	VARIATION OF CESIUM-137 IN SOIL WITH DEPTH USING GAMMA SPECTROMETRY	Prof. Dr. Raju Khanal
Nagendra Bd Karki	PHASE SPACE TRAJECTORY OF LINEAR HARMONIC OSCILLATOR	Prof. Dr. N. P Adhikari
Neelima Sharma	STUDY OF MAGNETIC LEVITATION USING NEURAL NETWORK	Prof. Dr. Raju Khanal & Dr. Madhav Pd Ghimire
Niraj Kumar Sah	REAL-TIME TRAFFIC ANALYSIS AND PREDICTION USING MONTE CARLO SIMULATION	Dr. Gopi C. Kaphle
Nirmal Saud	POSSIBILITY OF SOLARWATER PUMPING SYSTEM EFFICIENT FOR IRRIGATION IN RURAL AREA OF KAILALI DISTRICT AND RUPANDEHI	Dr. Madhav Pd Ghimire
Philemon Pun	A BRIEF STUDY OF EARTHQUAKE AND ITS DATA ANALYSIS OF NEPAL	Prof. Dr. Binil Aryal
Pradip Tiwari	APPLICATION OF FOURIER TRANSFORM IN BIO-MEDICAL FIELD	Dr. Gopi C. Kaphle
Pramila K Pokhrel	REVIEW OF SECOND QUANTIZATION AND ITS APPLICATION IN TIGHT BINDING MODEL AND MOTT TRANSITION	Dr. Gopi C. Kaphle
Pramod Subedi	A STUDY OF VERTICAL TEMPERATURE PROFILE AND ATMOSPHERIC STABILITY OVER KIRTIPUR AREA	Prof. Dr. Ram Prasad Regmi
Prashrit Baruwal	ANALYSIS OF SOLAR WIND PARAMETERS ON MARTIAN UPPER-ATMOSPHERE USING MAVEN's DATASET	Prof. Dr. Binil Aryal
Prem Chaudhary	BOUNDARY LAYER HEIGHT ESTIMATION OVER KIRTIPUR AREA USING VERTICAL TEMPERATURE PROFILE FROM SODAR-RASS	Dr. Ram Prasad Regmi
Prena Chaudhary	BAND STRUCTURE CALCULATIONS USING PSEUDOPOTENTIALS APPROACH	Dr. Gopi C. Kaphle
Puja Thapa	REVISITED OF CRITICAL EXPONENTS OF HOLOGRAPHIC SUPERCONDUCTOR	Prof. Dr. N. P Adhikari
Ram K Adhikari	CRITICAL PHENOMENA IN FLUIDS	Prof. Dr. N. P Adhikari
Ramesh Nath Yogi	A STUDY OF VERTICAL WIND SHEAR AND TURBULENCE OVER KIRTIPUR AREA	Dr. Ram Prasad Regmi
Ramila Khatiwada	ERRORS IN ROOT FINDING METHODS	Prof. Dr. N. P Adhikari
Rishi R Rana Bhat	LOGISTIC MAP: REVISITED	Prof. Dr. N. P Adhikari
Rishi Ram Gyawali	A PHASE TRANSITION OF STOCK MARKETS AND IT'S CRASHES: AN ANALOGY WITH PHASE TRANSITION OF WATER	Dr. Nurapati Pantha
Sagar Rawal	THESIS AND STUDENT RECORD MANAGEMENT SYSTEM	Prof. Dr. Binil Aryal

Solution of Schrodinger equation evolve with Time-dependent Perturbation

Shiva Bhandari
Fourth Semester, M.Sc. (Physics), CDP, TU, Kirtipur

ABSTRACT
Time-dependent perturbation theory is the approximation method treating Hamiltonians that depends explicitly on time. It is most useful for studying process of absorption and emission of radiation by atoms or, more generally, for treating the transitions of quantum systems from one energy level to another energy level..

Introduction

We have dealt so far with Hamiltonian that do not depend explicitly on time. In nature, however most of the quantum phenomena are governed by time dependent Hamiltonian. The general solution of Schrodinger equation involving time dependent perturbation can be presented in compact and manageable form for periodic & non-periodic perturbation. On the basis of the solution of Schrodinger equation involving time-dependent perturbation probability for various process including the interaction of electromagnetic field with matter can be calculated.

The most satisfactory time-dependent perturbation theory is the method of variation of constraints developed by Dirac. This is basically the power expansion in term of the strength of the perturbation just as the Rayleigh-Schrodinger perturbation theory in case of the time dependent perturbation. Method of variation of constant is useful only when the perturbation is weak. If the perturbation is strong then we must perform up to higher term. However, in practice this is impossible & the result may diverge. This technique is particularly useful for the clarification of resonance or transition phenomena of the system due to interaction with external perturbation

Mathematical formulation

Let us consider the physical system with an (unperturbed) Hamiltonian H_o, the eigenvalue and eigenfunction is denoted by E_n& $|\Phi_n\rangle$ for the simplicity we assumed H_0 to be discrete and non-degenerate

$H_0\ \Phi_n\rangle = E_n|\Phi_n\rangle$ (1)

At $t = 0$, a small perturbation of the system is introduced so that the new Hamiltonian is:

$H(t) = H_0 + \lambda\hat{W}(t)$

Where λ is real dimensionless parameter and which much less than 1. The system is assumed to be initially in the stationary state $|\Phi_i\rangle$, an eigenstate of H_0 of eigenvalue E_i.Starting at t = 0 when the perturbation is applied, system evolves and can be found in different state. Between times 0 and t the system evolves in accordance with Schrodinger equation:

$i\hbar\frac{d\psi(t)\rangle}{dt} = [H_0 + \lambda\hat{W}(t)]\psi(t)\rangle$ (2)

The solution of $\psi(t)\rangle$ is first order differential equation which corresponds to initial condition $\psi(t = 0)\rangle =$ $\Phi_n\rangle$ is unique. The probability of finding the system in another eigenstate

$|\Phi_f\rangle$ is, $P_{if}(t) = \langle\Phi_f|\psi(t)\rangle|^2$ (3)

Let $C_n(t)$ be the component of the ket $\psi(t)\rangle$ in the $\{\Phi_n\rangle\}$ basis then

$\psi(t)\rangle = \sum C_n(t)\{\Phi_n\rangle\}$ (4)

with $C_n(t) = \langle\Phi_n|\psi(t)\rangle$

The closer relation is:

$\sum_n|\Phi_n\rangle\langle\Phi_n| = 1$ (5)

Projecting both sides of equation (2) onto $\Phi_n\rangle$

$i\hbar\frac{\frac{d}{dt}\langle\Phi_n|\psi(t)\rangle\rangle}{\sum_n\Phi_n\rangle\frac{dC_n(t)}{dt}} = H_0 + \lambda\hat{W}(t)\sum C_n\{\Phi_n\rangle\}$

$i\hbar\sum_n\Phi_n\rangle\frac{dC_n(t)}{dt} =$
$\sum_{k,n}|\Phi_n\rangle\langle\Phi_n|H_0|\Phi_k\rangle + \lambda\sum_{k,n}\Phi_n\rangle\langle\Phi_n|\hat{W}(t)\Phi_k\rangle C_k(t)$

$i\hbar\sum_n\Phi_n\rangle\frac{dC_n(t)}{dt} =$
$\sum_{k,n}\Phi_n\rangle E_k\langle\Phi_n|\Phi_k\rangle + \lambda\langle\Phi_n|\hat{W}(t)|\Phi_k\rangle C_k(t)$

$i\hbar\sum_n\Phi_n\rangle\frac{dC_n(t)}{dt} = \sum_{k,n}\Phi_n\rangle E_k\delta_{nk} + \lambda\langle\Phi_n|\hat{W}(t)|\Phi_k\rangle C_k(t)$

$i\hbar\sum_n\Phi_n\rangle\frac{dC_n(t)}{dt} = \sum_{k,n}\Phi_n\rangle E_k C_n(t) +$
$\lambda\sum_k\langle\Phi_n|\hat{W}(t)|\Phi_k\rangle C_n(t)\}$

$i\hbar\frac{dC_n(t)}{dt} = E_n C_n(t) + \lambda\sum_k\langle\Phi_n|\hat{W}(t)|\Phi_k\rangle C_n(t)$

$i\hbar\frac{dC_n(t)}{dt} = E_n C_n(t) + \lambda\sum_k\hat{W}_{nk}(t)C_k(t)$ (6)

Here $\hat{W}_{nk}(t)$ denote the matrix element of observable $\hat{W}(t)$ in the $\{\Phi_n\rangle\}$ basis.

When λ $\hat{W}(t)$ is zero, equation (5) is no longer coupled and their solution are very simple it can be written as:

$C_n(t) = b_n e^{\left(\frac{-E_n t}{\hbar}\right)}$ (7)

where b_n is the constant depend on the initial condition.

For the nonzero perturbation we look the solution of the form,

$C_n(t) = b_n(t)e^{\left(\frac{-Ent}{\hbar}\right)}$ (8)

Then from equation (5)

$i\hbar e^{\left(\frac{-Ent}{\hbar}\right)}\frac{db_n(t)}{dt} + E_n\ b_n(t)e^{\left(\frac{-Ent}{\hbar}\right)} = E_n b_n(t)e^{\left(\frac{-Ent}{\hbar}\right)} +$
$\lambda\sum_k\hat{W}_{nk}(t)b_k(t)e^{\left(\frac{-Ent}{\hbar}\right)}i\hbar\frac{db_n(t)}{dt} =$
$\lambda\sum_k\hat{W}_{nk}(t)b_k(t)e^{i\omega_{nk}t}$ (9)

where $\omega_{nk} = \frac{E_n - E_k}{\hbar}$ is the Bohr angular frequency.

This equation is rigorously equivalent to Schrodinger equation. In general, we do not know how to find its exact solution. We look for the solution in the following form:

$b_n(t)=\sum_{q=0}^{\infty}\lambda^q b_n^{(q)}(t)$ (10)

[1] Using equation (9) in (8).

$i\hbar\sum_{q=o}^{\infty}\lambda^q \frac{db_n^{(q)}(t)}{dt} = \sum_{q=0}^{\infty}\sum_k \lambda^{q-1} e^{i\omega_{nk}t}\hat{w}_{nk}(t)b_k^{(q)}(t)$

If we set equal the coefficients of λ^q on both side of the equation we find:

For 0^{th} order:

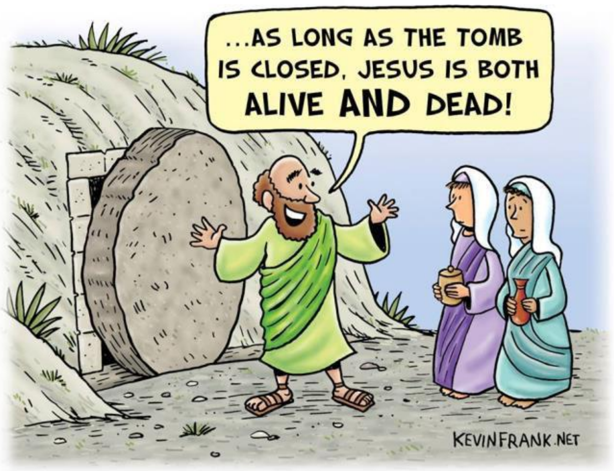
$i\hbar\frac{db_n^{(0)}(t)}{dt}=0$ (11)

Thus, if λ is zero $b_n(t)$ reduces to constant.

For higher order:

$i\hbar\frac{db_n^{(q)}(t)}{dt}=\sum_k e^{i\omega_{nk}t}\hat{w}_{nk}(t)b_k^{(q-1)}(t)$ (12)

Thus,we see that, with the zeroth-order solution determined by above equation and the initial condition this equation enable us to find the first-order solution.



Saint Schrodinger, the forgotten disciple.

Figure 1: *On probability and deterministic [6].*

Then we also find the second-order solution in terms of first one. Since at t < 0 system is in the initial state $\Phi_i\rangle$therefore, $b_n^0(t=0)=\delta_{ni}$. This relation is valid for all λ. Consequently, the coefficient of the expansion of$b_n(t)$ must satisfy.

$b_n^0(t=0)=\delta_{ni}$and $b_n^{(r\geq 1)}(t=0)=0$

Thus equation (10) immediately yields, for all positive t that,

$b_n^0(t)=\delta_{ni}$which completely determined the zeroth-order solution. This permits us to write equation (11) for r =1 in the form:

$i\hbar\frac{db_n^{(1)}(t)}{dt}=\sum_k e^{i\omega_{nk}t}\hat{w}_{nk}(t)b_k^{(0)}(t)$

$i\hbar\frac{db_n^{(1)}(t)}{dt}=\sum_k e^{i\omega_{nk}t}\hat{w}_{nk}(t)\delta_{ki}=e^{i\omega_{rt}t}\hat{w}(t)$ (13)

Then, we find the solution:

$b_n^{(1)}(t)=\frac{1}{i\hbar}\int_0^t e^{i\omega t'}\,\hat{w}_{nk}(t')d(t')$ (14)

Transition probability $P_{if}(t)$ is equal to $|c_f(t)|^2$,since $b_f(t)$ and $c_f(t)$ have the same modulus

$P_{if}(t)=|b_f(t)|^2$ where $b_f(t)=b_f^{(0)}(t)+\lambda b_f^{(1)}(t)+\ldots\ldots$

Hence the probability of finding the system in the state 'f ' after time t (f ≠ i) is:

$P_{if}(t)=\left|\lambda b_f^{(1)}(t)\right|^2$ (15)

Replacing $\lambda\hat{W}(t)$ by W(t) we finally obtained:

$P_{if}(t)=\frac{1}{\hbar^2}\left|\int_0^t e^{i\omega_{fi}t'}\,w_{fi}(t')d(t')\right|^2$ (16)

This result shows that $P_{if}(t)$ is proportional to the square of the modulus of the Fourier transform of the perturbation matrix element. This Fourier transform is evaluated at an angular frequency equal to the Bohr angular frequency associated with transition under consideration.

Figure 2: *E. Schrodinger[2]*

Limitations

Although time dependent Perturbation theory has wide applications while dealing with the small perturb in Hamiltonian it can not be valid for certain circumstances such as the interaction between quark and gluon in which the coupling constant is so high that the field cannot be treated with small energy. Similarly dealing to the convensional superconducting phenomena in which the strong correlated cooper pairs are formed should be treated with some other approximation called WKB such state is called non-adiabatic state.

Conclusion

In conclusion, the general solution of the Schrodinger equation evolving the time-dependent perturbation is express in manageable form. Here we discuss upto the first order solution. The second order solution also can be obtained in terms of first one. On the basis of this solution, we find the transition probability of system between two states after time 't' in which the system is charecterized with small perturbation.

References

[1] C. Tannouddji B. Diu, and F. Laloe, *Quantum Mechanics*, Wiley, New York (1977).
[2] B. K. Agrawal and H. Prakash, *Quantum Mechanics*, PHI, New Delhi (1997).
[3] T. Sasakawa, J. Math. Phys. **7,** 721 (1966).
[4] R. C. Hilborn Am. J. Phys. **50**, 982 (1965).
[5] https://www.patheos.com/blogs/religionprof/2016/03/saint-schroedinger.html (Dec 2018).

High-Temperature Superconductor

Bikash Chauhan
Fourth Semester, M.Sc. (Physics), CDP, TU, Kirtipur

ABSTRACT
The main idea of this article is to develop some idea about the unconventional high-temperature superconductivity. We begin form the brief introduction of the HTS and discuss about its different aspects (structure, properties and application and the mechanism explaining superconductivity).

Introduction

Thirty-two years ago in 1986 A.D, two IBM researchers shook the whole of physics society by their new discovery of HTS. Georg Bednarz and K.Alex Muller were awarded with Nobel prize in 1987 for their finding of high critical temperature (Tc) superconductivity in a Ba-La-Cu-0 system whose Tc was about 35K which was more than conventional superconductor whose Tc was below 8K. Before this discovery superconductivity was assumed to be a phenomena which occur at very low temperature. HTS with Tc as high as 138K are cooled to superconducting state using liquid a form of nitrogen.

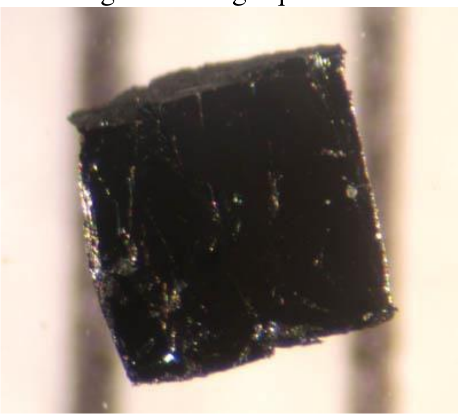


Figure 1: *A small sample of HTC.*

Whereas, the normal superconductor with Tc lower than 30K is cooled to the superconducting state using liquid helium. Till 2015 the highest transition superconductor was Mercury Barium Calcium oxide ($HgBa_2Ca_2Cu_3O_8$) at around 133K. But in 2015, it was found that H_2S under the very high pressure of 150 gigapascals undergoes superconducting transition near 203K. Temperature is not the only factor which separates HTS form conventional superconductor but its superconducting mechanism is also very different than that of convectional one which we shall discuss in segments to come.

Structure of high Tc ceramic superconductor

Different families of copper-oxide based ceramic with higher critical temperature than that of La-Ba-Cu-0 have been synthesized. These include Y-Ba-Cu-O series with Tc~90K, Ba-Sr-Ca-Cu-O series with Tc~80-115K, Tl-Ba-Ca-Cu-O group with Tc~85-125K. Till date, YBCO remains one of the best ever studied ceramic superconductor although another superconductor like Bi|Sr|Ca|Cu|O have been synthesized with higher critical temperature. Crystal structure of cuprates or copper oxide with high Tc is very much similar to that of perovskite structure which are described as distorted, oxygen deficient multilayer perovskite structure. Oxide superconductivity consists of an alternating multilayer CuO_2 planes, where superconductivity takes place between the layer of CuO_2. As the number of CuO_2 layer increases, it also increases the critical temperature.

Structure of YBaCuO superconductor

It consists of three different metals Yttrium, Barium and Copper in the ratio of 1:3:2. The unit cell of $YBa_2Cu_3O_7$ consists of three pseudo cubic elementary perovskite unit cells; each of which consists of a Y or Ba at the center. Ba in the bottom unit cell, Y in the middle one, and Ba in the top unit cell. Therefore Y and Ba are arranged in the sequence (Ba-Y-Ba) along the c-axis. The corner sites in the unit cell contain Cu atom with different co-ordinate Cu(1) and Cu(2) with respect to O. The possible position for O is O(1), O(2), O(3) and, O(4). Tripling the perovskite unit cells gives nine oxygen atom, therefore it is called as oxygen-deficient perovskite structure. The YBCO consists of the orthorhombic structure. The main property of YBCO is the presence of two-layer Cu_2O planes. The CuO chain in YBCO, plays a vital role in superconductivity.

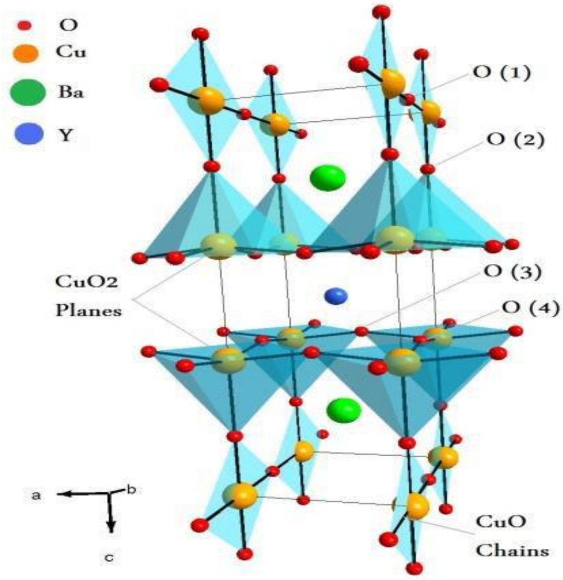


Figure 2: *Unit cell of YBCO. [1]*

Bi-, Tl- and Hg-based high-*Tc* superconductors

Bi-, Tl- crystal structure and Hg-based high-Tc superconductors are very alike. Similar to YBCO, the perovskite-type feature and the presence of CuO_2 layers also exist in these superconductors. However, unlike YBCO, Cu–O chains are not present in these superconductors. The YBCO superconductor has an orthorhombic structure, whereas the other high Tc superconductors have a tetragonal structure.

Explanation of Tc superconductivity

After the discovery of HST P.W. Anderson gave the first description of HST using the resonating valance bond theory. These superconductors are known to possess a d-wave pair symmetry. This idea was initially proposed by Bickers, Scalapino and Scalettar in 1987. Unlike in conventional superconductor, the cooper pair formation in HTS does not involve phonon's but their role is replaced by spin-density waves. Just like small Tc superconductors are strong phonon system,

HTS are strong spin-density wave system. The spin of the electron moving in the HTS creates a spin-density wave around it. As a result a spin depression is created where a nearby electron falls (water bed effect), which in result creates a cooper pair. More spin-density and cooper pairs are formed on lowering the temperature slight more leading to the formation of the superconductor. In HTS there is strong coulomb repulsion as it is a magnetic system due to coulomb interaction which prevents the pairing of cooper pairs in the same lattice. Here pairing only occurs at neighboring lattice sites. Here we find that the pairing state has a node at origin so it is called d-wave pairing. Various experiments confirmed the d-wave nature of cuprate superconductors which also include the d-wave nodes observation in excitation spectrum through Angle-Resolved Photometry Spectroscopy. Various experiments like photoemission spectroscopy, specific heat, NMR, etc have been conducted. Some reports support the d-symmetry whereas some supports symmetry, but a conclusive theory is yet to come.

Properties and application

The high Tc might be considered as the critical temperature greater than that of the boiling point of the liquid nitrogen. But the recent discoveries like pnictide superconductor have Tc below the boiling point of liquid nitrogen but are considered as high Tc superconductor. High Tc superconductor is type-2 superconductor and allows the magnetic field to penetrate their interior on quantization unit of flux, creating holes or tubes of normal metallic regions in the superconducting bulks called vortices. Due to this regions, they can withstand relatively higher magnetic fields.

Due to the discovery of HTS the technology application could benefit as it has higher Tc (above the boiling point of nitrogen usually) and higher critical magnetic field. Few cuprates which have upper critical field of about 100 teslas can be a great asset in a magnetic field rather than high Tc. Despite of its high field the problem till date for its application is that they don't form large and continuous superconducting domain, but possess cluster of micro domains within which superconductivity exists. If we vary the oxygen content it changes the transition temperature dramatically, it also affects the critical magnetic field and other properties. Talking of the machinery used in thin-film or bulk form it can be used in computers parts (logic device, memory, and interconnets), particle accelerators, MRI'S, magnetic energy storage system, levitated vehicles etc.

Future prospects

Failure to form large and continuous superconducting domain is a big problem for HTS in its use. However a room temperature superconducting material shall be a boon for human civilization. Room temperature superconductor means a material with zero resistivity i.e an endless source of current flowing without loss of any energy which we can use in the normal condition and which acts as a perfect storage of energy. Magnetic field of huge power could be produced by passing a huge current through the superconducting wire. Phenomena like levitation can be used in transport field which shall save huge energy and will be very fast means of the transport system. This will take the technology to a new level. They can also be used in quantum computers as the two-level system required for a "qubit", in which the zeros and ones are replaced by current flowing clockwise or anticlockwise in a superconductor. After the discovery of HTS, a light of hope has been seen to bring the imagination of room temperature superconductor to reality. The scientist is working on various compounds and various experiments are being carried out. Some focus on cuprates, complex crystals. Graphite soaked in water is another thing that scientists are interested in as it shows promising results. Scientists are also trying to manufacture metallic hydrogen and if something come out of it. Hence the field of HTS is very much exciting and a small breakthrough in this part of condensed matter physics can resolve various physics problems, moreover, it can change the face of human technology.

References:

[1] https://en.wikipedia.org/wiki/Hightemperature_superconductivity (Aug, 2019).

[2] A.P. Bednarz, K.A. Muller, *Possible high Tc superconductivity in the Ba-La-Cu-O system, Zeitschrift fur Physick B*, **64,** 189-193 (1986).

[3] A.P. Drozdov, M.I. Eremetes, et al., *Convectional superconductivity at 203 kelvin at high pressure in the sulfur hudride, Nature*, **525**, 736 (2015).

[4] R. Hazen, L. Finger, et al., *Crystallographic description of phase in Y-Ba-Cu-O superconductor,Physical Reviwe B*, **35**, 7238-7241 (1987).

[5] https://trove.nla.gov.au/work/19607247 (Aug, 2019).

[6] https://www.revolvy.com/page/High%252Dtemperature-superconductivity (Aug, 2019).

[7] S. Chakaravarty, A. Anderson, P.W. Strong, *Interlayer tunneling and gap anisotropy in high temperature superconductor, Science*, **261**, 5119 (1991).

[8] https://singularityhub.com/2018/05/13/the-search-for-high-temperature-superconductors/).

Monte Carlo Simulation in Astrophysics

Sujan Prasad Gautam
Fourth Semester, M.Sc. (Physics), CDP, TU, Kirtipur

ABSTRACT

The use of Monte Carlo simulation to solve one of the problems of astrophysics will be discussed in this article.

Introduction

Simulation can give reliable predictions when experiments are not possible or very difficult. Some examples: What is the equation of state of hydrogen at 10M Bars? How do polymers move? Monte Carlo methods are a broad clas of computational algorithms that rely on repeated random sampling to obtain numerical results [1]. Their essential idea is using randomness to solve problems that might be deterministic in principle.

Figure 1: *Monte carlo City [2]*

The technique was first developed by Stanislaw Ulam, a mathematician while playing countless games of solitaire. He became interested in plotting the outcome of each of these games in order to observe their distribution and determine the probability of winning. After he shared his idea with John Von Neumann, the two collaborated to develop the Monte Carlo simulation with the concept that a similar approach should work for neutron diffusion [2].

Monte Carlo simulations have many astrophysical applications such as in Radiative transfer, Star formation processes, Cosmological simulations, galaxy formation (semi-analytical model), Fitting of datasets (Monte Carlo samplers) etc. It has other broader applications such as in Health population modeling, Policy decision modeling, Optimization problems, Risk assessment for businesses, Modeling of financial instruments etc.

Let us take one example to solve that has been an active research area of astronomy in this century, despite the fact that the problem is fairly basic conceptually.

Problem:

Estimate what is the massive star M_{obs} that can be observed in a young star cluster of total mass $M_{cluster}$ assuming that the initial stellar mass function has a Salpeter form (between M_{min} and M_{max}). Plot M_{obs} as the function of $M_{cluster}$ and M_{max}. Use the results to discuss how we can infer M_{max} from M_{obs}.[3]

The goal of this question is to think about how stars are formed from molecular clouds and what is the relation between the theoretical maximum mass of the star and maximum mass observed in star forming regions. We can use the general idea that if we have a small (low mass) star forming region, then we might not have enough total mass to sample the full IMF and form stars with the mass close to the maximum possible. Therefore, the theoretical maximum mass M_{max} will be in general higher than the observed maximum mass M_{obs} in the star forming region. To investigate the relation between M_{obs} and M_{max} a Monte Carlo Simulation is the very useful approach.

We set up a simulation to produce discrete realizations of the stellar mass distribution in the star cluster and therefore find the relation between M_{obs} and M_{max}. Here we will assume for simplicity that the stellar IMF is described by a power law (Salpeter IMF) with exponent α = -2.3 and boundaries M_{obs} and M_{max}. Further let's assume that M_{min} = 0.2 M_{sun} and M_{max}>100 M_{sun} [4].

The Initial Stellar Mass Function is a probability distribution function which is an empirical one that describes the initial distribution of masses for a given population of stars. By mass plays a significant role in determining the properties and evolutionary path of stars, the IMF is an important diagnostic tool for astrophysicists studying a large group of stars [4]. The IMF we have considered in our problem is called the Salpeter function named after Edwin Salpeter, who first quantified the IMF for massive stars in 1955 [5].

The Salpeter IMF function is given by

$$\emptyset(m) = \emptyset o m{-}2.35 \quad (1)$$

If we take natural log on both sides,

$$\log(\emptyset(m)) = \log(\emptyset o) - 2.3 \log(m) \quad (2)$$

Equation (2) is the equation of a line which we use in this problem.

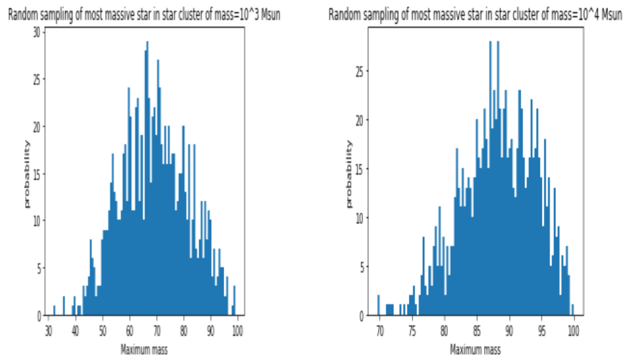
Steps we follow:

- Defining mass range: We have first considered that the stars in the cluster can only have masses ranging from Mmin (0.2 Msun) to Mmax. (100 Msun).
- Determining the most massive star observed:
  - We implement the hit and miss method with our given probability function.
  - We start with total mass=0 and take a random sampling from our probability function. If we have a hit, we add the mass of the star to the total mass.
  - We run the above step in a loop and when we have the total mass= mass of the cluster, we break the loop.

- The maximum value of these mass values (the hits) will give us the maximum observed mass.

- We run step 3 in a loop to get a random sampling of the maximum observed masses and produce a histogram from our results.
- We repeat all the above steps for different star cluster masses ranging from 10^2 M_{sun} to 10^6 Msun.

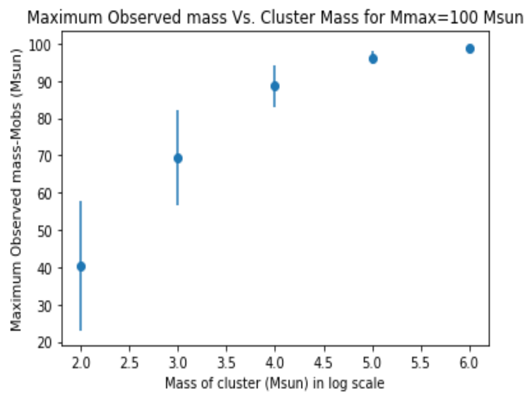
Plot we get:



The most massive star observed in a star cluster of mass 10^3 M_{sun} was calculated to be 69.524 M_{sun}. The most massive star observed in a star cluster of mass 10^4 M_{sun} was calculated to be 88.659 M_{sun}.

In the above scatter plot, we observe the following:

- The maximum observed mass in a cluster increases with the mass of the cluster. For the above case, we have considered M_{max}=100 M_{sun}. For a low mass cluster ($M_{cluster}$=10^2 M_{sun}), the maximum observed mass is as low as ~ 40 M_{sun}. Whereas, when we have a high mass cluster, the maximum observed mass can be as high as ~ 99 M_{sun}, which is almost equal to Mmax (100 M_{sun})
- The error for each point keeps decreasing as the mass of the cluster keeps increasing. This may be interpreted as high mass stars (close to M_{max}=100 Msun) are highly probable in high mass clusters and low mass stars have low probability. For Mcluster=10^2 M_{sun}, we get a standard deviation of ~ 17 Msun. Whereas, for Mcluster = 10^6 M_{sun}, we get a standard deviation of ~ 0.6 M_{sun}.



- Finally, in the above plot we have plotted using symmetric error bars. As mentioned in the above results, the standard deviation keeps decreasing as Mcluster increases. Although the error bars are strictly asymmetric, as we have small deviations, we have approximated the errors to be symmetric.

References:

[1] D. P. Kroese, T. Brereton, T. Taimre, Z. I. Botev,"*Why the Monte Carlo method is so important today*". WIREs Comput Stat., **6**, 386–392 (2014).

[2] https://www.investopedia.com/terms/m/montecarlosimulation.asp, (Dec 2018).

[3] M. Shrestha, "*The Massive Star*", Lecture Notes, University of Denver, USA (2012).

[4] Salpeter E., "*The luminosity function and stellar evolution*", Astrophysical Journal, **121**, 161(1955).

[5] Geha M. et al., *The Stellar Initial Mass Function of Ultra-faint Dwarf Galaxies: Evidence for IMF Variations with Galactic Environment*, The Astrophysical Journal, **371**, 477 (2013).

[6] [Note: Find here the code, used to solve this problem using python:https://drive.google.com/drive/u/1/folders/16Z7BPkyOZmgT3tx4sMo9SHBr8uBPJkAa] (Dec 2018).

TERM PAPER TITLES & SUPERVISORS OF FIRST BATCH STUDENTS, 2019, CDP, TU (3)

Name of Student	TERM PAPER TITLE	Advisors
Sanjeev Shapkota	TO PREDICT THE GLOBAL SOLAR RADIATION (GSR) USING EMPRICAL MODEL AT POKHARA AIRPORT	Prof. Dr. K. N. Poudel & Dr. Nurapati Pantha
SAntosh Sodari	DISTRIBUTION OF K-40 IN SOIL SAMPLE OBTAINED FROM VARYING DEPTH USING GAMMA SPECTROMETRY	Prof. Dr. Raju Khanal
Sarita Lawaju	SOLAR POWER AS REPLACEMENT	Dr. Madhav Pd Ghimire
Sishir Bhusal	CRITICAL EXPONENTS OF Λ-TRANSITION IN HELIUM	Prof. Dr. N. P Adhikari
Sita Dwanse	STUDY THE BEHAVIOUR OF STOCK MARKET: A PHASE TRANSITION MODEL OF WATER	Dr. Nurapati Pantha
Subash Ghimire	LYAPUNOV EXPONENT IN NON-LINEAR SYSTEM	Prof. Dr. N. P Adhikari
Sudeep Gnawali	ANALYSIS OF DOSIMETRIC DATA OF CIVIL SERVICE HOSPITAL FOR THE YEAR 2018	Dr. Madhav Pd Ghimire
Sujan K Gautam	STUDY OF BACKGROUND RADIATION DOSES AT DIFFERENT PLACES OF POKHARA VALLEY	Prof. Dr. Binil Aryal
Sujit Bati	CALCULATION OF RADIAL WAVE FUNCTIONS OF HYDROGEN ATOM USING NUMERICAL METHODS AND VISUALIZATION OF DENSITY PLOTS FOR HYDROGEN WAVE FUNCTIONS	Dr. Madhav Pd Ghimire
Suman Shrestha	STUDY OF FLUCTUATION OF STOCK MARKET USING PHASE TRANSITION MODEL OF WATER	Dr. Nurapati Pantha
Yogendra Limbu	REVIEW OF SECOND QUANTIZTION AND IT'S APPLICATION IN WEAK INTERACTING BOSONIC SYSTEM	Dr. Gopi C. Kaphle

A Simple Technique for the Construction of Thin film and its utilization for making Gas Sensor

Ramesh Chalise
Fourth semester, M.Sc. (Physics), CDP, TU, Kirtipur

ABSTRACT

By the process of spray pyrolysis technique, the thin film can be prepared and can be studying its optical and structural properties. Thus, the prepared thin film can be used to make the gas sensor that especially can detect liquid petroleum gas(LPG) leakage and other dangerous gas leakages also. Tin oxide (SnO2) layer or metal doped tin oxide thin layer is used for detection of leakage in this experiment. X-ray diffraction (XRD) and sem-micrograph can explain the structural properties of the thin film .

Background

Thin films are the thin-material layer ranging from the fraction of several micrometer scales to nanometer in thickness. The layer having the low volume to area ratio is better in performance and shows unique material properties. Thin film has properties significantly different from the corresponding bulk material, because of the unusual nature of their physical dimension and nonequilibrium microstructure.

In recent years, thin film science has grown worldwide as a major research area. A large amount of developmental work has taken place in the production and application of thin optical film in mirror and interferometer. Reflection and antireflection mirrors have been designed and reflection and transmission can be exactly controlled to our requirement. The ferromagnetic films are used in information storage in computer circuitry and in scientific studies of solar cells. The miniaturization of the electronic component in the microelectronic industries reduces the cost of the material and production volume, transportation economics etc., so thin-film technique is the better technique for maintaining size and shapes of any devices. [1]

The metal oxide thin films have attracted a large interest because of the huge application on wide areas. Tin oxides are better in magnetic data storage, anti-reflecting coating in solar cell and in magnetic resonance imaging (MRI). There are large no. of metal oxide SnO_2, , Fe_2O_3, FTO etc. That has a wide band gap and called n-type semiconductors, the most frequently used as a sensitive material for gas sensor. Metal oxides gas sensor are widely used due to their high sensitivity to harmful gases such as CO, NO, NO_2 , H_2 etc. Among these metal oxides, tin oxide (SnO_2) is one of the most widely used materials for gas sensor application because of its ease of fabrication and its special properties such as chemical and thermal stability, natural non-stoichiometry, high sensitivity, low cost, fast response and good ability to absorb oxygen. However, the gas-sensing properties of pure SnO_2 are not sufficient to identify a given gas, due to its low sensitivity and selectivity. Some doping metal agent like Pt, Pd, Ru, Cu, Al etc. and oxide catalyst like Fe_2O_3 , La_2O_3 , Cr_2O_3 , V_2O_5 , CO etc. are required to improve sensory characteristics of material particularly their selectivity. [2]. According to the working mechanism and device structure, one dimension metal oxide nanostructure sensor has been divided as in three ways, conductometric type, field effect transistor (FET) type and impedometric type. Conductometric type of gas sensor is based on the principle of resistance variation on expose of the sensing elements whereas FET types of gas sensor are based on change on FET parameters due to exposing of the sensing channel to target gases. Impedometric type of gas sensors are based on the impedance changes upon expose to the target species. The FET gas sensor may also refer to as a metal oxide semiconductor FET gas sensor based on the different gas element in the channel. A change in the channel current gives sensing signals.

Methodology

There are various techniques that used for the synthesis of the Tin oxide thin film such as physical vapor evaporation, chemical vapor evaporation, sputtering, electrochemical deposition, sol-gel method and spray pyrolysis techniques etc. Among this process, we will use spray pyrolysis technique for the preparation of SnO_2 thin film and which is the better technique because a large area of the thin film can be prepared in short time by using the simple instrument. In this technique, the thin film is deposited on the hot substrate by spraying the given solution through a Nozzle. In this process decomposition rate and thickness of the thin film can be controlled over a wide range by changing the spray parameters like temperature, chemical solution, Nozzle to substrate distance etc. [1]

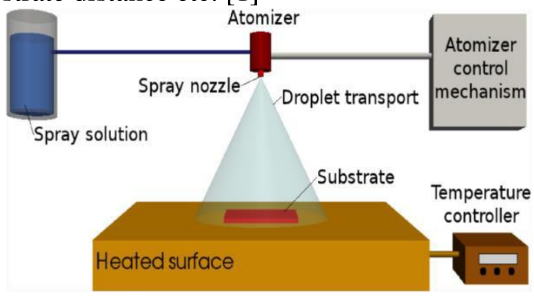


Figure 2: *Showing schematic diagram of spray pyrolysis set up for thin film preparation).[2]*

Once the film deposited we will use x-ray diffraction technique(X-RD) for identification and determination of the required phase in the deposited sample and also find out the structure of the sample.

After the thin film synthesize we will use it to build of the SnO 2 FET gas- sensor that works on different sensing mechanism of catalytic interaction between metal gate and gas molecules. The change on channel current can be measured to give out the sensing signals. The schematic diagram for experimental set up of spray pyrolysis technique, a schematic diagram of gas sensor and the flowchart diagram are shown below in Figure 2, Figure 3, and Figure 4.

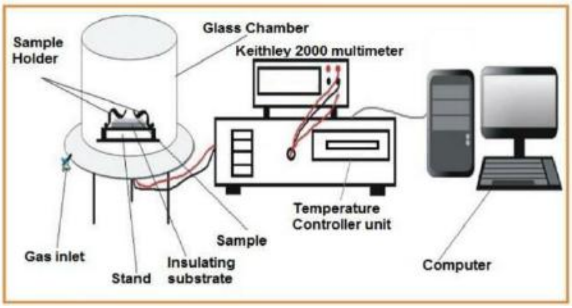


Figure 2: *Showing Schematic diagram for a gas sensor. [3]*

Expectation

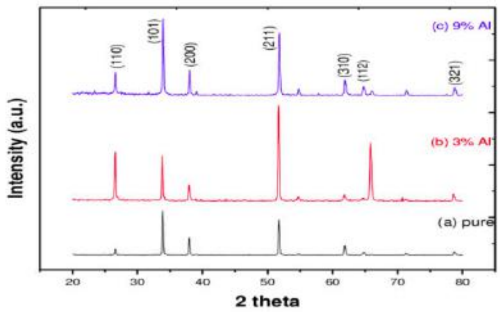


Figure 3: *XRD of thin film of pure tin oxide and Al -doped tin oxide at different concentration.[3]*

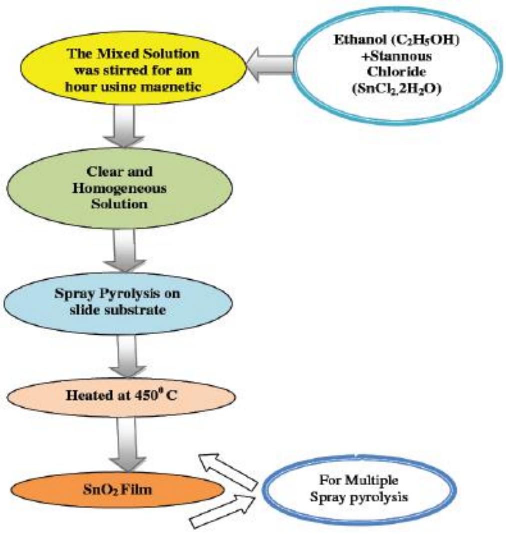


Figure 4: *showing flow chart diagram for preparation of tin oxide (SnO2) by spray pyrolysis method.*

I have expected that the XRD of the thin film of tin oxide and Al-doped tin oxide will show the following type of graph. Using this thin film, I have expected to make a gas sensor that works below 200^0 C. The gas sensor will be based on the principle of variation of FET parameters like (VDS, ID, IDSS, VGS).

References

[1] P. Basnet, *Structural, Electrical and optical properties of spray deposited ZnO and ZnO:Al thin films*, M.Sc. (Physics) Dissertation, Central Department of Physics, Tribhuvan University, Nepal (2005).

[2] S. Chaisitsak, *sensors*, **11**, 7127, (2011).

[3] https://www.researchgate.net/figure/280774340_fig5_Fig-5-Schematic-Diagram-of-laboratory-as-Sensor-set-up (2017).

[4] G. J. Shyju, S. Nagarani, S. Dawn, D. Roy, C. Sanjeeviraja, Archives of Applied Science Research, **5**, 2149 (2012).

List of M.Sc. Dissertation 2018-19 (4)

Name of Student	M.Sc. Dissertation Title	Supervisor
Roshan Shrestha	A MOLECULAR DYNAMICS STUDY IN STRUCTURAL DYNAMICS OF A V717I SUBSTITUTION IN THE AMYLOID PRECURSOR PROTEIN	Dr. Hari Prasad Lamichhane
Rupesh Kumar Jha	EFFECT OF ION MACH NUMBER ON ELECTRO-NEGATIVE MAGNETIZED PLASMA SHEATH	Prof. Dr. Raju Khanal
Sandeep Prashad Pant	ULTRASONOGRAPHIC FINDINGS IN BIOCHEMICALLY HYPOTHYROID PATIENTS	Dr. Hari Prasad Lamichhane
Sangeeta Chaulagain	EFFECT OF OBLIQUENESS ON MAGNETIZED DUSTY PLASMA SHEATH USING KINETIC TRAJECTORY SIMULATION MODEL	Prof. Dr. Raju Khanal
Sashi Nepal	EFFECT OF Cr DOPING ON ELECTRONIC AND MAGNETIC PROPERTIES OF INVERSE HEUSLER ALLOY Mn2CoGa	Dr. Gopi Chandra Kaphle
Saurabh Lamsal	FIRST-PRINCIPLES STUDY OF ELECTRONIC AND MAGNETIC PROPERTIES OF TWO DIMENSIONAL HEXAGONAL BORON NITRIDE DOPED WITH Sn ATOM	Dr. Nurapati Pantha
Sujan Pokhrel	METEOROLOGICAL FLOWS AND AIR POLLUTION DISPERSION MODELING OF BUTWAL CEMENT INDUSTRY, NAWALPARASI DISTRICT OF NEPAL	Prof. Dr. Ram Pd Regmi
Sunil Lamichhane	ELECTRONIC AND MAGNETIC PROPERTIES OF THE DOUBLE PEROVSKITE BaLaNiOsO6: FIRST-PRINCIPLES STUDY	Dr. Gopi Chandra Kaphle
Tulasi Acharya	STRUCTURAL AND ELECTRONIC PROPERTIES OF PEROVSKITE - TYPE HYDRIDES MMgH3 (M=Na,K)	Dr. Gopi Chandra Kaphle
Upama Karki	EFFECT OF COLLISION IN MAGNETIZED PLASMA SHEATH	Prof. Dr. Raju Khanal

Josephson Effect And Its Applications

Bivek Pokhrel
Fourth Semester, M.Sc. (Physics), CDP, TU, Kirtipur

ABSTRACT

Some never thought ideas which were completely counter intuitive at the time and moreover the manifestation of quantum mechanics in subtle way to show such bizarre phenomena is presented in this article starting with brief history, basic theory and application of Josephson's effect in present days.

Historical Touch

A 22 year old student, taking class of solid state physics delivered by Philip W. Anderson came up with the solution within 2-3 days after the issue was discussed. At first he followed directly the calculations, by Cohen, Falicov and Phillips, of the tunneling Hamiltonian method. But by the time Anderson saw this calculations, Josephson had separately already worked out rather sophisticated formalism which he later published where he incorporated charges of particles. They were puzzled by the meaning of the fact that the current depends on the phase. This is the famous J = J sin(φ) (shown below also) where φ is the phase difference between the two superconductors. Anderson stated that two things about that original paper which struck him as remarkable. First was that, from the original idea of a dc supercurrent, how Josephson immediately made the important steps not only to the ac supercurrent but also to the mathematics of how to synchronize it with an external ac signal. Furthermore, he explained how to observe the effects Sidney Shapiro did nearly two years later, which is now standard method for measuring e/h. The second thing was the response of patent lawyer at Bell Telephone Laboratories when John Rowell and Anderson consulted him; in his opinion Josephsons paper was so complete that no one else was ever going to be very successful in patenting any aspect of the Josephson effect.

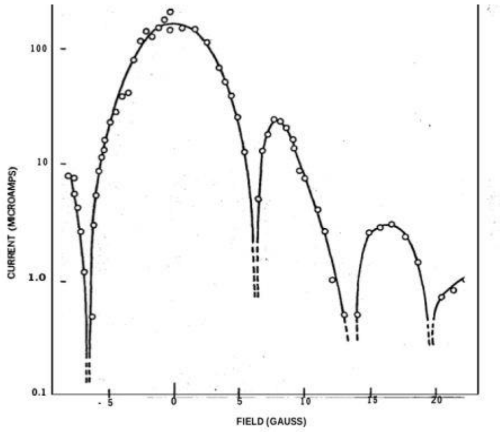


Figure 1: *Single-slit interference pattern shows dependence of Josephson current in a lead-lead oxide-lead junction on magnetic field.[2].*

Even the experiment done several years later by Anderson and Rowell, was already stated by Josephson in his earlier paper without knowledge that his mentor would do them in future. It was possible due to great experimentalist of the time, Rowell that made the success of experiment. Such sophistication of experimental setup could be seen from such a deep sharp-line as in figure 1. Although Josephson could not produce this experimentally major credit (theoretically) of this goes to Josephson; stated Anderson

Basic thoery

Superconductivity is a thermodynamic state which is obtained below some material dependent characteristic temperature called critical temperature Tc . The two most prominent features of superconducting phase are the repulsion of magnetic fields and zero-resistance state. The latter was first discovered by Kamerlingh Onnes in 1911at Leiden. In 1962, Josephson analyzed junction between two closely separated superconductors, spaced by an insulating material. He discovered that if the insulating barrier is thick, the electron pairs can not pass it; but if the layer is thin (approx. 10-15 nm) then there is a probability for electron pairs to tunnel through. This is what now known as 'Josephson tunneling' (different from single particle tunnelling).

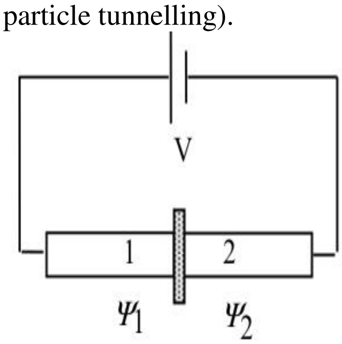


Figure 2: *Two superconductors separated by thin insulator[2].*

Superconducting tunneling

Oxidise a strip of superconducting film (eg lead) very lightly to a depth of 10-20 A; then evaporate a cross strip of lead film as shown if figure 2. Then simply plotting the current-voltage characteristic of the resulting tunnel junction shows that electrons can tunnel quantum mechanically directly from an energy level in one piece of lead to an equal energy in the other. At temperatures less than Tc, the superconducting transition temperature, normal current does not flow very well until we apply enough voltage to overcome the energy gap 2, because there are no single-particle levels in the gap (oxide).

Josephson effect

But Josephson showed that superconducting pairs of electrons can also tunnel, almost equally well. The supercurrent is $J = J_1 \sin(\Phi)$ where J is comparable with the normal current at V = 2δφ is the difference between the phases of the electron-pair wave functions in the two superconductors on opposite sides of the insulating barrier of oxide. Later it was realized that the phases are coupled by an energy $E = -E_1 \cos(\varphi)$, that the minimum energy is achieved by equal phases and zero current. But an external current source as a perturbation can make the phases unequal. If the phases are time independent, then a dc supercurrent flows with no voltage as seen from (2) and relation of J. The phenomenology of superconductivity can be summarized in terms of the phase of the pair wave functions. The superconducting electrons (usually most of them) move with a velocity v, which is given (except for a factor 2 in the vector-potential term) by the standard quantum- mechanical equation.

$$vs = \frac{h}{(2\prod m)}\left(\delta\varphi - 2\frac{e}{c}\right)$$

If the phase is uniform, v, is proportional to the vector potential A, which describes the Meissner effect of flux exclusion (as δφ = 0). We see from this equation that eithera magnetic field A or a current v s can lead to a gradient of φ; either may be used in a Josephson interferometer (practically important device). The time dependence of the phase is given by the Josephson equation

$$\frac{h}{(2\prod)}\frac{d\varphi}{dt} = 2eV$$

This equation along with the previous one, shows that to maintain voltage across a superconductor the only way is by accelerating the supercurrent.

Significance and Applications

Imagine that we had a geological model of earth that predicts the existence of magnetic filed it generates, but unfortunately the magnetic needle compass was not yet invented. We could not then verify the presence of magnetic field. In analogy, Josephson Effect was the measuring instrument that confirm the theory and brings it into the practical uses. The impact of the Josephson discovery on our understanding of superfluidity and superconductivity is huge. One example of great importance is in the study of dissipative phenomena. The idea and the experimental verification of flux and vortex quantization, and the Josephson frequency condition. This made two phenomena, of superconductor dissipation and dissipation in superfluid helium explained under similar mechanism. In each case the key to what is going on in the dissipative effects is the Josephson frequency condition and the idea of phase slippage by vortex motion. To this date the most famous application is the measurement of $\frac{h}{e}$, as suggested by Josephson and as carried out by Donald et.al. which is the voltage measurement became the comparison with frequency via Josephson's equation. This role is analogous to that of Light interferometry in length measurements. Ultra-sensitive electromagnetic measurements detection of high frequency radiation, light-sensitive Josephson junction that can be switched on with light are some of other practical applications. By far the most interesting application is use of Josephson junctions for the control and movement of single quantized vortex lines used in computer elements proving it advantageous in size and speed. Measurement of very minute magnetic field (10^{-14} T).Despite the technical difficulty and reproducibility of several processes , the potential of future science can greatly depend on macroscopic quantum interference, exploitation of which we owe in large part to Brian Josephson.

Reference

[1] P. W. Anderson, *How Josephson discovered his effect,* Phys. Today, **23**(11), 23-29 (1970).
[2] B. D. Josephson, Phys. Lett. **1**, 251 (1962).
[3] P. W. Anderson, J. M. Rowell, Phys. Rev. Lett. **10**, 230 (1998).

Boy or Girl? It's in the Father's Genes

A study of hundreds of years of family trees suggests a man's genes play a role in him having sons or daughters. Men inherit a tendency to have more sons or more daughters from their parents. This means that a man with many brothers is more likely to have sons, while a man with many sisters is more likely to have daughters. A Newcastle University study involving thousands of families is helping prospective parents work out whether they are likely to have sons or daughters. The work by Corry Gellatly, a research scientist at the university, has shown that men inherit a tendency to have more sons or more daughters from their parents. This means that a man with many brothers is more likely to have sons, while a man with many sisters is more likely to have daughters. The research involved a study of 927 family trees containing information on 556,387 people from North America and Europe going back to 1600.

"*The family tree study showed that whether you're likely to have a boy or a girl is inherited. We now know that men are more likely to have sons if they have more brothers but are more likely to have daughters if they have more sisters. However, in women, you just can't predict it,*" Mr Gellatly explains. Men determine the sex of a baby depending on whether their sperm is carrying an X or Y chromosome. An X chromosome combines with the mother's X chromosome to make a baby girl (XX) and a Y chromosome will combine with the mother's to make a boy (XY).

Source: https://www.sciencedaily.com/releases/2008/12/081211121835.htm

Quantum Decoherence and Einselection

Tika Ram Bhandari
Second semester, M.Sc. (Physics), CDP, TU, Kirtipur

ABSTRACT

Different wave function representing two coherent sources gives superposition, but when the system interacts with the measuring devices there is decay of wave with time. This entangled results the collapse of wave function called decoherence. Selection of the stable state calledeinselection is very crucible in quantum mechanics which help to give the more accurate results on quantum problem associated with system and also verifies Schrödinger equation.

Introduction

Quantum mechanics works very nicely to predict the future of experiment. Quantum mechanics is subjective because result of measurement depends on measuring conditions or other condition during observation. This branch of physics explain many difficulties related on working and structural framework of the DNA, action of the laser, superconductivity, superfluid, different properties of the solid as well as the colorful appearance of the star. Generally, states in quantum mechanics are determined by symbol |Ψ>. These states are govern by the deterministic, linear Schrödinger equation,

$$i\hbar \frac{d}{dx}|\Psi> = H|\Psi> \qquad (1)$$

Systematic, controlled and isolated experimentalways verifies the deterministic evolution of |Ψ>.When two coherent sources represented by certain wave function in the system meet then the phenomenon called superposition appears [1, 2, 3]. The concept superposition of the states has made Hilbert space H in reality where a few portion of these state in Hilbert space is used to govern classically allowed states.Moreover, principle of Superposition has been included as a fundamental postulates in quantum mechanics which has no any classical analogue i.e. in the real (classical) world this principle is violated. Although, there is a logical gap between quantum and classical mechanics in the results of measurement, experiment like double slits experiment for interference of fullerenes, superposition on Josephson junction,microwave activities and atominterferometry provide experimental evidence for the validity of principle of superposition. Existence of this reflects coherence as fundamental properties of quantum mechanics. However, poor experiment setup imparts some connection between a quantum system and surrounding (measuring device). Lately, tangible results obtained after measuring arises a question about the prediction of the above equation (a). This is because coherence decays with time in imperfectly isolated system and expected quantum behavior is lost. Difficulties to predict the future of the experiment is due to decoherence which means the loss of information from the system to surrounding. The notion of decoherence leads to classical mechanics from quantum mechanics [5].

Decoherence

When the measuring device has many degree of freedom, then a certain portion of the system`s wave function entangled with surrounding in different ways and results decoherence.

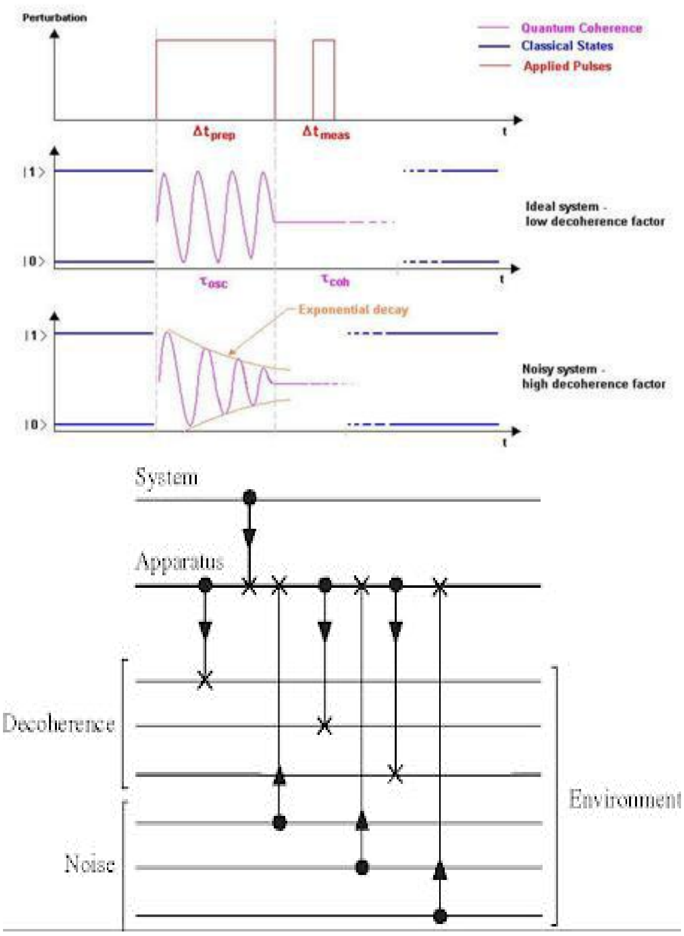


Figure 1: *First figure represents thedecay of wave with certain decoherence factor and the second one shows system and surrounding intraction[3]*

This directly effect in the result of the measurement in quantum adiabatic evolution. Decoherence is obtained when electron or light wave entangled with the stray particles such as cosmic rays between slits and screen. The measurement of the microscopic and isolated system inmacroscopic domain results in the effective "*collapse of the wave packet*". This idea of decoherence is regarded as the central popular image of the Copenhagen interpretation (CI) but it was not directly displayed in that interpretation. Decoherence is the inevitable tool by which we can conclude the evolution of the classical mechanical states from quantum states; it also allows us to derive Chaotic trajectories in quantum mechanics. The idea of particle in quantum field theory can be explained by decoherence. Further it also acts as basic components in a theory of quantum gravity [6,7].

Einselection

In quantum mechanics, openness of the system induces some perturbation on it`s by surrounding environment. Einselection is the short form of environment-induced superselection of stable states (pointer states). Determination of detail picture of these pointer states and phenomenon of their dynamical selection is of fundamental importance in Quantum mechanics. These pointer states are the mininum entangled states where the entropy of the system is very low. If ρ_Ψ(t) represent the density matrix of the measuring system with initial condition,

$$\rho_\Psi (0) = |\Psi\rangle \langle\Psi|. \quad (2)$$

Then entropy of the system is represented as

$$H_\Psi (t) = -Tr(\rho_\Psi(t) log \rho_\Psi(t)) \quad (3)$$

Where, |Ψ> is the initial pure states. Moreover, einselection is complimentary to decoherence that imparts selection of the states of the environment $|\varepsilon_i\rangle$such that corresponding pointer states remains orthogonal i.e

$$\langle\varepsilon_i |\varepsilon_j\rangle = \delta_{ij} \text{ [8,9].} \quad (d)$$

Conclusion

Decoherence is the quantum phenomenon which supress the action of superposition. It is sometime taken as a pathway from quantum mechanics to classical mechanics which means decoherence results the collapse of the wave packet. So while dealing with quantum problem, one must be careful in the selection of the stables states representating the system to be measured. Proper pointer states reduces the entangled between the system and surrounding so that predictive nature of the time evolution of the schrodinger equation preserved.

References

[1] S. Maximilian, *Decoherence, the measurement problem, and interpretations of quantum mechanics*, Reviews of Modern Physics. **76**, 1267–1305 (2005).

[2] H. D. Zeh, *On the Interpretation of Measurement in Quantum Theory*, Foundations of Physics.**1**, 69-76 (1970).

[3] W. H, Zurek, *Decoherence and the transition from Quantum to classical- Revisited,* Los Alamos Science, Springer. **27**, 86-109 (2002).

[4] M. Tegmark, *The Importance of Quantum* Decoherence *in Brain Processes,* Physical Review letters. **211**, 1-15 (1999).

[5] D. S. Golubev, A. D. Zaikin, *Quantum Decoherence in Disordered Mesoscopic Systems*, Physical Review Letters, **86**, 1-3 (1997).

[6] D. Howard, *Who Invented the "Copenhagen Interpretation? A Study in Mythology*, Philosophy of Science, **71**, 5, Proceedings of the 2002 Biennial Meeting of The Philosophy of Science Association. 669-682 (2004)

[7] F. Jan, *Copenhagen Interpretation of Quantum Mechanics*, The Stanford Encyclopedia of Philosophy, Edward N. Zalta (ed.) (2014).

[8] B. Guido, *The Role of Decoherence in Quantum Mechanics*, The Stanford Encyclopedia of Philosophy, Edward N. Zalta (ed.) (2016).

[9] M. Tegmark,H.S. Shapiro, *Decoherence produces coherent states: An explicit proof for harmonic chains,* Physical Review E **50**, 2538–2547 (1994).

Are Black Holes Made of Dark Energy?

Researchers have identified and corrected a subtle error that was made when applying Einstein's equations to model the growth of the universe. Two University of Hawaii at Manoa researchers have identified and corrected a subtle error that was made when applying Einstein's equations to model the growth of the universe. Physicists usually assume that a cosmologically large system, such as the universe, is insensitive to details of the small systems contained within it. Kevin Croker, a postdoctoral research fellow in the Department of Physics and Astronomy, and Joel Weiner, a faculty member in the Department of Mathematics, have shown that this assumption can fail for the compact objects that remain after the collapse and explosion of very large stars. "*For 80 years, we've generally operated under the assumption that the universe, in broad strokes, was not affected by the particular details of any small region," said Croker. "It is now clear that general relativity can observably connect collapsed stars -- regions the size of Honolulu -- to the behavior of the universe as a whole, over a thousand billion billion times larger.*" Croker and Weiner demonstrated that the growth rate of the universe can become sensitive to the averaged contribution of such compact objects. Likewise, the objects themselves can become linked to the growth of the universe, gaining or losing energy depending on the objects' compositions. This result is significant since it reveals unexpected connections between cosmological and compact object physics, which in turn leads to many new observational predictions.

Source: https://www.sciencedaily.com/releases/2019/09/190910095419.htm

CDP Activities
International Conference on Nanoscience and High Energy Physics (ICNHEP-2019): 4-6 Feb, 2019

Central Department of Physics organized 'International Conference on Nanoscience and High Energy Physics (ICNHEP-2019) during 4-6 Feb, 2019. The main aim of the program was to bring together leading academicians, scientists, and researchers to exchange and share their experiences and research results related to Nano materials, computational Physics and magnetic materials and applications. It provided a premier interdisciplinary platform for researchers and educators to present and discuss the most recent innovations and trends in Physics like, Astrophysics, Nano-Materials High-energy and computational Physics. The practical challenges encountered and solutions adopted in research activity in these area has also been discussed.

Organisers and participants

Organisers, Guest speakers and participants

The following activities were successfully conducted during the conferences:

- Invited Talks by Eminent Speakers
- Selected Oral Presentations
- Interactive Poster Presentations

The conference covered the following topics:

- Magnetic Recording, Memories and Spintronics
- Nanostructures and Magnetism
- Thin film and Functional Magnetic Materials
- Astrophysics and Geology
- Biomaterials and Nanobiotechnology
- Nanotechnology Applications: Atmospheric, etc.

There was a panel of advisory committee of following distinguishes persons:

1. Prof. Dr. A. Mookerjee (SNBNCBS, Kolkata, India)
2. Prof. Dr. Walter Saurer (Innsbruck Univ, Austria)
3. Prof. Dr. Quisar Shafi (Univ of Delaware, USA)
4. PD Dr. Manuel Richter (IFW Dresden)
5. Prof. Dr. Anurag Srivastava, (IIITM,Gwalior)
6. Prof. Dr. Lok Narayan Jha (TU)
7. Prof. Dr. Sitaram Pd. Byahut (TU)
8. Prof. Dr. Pradeep K Bhattarai (NPS, Nepal)
9. Prof. Dr. R. K. Thapa (MZU, India)
10. Prof. Dr. Indra Bdr. Karki (Open Univ, Nepal)
11. Prof. Dr. Devendra Adhikari (TU, Biratnagar)
12. Prof. Dr. Nilam Shrestha Pradhan (TU)

Fifteen invited speakers contributed the conference by delivering their talks, as follows:

1. Prof. Dr. S. S. Islam, CNN, JMI Delhi
2. Prof. Dr. C. K. Sarkar, Chair EDS, IEEE, Kolkata
3. Prof. Dr. Anisul Haque, Bangaladesh
4. Prof. Dr. Anurag Sriastava, IITM, Gwalior,India
5. Prof. Dr. Manika Khanuja,CNN, JMI, Delhi
6. Prof. Dr. Shanker Prasad Shrestha, PMC, Nepal
7. Prof. Dr. Jeevan Jyoti Nakarmi, CDP, TU, Kirtipur
8. Prof. Dr. Binil Aryal, HOD, CDP, TU, Nepal
9. Prof. Dr. Narayan Pd. Adhikari, CDP, TU, Nepal
10. Prof. Dr. Raju Khanal, CDP, TU, Kirtipur
11. Prof. Dr. Ram Prasad Regmi, CDP, TU, Kirtipur
12. Prof. Dr. Bhadra Pokhrel, IOE, Pulchowk, Nepal
13. Prof. Dr. Narayan Chapagai, ASCOL, T U
14. Er. Bhola NS Ghimire, IOE, Pulchowk
15. Prof. Dr. Rameshwor Adhikari, RECAST

There were 150 national and international participants. The national participants are mostly Ph.D. snd masters' students of physics from various colleges. There were 16 invited talks, 45 oral presentations and more than 50 poster presentations. The conference was inaguarated by Dean of Institute of Science & Technology, Prof. Dr. Ram Prasad Khatiwada. During the opening program IEEE EDS Chair, Prof. Dr. C. K. Sarkar and Prof. Dr. Manika Khanuja of JHI, Delhi highlighted the importance of nano-materials for the development of nation. Prof. Binil Aryal, HoD of CDP, TU, welcomed the participants and highlighted the conference. The closing ceremony was chaired by Prof. Dr. Rameshwor Adhikari, Executive Director of RECAST. The best contributory presentation and best poster award is given to winners, selected by a committee of Judges. The conference co=ordinator Dr. Gopi Chandra Kaphle thanks all sponsors, supporters, and individuals for their contributions to make this event successful.

CDP Activities

SITARE Workshop, Nepal (13-15 June, 2018)

Southampton, (UK) – IUCAA (Inter University Centre for Astronomy &Astrophysics, India) training for Astronomical Research and Education (SITARE) was held at the Central Department of Physics, Tribhuvan University on 13-15 June, 2018. The SITARE Workshop was started with welcome speech of Prof. Dr. Binil Aryal, Head of Central Department of Physics, TU, Kirtipur. Professor Aryal expressed happiness in organizing such workshop in Department and encouraged the young participants to take part actively. He also briefly introduced about exports and participants.

Experts are discussing

There were 58 total participants including 3rd semester students, faculty (Astrophysics) members and 5 experts. Exports were from different field and countries. Experts delivered their lectures in different topics of Astrophysics and observational Cosmology in three different sessions of the day during workshop.

- Prof. Dr. Ian Johns, Univ. of Southampton, UK: gravitational wave Astronomy
- Prof. Dr. Somak Raychaudhury, IUCAA, India: observational cosmology
- Prof. Dr. Binil Aryal, Tribhuvan University, Nepal: About galaxy evolution
- Prof. Dr. Sanjit Mitra, IUCAA, India: Cosmic microwave background
- Associate. Prof. Dr. Kanak Saha, IUCAA, India: Dynamics and structure of galaxies

Director of IUCAA, Prof. Dr. Somak Raychaudhury briefly introduced about IUCAA and Astronomy in India during his lecture. He also delivered his lecture on observational cosmology. All experts highly encouraged participants for research work. Aim of SITARE workshop was to motivate and provide front end Astronomical research opportunities to young and enthusiastic M.sc students. At the last day of workshop 10 students were selected, by taking exam, for advanced SITARE workshop which is going to be organized during 10-16 Jan, 2019 in IUCAA Pune.

M.Sc. (Physics) students with Astrophysics Major

The work shop was organized at seminar hall of Central Department of Physics, TU, Kathmandu and sponsored by the Science and Technology Facilities Council (STFC) United Kingdom.

CDP Activities

Winter Lecture Series in Natural Science: Technique and Philosophy in Physical Sciences (10-12 Feb., 2019)

Central Department of Physics and Central Department of Chemistry, TU jointly organized Winter Lecture Series in 'Natural Science: Technique and Philosophy in Physical Sciences' during 10-12 Feb 2019. The aim was to teach the historical and current topics of philosophy and scientific writing to students. Eight lectures of 1 to 2 hours were presented in the program which had more than 100 participants including organizers, speakers, guest and staff. The program ended with the promise to continue in coming years. The objective of the program was to develop the concise notion physical sciences; researchers must have a high command on techniques needed for scientific writing and the philosophical background behind their part of study. However, these all are lagging in research scientist as well as to students in Tribhuvan University. So, this program was organized with the objective to give introductory insight to graduate students of physical sciences about the philosophical aspects of science and the techniques of scientific writing. Following speaker presented thir talks:

1. Dr. Basant Pant (Annapurna Neurological Institute and Allied Sciences): "Science: What and why?"
2. Dr. Sammod Acharya (Nepal Army Institute of Health Sciences): "Science Philosophy in East: History and Achievement"
3. Prof. Dr. Narayan Adhikari (Central Department of Physics, Tribhuvan University): "Problem Finding and Literature Review"
4. Prof. Dr. Niranjan Parajuli (Central Department of Chemistry, Tribhuvan University): "Scientific Documents; Proposal Writing"
5. Prof. Dr. Megh Raj Pokhrel (Central Department of Chemistry, Tribhuvan University): "Scientific Documents; Thesis and Research Article Writing"
6. Dr. Deepak Kumar Khadka (University Grants Commission): " Ethics in Writing and Finding Research Fund"
7. Prof. Dr. Binil Aryal (Central Department of Physics, Tribhuvan University):" Philosophy of Quantum Mechanics"
8. Prof. Dr. Sitaram Prasad Bhyaut (Central Department of Physics, Tribhuvan University): "Symmetry in Nature and Culture"

There was one panel discussion on topic, "Techniques and Philosophy in Physical Sciences" Coordinated by Prof. Dr. Raju Khanal (Central Department of Physics, Tribhuvan University) and panelists were; Prof. Dr. Niranjan Parajuli, (Central Department of Chemistry), Dr. Deepak Kumar Khadka, (University Grants Comission) and Mr. Surendra Subedi Joint Seretary, (Ministry of Education Science and Technology, Nepal Government). During these three days, participants learnt different philosophical and technical aspects of Physical Sciences. It is recommended that the scientific philosophical discussion on particular topic should be incorporated in the curriculum.

The members of scientific organizing committee were as follows: Prof. Dr. Raju Khanal, Prof. Dr. Narayan Adhikari, Prof. Dr. Niranjan Parajuli, Dr. Ishwar Koirala, Dr. Bhanubhakta Neupane and Dr. Achyut Adkikari. Bidit lamsal and Tika Ram Bhandari of CDC and CDP coordinated the program. Other members of organizing committee were Hari Timsina, Ramesh Giri, Tirth Bhatta, Lokendra Singh Dhami, Pratibha Khanal, Bibek Raj Bhattrai, Babita Aryal, Nirab Sharma, Bikash Adhikari, Rajeeb Kunwar, Lalit Singh Karki and Lalit Dhami.

CDP Activities
CDP Wins Geo-Science Exhibition (11-13 Feb, 2019)

CDP wins Geo Science Exhibition 2019, organized by Central Department of Geology during 11-13 Feb 2019. There were more than 60 exhibition stalls of various other central departments, institutes and colleges in the program. These stalls cover various aspects of Earth Sciencve and physical science. About 20,000 students from various schools of the capital city were observed the program. In addition to this, hundreds of professors, doctorate students, masters' students, officials and public visited and observed the program.

Telescope and pieces of Astoroid were major attaraction!

CDP prepared 10-12 exhibition items showing various aspects of applications of physics. The third semester students were involved in the program. CDP stall was always occupied by young students of schools and colleges. The main attaraction was the explanation plan by the voulenteers. All the voulenteers did hard work. CDP is thankful to our students namely, Niraj – for your sincerity, Kisan – for your dedication, Pramod – for your hardworking, Meelan – for your probity, Sanjeev – for your versatility, Kisor – for your integrity, Sagar (R) – for your genuineness, Sagar (T) – for your passion, Prakash – for your indefatigable, Anil – for your studious and Mahesh for your upheaval, finally, Sujan – for your leadership!!! Our third semester students made CDP to rock by giving this memorable valentine gift to CDP!!! CDP has decided to mention this achievement as recommendations to them.

School students are listenting demonstration of CDP stall

Prof. Dr. Lalu Prasad poudel, HoD, Central Department of Geology mentioned the exhibitory skill of CDP groups as well as dedications.This exhibition was inaugurated by state minister of Education, Science & Technology Mr. Giriraj Mani Pokhrel. The objective of organizing geo-science exhibition was to The main objectives of organising was to promote interest in Geo-science and Technology among younger generation.

CDP Activities

CDP celebrates 'Astrofest Nepal 2018' (22 April, 2018)

Every year the astronomers celebrate an event, the global astronomy month (GAM). The GAM invites everyone from all countries to participate in this event and encourages to take part in night sky party, Astro-poetry, Astro-art and Astro-poster contests. For the first time in Nepal, the Central Department of physics hosted Global Astronomy Month (GAM) in presence of renowned professors and professionals interested in Astronomy.

The program was conducted in two sessions, the first session was professional lectures, invited talks, and Astro-contests organized in the department's seminar hall and the second session was a bit informal and casual with intention of involving participants who despite lacking formal science education are science enthusiasts. Outside of seminar hall, in the Department premises general public had the opportunity of enjoying -- the night sky party where they could observe with the six- and four-inches telescopes into the deep sky.

To mark the importance of occasion there were two special lectures delivered by Head of Department Professor Binil Aryal and Professor Uday R. Khanal. Being an expert in the field of Astrophysics Professor Aryal gave a talk on the topic of "*A path to world-class University: Astrophysics Research* ". He highlighted the strategic plan of world-class University and the way we can upgrade ranking of our University to reach within 500 best universities globally. "We believe that by developing faculties strength, raising research funding and collaborating with different renowned institutes we will undoubtedly achieve 2030's goal of our university", he said. Prof. Khanal in his talk emphasized the necessity of government investment in research activities and need of prioritizing scientific research from policymakers.

To add to the gravity of programme, offline messages delivered by Dr. Prajwal Kafle, who is working at the ICRAR, the Univerisity of Western Australia as a Research Associate, Dr. Sanjaya Paudel, a postdoctoral researcher at Astronomy department in Yonsei University, Seoul, and Dr. Rajan Chhetri, at the ICRAR, University of Curtin as a Research Associate, were played in multimedia. They shared their research experiences, a new avenue of research fields in astronomy in the current time thus inspiring the eager and enthusiastic participants.

Talk at the seminar hall

Around a hundred participants along with some volunteers patiently listened to the lectures and celebrated this event with night sky party. The department had offered snacks and tea. Around 50 astrophotos and posters were displayed on the corridor of the department. The best poem and best poster awards were presented with cash prize and certificate. At the night sky party, around a hundred spectator came to observe the Venus and Jupiter through the telescopes. The organizers believe that the event lived up to its expectation and hope that the culture of celebrating GAM in Nepal slowly gains pace.

The faculty and organizer of the program were Prof. Dr. Binil Aryal, Prof. Dr. Om P. Niraula, and Dr. Ajay K. Jha CDP, TU, and Raj Kumar Pradhan (Coordinator), Prakash Chalise, Pawan Giri, Ashwin Thapa Magar, Sashi Nepal, Ramesh Dhakal, Saurabh Lamsal, Mahesh Thakuri, Abhinna Rajbanshi. Supported by: BPKMPOSMD, Golden Gate International, NASO, PAS, and Beyond APOGEE.

CDP Activities

Workshop on Computational Materials Engineering and Scientific writing (CMESW-2018/ 30 December 2018)

With the goal of promoting interactions and collaborations among the local physicists in Nepal, a one day workshop on "*Computational Materials Engineering and Scientific Writing (CMESW-2018)*" was organized by Advanced Materials Research Laboratory (AMRL), Central Department of Physics (CDP), Tribhuvan University (TU), Kirtipur on 30th December 2018. The invited Guest Speaker was Dr. Dibya Prakash Rai, from Pachhunga University College, Mizoram University, India. The convener of this workshop was Dr. Madhav Prasad Ghimire, Associate Professor, CDP, TU. The main aim of this workshop was to norture the M. Sc and PhD students, as well as faculty members from within Nepal to improve their knowledge and skills on density functional theory (DFT) using different computational packages for scientific research, and to refine their scientific writing skills. This workshop was supported by Condensed Matter Physics Research Center (CMPRC), Butwal, Nepal. The participants on CMESW-2018 were around ninety-five which includes the M.Sc. and PhD students as well as the faculty members from different academic institutions in Nepal. Under the chairmanship of Prof. Dr. Om Prakash Niraula, the inaugural program was started at 10 am. The session was started with a motivational welcome speech by Prof. Dr. Raju Khanal, CDP, TU. All together seven invited speakers' gives their valuable talks in this workshop.

Dr. Gopi Chandra Kaphle gives an opening scientific talk on a review lecture on DFT. He discusses the necessary theory involved and their applications to scientific community. The second talk was by Asst. Prof. Dr. Nurapati Pantha, CDP, TU on 'Tutorial on Quantum Espresso (QE)'. He discussed the pseudopotential method QE was based, and taught how one can download those potential files from the QE¬ website for the calculations. After this presentation Prof. Dr. Pramod Aryal, Central Department of Biotechnology (CDB), TU proceeded with his talk on scientific paper writing and methodology. He shared many helpful tips on how one should carry out his/her thesis research. He described the necessary steps required to write effective paper with originality. Moreover, he shared his research experiences he got from working in different institutions all around the world. He also showcased some of the researches being carried on at CDB, TU. This presentation concluded the morning session.

Prof. Dr. Rajendra Parajuli, of Amrit College talked on 'Use of Gaussian and its Methodology'. He concisely explained the Hartree-Fock and B3LYP methods used in Gaussian. After that, Asst. Prof. Dr. Rajendra Prasad Adhikari of Kathmandu University (KU) presented his talk on Supercomputing facilities in Kathmandu University. Guest speaker Dr. Dibya Prakash Rai from PUC, India delivered a talk on 'Thermoelectric Properties using WIEN2k and BoltzTraP'. Finally, Assoc. Prof. Dr. Madhav Prasad Ghimire delivered talk on the application of using different DFT tools, and that how Full Potential Local-Orbital minimum-basis (FPLO) code is better over other pseudopotential codes.

CDP Activities

Confident, Successful and Clean CDP (5 April, 2018)

The Central Department of Physics organized one day event "*Confident Success and Clean CDP*" on 5 April 2018 with aiming to give a memorable condolence to our late scientist, theoretician and the writer Dr. Stephen Hawking. The programme was started with the discussed of contribution of Dr. Stephen Hawking in Physics and Cosmology. In the first session as a part of programme students from second semister; Niroj Kumar Shah and Sagar Rawal delivered talks on Hawking, his life and contributoin. And then respected Professor Dr. Mukunda Mani Aryal gave a lecture on "*Relativistic Cosmology*". The talk was very interactive. After that respected proffesor Dr. Binil Aryal delivered a talk on "*Hawking Ratiation*". In this way first session of the prgramme was completed.

Students and faculties cleaned CDP premises

Dr. Stephen Hawking was a British scientist, professor and author who performed ground breaking work in physics and cosmology, and whose books helped to make science accessible to everyone. At age 21, he was diagnosed with amyotropic lateral sclerosis. He died in Cambridge, England on March 14, 2018 at age of 76.

This programme was divided into two sessions. First session was to discus about hawking and his contribution in Physics. After discussing about Hawking and his contribution there is a short break. The break is for the tea and biscuit. All participants were ready to start second session of the programme. In second session students, faculty members along with staff cleaned department with slogan Confident, Success and Clean CDP.

Confident Success and Clean CDP

To make this event effective and joyfull the faculty members and students are divided in different groups. Gopi sir and his team's task was to clean the Nuclear lab, General lab, Electronics lab and passage infront of them, Nurapati Sir and his team's task was to clean the ground inside the octagon building, Ajaya sir and his teams's task was to clean the class room and passage infront of it. Sanju mam and her team's task was to clean the library, semminar hall and passage infront of it. All groups have done their job sincerly and cleaned our CDP. This programme was very successful. The success of this programme was distinctly visible with the cleaness of CDP.

CDP Activities

TU Futsal Competition (BS 2075)

As a part of extracurricular activities, Central Department of Physics with the collaboration with Central Department of Chemistry, TU organized the TU Futsal Competition -2075 from Ashad 20 to 22 in Kirtipur. Prof. Dr. Ram Chandra Basnet, Head of Central Department of Chemistry and the chief guest of the opening ceremony inaugurated the tournament with the concise and inspiring speech explaining the importance of sports on the all-round growth of the students. Similarly, Prof. Dr. Narayan Prasad Adhikari, special guest of the event gave a succinct and inspiring speech underlying the importance of extracurricular activities on education. At the same event, Mr. Kamalchandra Nepali, Co-ordinator of Physics & Chemistry University Student Association, highlighted the purpose of conducting the tournament and delivered a welcome speech welcoming all the participants from various Departments in the tournament. Before the kick off of official matches, a friendly match was played between distinguished faculties and staffs of CDP and CDC. Prof. Dr. Raju Khanal, special guest of the event, opened the friendly match by kicking the ball. The match was exhilarating enough to watch; team CDP won the game by five to one. Suman Acharya, host of the opening ceremony, thanked all the participants of the program and declared the end of opening ceremony.

Cheering momet after a long

Twenty-two teams participated in the tournament; the first game if the tournament was played between Central Department of Management and Central Department of education. The referee of the game was Dipesh Paudel. Although all the participating teams were demonstrated outstanding talents to win games, only two teams, by rules, managed to reach the finale. The final match between host team and School of Managements was absorbing and exciting to watch as each player evinced their sensational and electrifying knack. The Host team (CDP) clinched the title by beating the School of Management team by 5 goals to 1, taking the revenge of previous competition held last year.

Host team clinched the first place. The School of Management, TU secured the first runner up position of the tournament. Anupam Marasini , the striker of School of Management was awarded the Man of the Series Award for his outstanding skills and contributions throughout the tournament. On the other hand, Aakash Limbu, the striker of the host team captured Highest Goal Scorer Award of the tournament scoring 10 goals. He was highly praised by the audiences due to his sensational finishing. Similarly, Pushkar Thapa, goalkeeper of the host team, won the best goalkeeper award of the tournament. He just conceded two goals during the tournament and, interestingly, scored two goals during the tournament, though he was a goalkeeper.

Last year's runner wins this year's trophy!

Prof. Dr. Binil Aryal, Head of Central Department of Physics, Chief Guest of closing ceremony, performed the closing ceremony of TU Futsal Competition-2075. He gave a succinct and inspiring speech underlining the importance of extra-curricular activities on education. Furthermore, He lavishly appreciated all the teams for their participation and expressed his genuine congratulations to the winner and the first runner-up team. Also he expressed his kudos to all the helping hands of the tournament. During the award distribution ceremony, Prof. Dr. Binil Aryal along with other faculties of CDP awarded the trophy, medals and certificates jointly. Finally, Ravindra Aryal, the host of closing ceremony thanked all the members of the tournament for their direct or indirect support to make TU Futsal Competition-2075 a grand success and declared the end of the tournament.

CDP Activities

Welcome & Farewell Program (27 December 2018)

One of the most anticipated events for any incoming and outgoing batch is their welcome and farewell program, held with the objective to welcome the new students into the Ace Family with a lot of love and warmth, and bidding the outgoing batch goodbye, expressing gratitude to them for their contribution at Ace, and wishing them the best for their future. And all of this is done with a lot of fun and frolic.

Entrance Topper Hari Timsina receiving award from HoD

Third semester students of batch 2073, CDP, TU organized '*welcome and farewell program*' on 27 December 2018 (12 Paush 2074) at the auditorium Hall, Education building premises, Kirtipur. All the faculties, Ph.D. students and staffs attended the program. The main aim of this program was to welcome first semester students and farewell fourth semester students. The goals and objectives of welcome program is to introduce students to familiarize students with the campus environment and physical facilities and to create an atmosphere that minimizes anxiety, promotes positive attitudes, and stimulates an excitement for learning. In addition, student leaders will have opportubity to gain valuable leadership experience at the college level.

Our students performing

Prof. Dr. Binil Aryal, HoD, shared his words to every person present during the program. He said that the time has come to think on the '*need of physics for the nation*'. He said that the smell and flavor of motherland can not feel in abrood. Nation needs contribution in terms of applicable research from fundamental science as well.For this, Prof. Aryal hinted that the curriculum need a thorough revision. Prof. Dr. Narayan Pd Adhikari advised students to be academic and professional both. Dr. Sanju Shrestha suggested students to focus of practical to develop skill.

On the behalf of CDP family, senior faculty welcomed all first semester students by giving a tika and welcome momento. At the end, HoD of CDP handed 'token of love' to all pass-out fourth semester students. There was musical welcome lead by national anthem in the beginning of the program.

Fourth Semester students celebrating farewell

The highlight of the program was the *sarangi* performance by fourth semester student Kiran Neupane.

With Token of Love

Niranjan Bhatt, Sanjeev Sapkota, Madan Somai, Sagar Rawal, Dipak Chaulagain, Arun Kumar Karn, and many others perform at the stage. Sujan Prasad Gautam, Gita Pandey, Pramod Subedi, Ram Chandra Nepal and many others presented their poem. Babita Gyawali, Tirtha Bhatt, Laxmi Bhujel, Ependra Tamang, Ganesh Shrestha, Neelima Sharma and Kisan Khatri perform on the stage differently.

CDP News
International Publications (2017-2019)

2019 (till March)

1. Arjun Kumar Gautam & **Binil Aryal**, A study of four low-latitude ({\mid } l{\mid }<10°) far-infrared cavities, *Journal of Astrophysics and Astronomy, Springer*, 40, 2, 116-125 (2019). DOI: 10.1007/s12036-019-9578-1
2. Binod Adhikari, Niraj Adhikari, **Binil Aryal**, Narayan P. Chapagain, Ildiko Horvath, Impacts on proton fluxes observed during differennt interplaneray conditions, *Journal of Solar Physics, Springer*, 295(3), 163 (2019). DOI: 10.1007/s18217-03482
3. **R. P. Regmi**, Kitada, T., Maharjan, S., Shrestha, S., Shrestha, S., & Regmi, G., Winter time boundary layer evolution and air pollution potential over the Kathmandu Valley, Nepal, *Journal of Geophysical Research: Atmospheres,* **124**, XXX (2019). DOI: https://doi.org/10.1029/2018JD030198
4. Suresh Basnet and **Raju Khanal**, Kinetic trajectory simulation method for the multi-component magnetized plasma sheath, accepted for publication in Plasma Physics and Controlled Fusion (published online 01 April) (2019). DOI: 10.1088/1361-6587/ab1708
5. Suresh Basnet and **Raju Khanal**, Magnetized plasma sheath properties in the presence of Maxwellian low-temperature and non-Maxwellian high-temperature electrons", Physics of Plasmas (published online 11 April) (2019).. (#POP19-AR-56926R1)
6. Ghanshyam Thakur, **Raju Khanal** and Bijoyendra Narayan, Characterization of Arc Plasma by Movable Single and Double Langmuir Probes, Fusion Science and Technology (published online 17 April) (2019). DOI: 10.1080/15361055.2019.1579623
7. Zeisner, A. Alfonsov, S. Selter, S. Aswartham, **M. P. Ghimire**, M. Richter, J van den Brink, B. Büchner, & V. Kataev, Magnetic anisotropy and spin-polarized two-dimensional electron gas in the van der Waals ferromagnet Cr2Ge2Te6, *Physical Review B*, APS,99, 165109 (2019). DOI: 10.1103/PhysRevB.99.165109
8. **M. P. Ghimire**, J. I. Facio, J.-S. You, Linda Ye, J. G. Checkelsky, S. Fang, E. Kaxiras, M. Richter & J. van den Brink, Creating Weyl nodes and controlling their energy by magnetization rotation, arXiv:1903.03179 (2019).
9. **M. P. Ghimire**, J. I. Facio, J.-S. You, Linda Ye, J. G. Checkelsky, S. Fang, E. Kaxiras, M. Richter & J. van den Brink, Creating Weyl nodes and tuning their energy by magnetization rota-tion in a metallic ferromagnet, *Bulletin of the American Physical Society*, MAR19, B04.6 (2019).
10. Bishnu P. Belbase, Dinesh K. Yadav, Shalika R. Bhandari, **Gopi C. Kaphle**, and **Madhav P. Ghimire**, Investigations of electronic and optical properties of double perovskite Ba2BiSbO6, *Bulletin of the American Physical Society*, MAR19, P33.14 (2019).
11. Dinesh K. Yadav, Bishnu P. Belbase, Shalika R. Bhandari, **Madhav P. Ghimire** & **Gopi C. Kaphle**, Electronic structure and magnetic phase transition in double perovskites La2-xNaxMnMoO6 (x=0, 0.5, 1.0, 1.5, 2.0), *Bulletin of the American Physical Society*, MAR19, B07.13 (2019).

2018

12. **A. K. Jha**, **B. Aryal,** R. Weinberger, Dust color temperature distribution of two FIR cavities at IRIS and AKARI maps, Journal of Astrophysics and Astronomy, Springer, 39, 2, 24-32 (2018). DOI: 10.1007/s12036-018-9517-6
13. A. K. Gautam & **B. Aryal**, A Study of Dusty Environment at Far Infrared IRAS Map Around the Mass-Losing Carbon-rich AGB Star at Latitude -53 degree, *International Journal of Applied Physics (IJAP),* 9(1), 24 (2018).
14. A. K. Gautam & **B. Aryal**, A Study of Dusty Environment at Far Infrared IRAS Map Around the Mass Losing Carbon-rich AGB Star at Latitude -59.6 degree, *International Journal of Multidisciplinary Research Review (IJMDRR)*, 1(35), 45 (2018).
15. **Bal Ram Ghimire**, Shanker Prasad Chimouriya, Ju H. Kim, Collective Phase Frustrationand Time Reversal Symmetry Broken on Single Long Josephson JunctionBased on MgB2Superconductor, *Journal of Applied Physics (IOSR-JAP)*, iosrjournals.org, **10**, 5 Ver. II, 38-44 (2018). DOI:10.9790/4861-1005023844.
16. Shanker Prasad Chimouriya, **Bal Ram Ghimire**, Ju H. Kim, Phase Dynamics of SingleLong Josephson Junctionin MgB2Superconductor, *AIP Conference Proceedings, American Institute of Physics*, **1953**, 120074-1-1200744 (2018). DOI:10.1063/1.5033139.
17. Yubaraj Regmi, Roshan Chalise and **Raju Khanal**, Response of Carbon and Tungsten Surfaces to Hydrogen Plasma of Different Temperatures, *Physics of Plasmas* 25, 043521 (2018). DOI: 10.1063/1.5020386
18. Suresh Basnet and **Raju Khanal**, Effects of Collision and Ion Mach Number on Magnetized Plasma Sheath with Two Species of Positive Ions, *AIP Advances* 8, 105321 (2018). DOI: 10.1063/1.5045370
19. G. S. Thakur, **R. Khanal** & B. Narayan, Comparative Study of Plasma Parameters by using Movable Langmuir Single and Double Probe in Arc Plasma, International *Journal of Information Research and Review* (IJIRR), ISSN: 2349-9141, 5, 9, 5700-5704 (2018)
20. G. S. Thakur, **R. Khanal** & B. Narayan, Measurement of Plasma Density in Brass Arc at Atmospheric Pressure using a Langmuir Single Probe, *Journal of Materials Science and Engineering B*, 8, 143-149 (2018) DOI: 10.17265/2161-6221/2018.7-8.002
21. S. Pokharel, N. Aryal, B..R. Niraula, A. Subedi, **N..P. Adhikari**, Transport properties of methane, ethane, propane, and n-butane in water, *Journal of Physics Communications* 2 (6), 06500. DOI: 10.1088/2399-6528/aabc45
22. H. P. Bhusal, **N. P. Adhikari**; Molecular Dynamics Study of Transport Properties of Cysteine in Water, arXiv preprint arXiv:1809.08768 (2018)
23. D. Pandey, **N. P. Adhikari**; Transport properties of Valine in water at different temperatures, arXiv preprint arXiv:1809.04996 (2018)
24. E. Mishra, **N. P. Adhikari**; Transport properties of Gamma-Aminobutyric Acid in water, arXiv preprint arXiv:1806.09956 (2018)

25. **M. P. Ghimire**, J. van den Brink & M. Richter, Cleavage energies of layered materials: Bi14Rh3I9, Bi2TeI, β-Bi4I4 and 2H-MX2,Bulletin of the American Physical Society, MAR18, B07.13 (2018)
26. Dinesh K. Yadav, Sunil Lamichhane, Shalika R. Bhandari, Bishnu P. Belbase, **Gopi C. Kaphle** & **Madhav P. Ghimire**, A possible spin orbit coupling assisted semiconductor in AlaNiOsO6 (A=Sr, Ba), *Bulletin of the American Physical Society* MAR18, K23007Y (2018).
27. S. P. Kollur, R. R. Pillai, **M. P. Ghimire**, R. Ray, M. Richter, Stevan Armakovic & Sanja Armakovic, Indole moiety induced biological potency in pseudo- peptides derived from 2-amino-2-(1H-indole-2-yl) based acetamides: synthesis, structure and computational investigations arXiv: 1802.04096v1 (2018).
28. **P. B. Adhikari**, Time Varying Electric and Magnetic Fields from Lightning Discharge. International Journal of Electrical and Electronic Science. *American Association for Science and Technology*, 5, 2, 50-55(2018).
29. **P. B. Adhikari** & B. Bhandari, Jefimenko Equations in Computation of Electromagnetic Fields for Lightning Discharges. *International Journal of Scientific & Engineering Research*. 9, 6, 1678 - 1687 (2018).

CDP News

Three Ph.D. Awarded in Physics: 2018-19

Dr. Ajay Kumar Jha

Institute of science & technology (IoST), TU awarded Ph.D. degree to Mr. Ajay Kumar Jha, Associate professor of Central Department of Physics, TU on 30 September 2018. The Ph.D. thesis title of Mr. Jha is '*Structures Around Neutron Star and Pulsar: A Study of Shaping Mechanism in the ISM*'.

The supervisor and co-supervisors of this Ph.D. work is Prof. Dr. Binil Aryal of CDP, TU and Prof. Dr. Ronald Weinberger of Innsbruck University, Austria. There were about 100 participants during viva-voce program. The Dean, Assistant Deans, Research committee members, Professors, faculties of science departments, Ph.D. and masters' students attended the program.The external examinor was Prof. Dr. Narayan Prasad Chapagain of Amrit College, TU.

Dr. Pitri Bhakta Adhikari

Institute of science & technology (IoST), TU awarded Ph.D. degree to Mr. Pitri Bhakta Adhikari, Assistant professor of Tri Chandra College, TU on 21 Jan 2019. The Ph.D. thesis title of Mr. Adhikari is '*Investigation of the features of Electromagnetic Fields due to Lightening Measured in Kathmandu'*.

The supervisor and co-supervisors of this Ph.D. work is Prof. Dr. Kedar Nath Baral and Dr. Sri Ram Sharma of Amrit College, TU.

The external examinor was Prof. Dr. Rabindra Arora of Gorgaon, India. During viva-voce examination, Prof. Dr. Lok Narayan Jha, Prof. Dr. Shekhar Gurung, former HoDs of CDP were present.

Dr. Kisori Yadav

Institute of science & technology (IoST), TU awarded Ph.D. degree to Mr. Kisori Yadav, Associate professor of Patan Multiple College, TU on 2 April 2019. The Ph.D. thesis title of Mr. Yadav is '*Theotritical Study of Multiphoton Ionization of Hydrogen Atom by Non-perturbative Method with Intense Laser Pulse'*.

The supervisor of this Ph.D. work is Prof. Dr. Jeevan Jyoti Nakarmi of CDP, TU. The external examinor was Prof. Dr. Lok Narayan Jha, former head of CDP, TU.

CDP News
Talk Program at CDP (2017-2018)

2018

1. **Dr. Laxman Mainali**, Department of Biophysics, Medical College of Wisconsin, Milwaukee, WI, USA delivered a talk entitled ***'Membrane Cholesterol in Eye Lens Health***' on 22 Jan 2019.
2. **Dr. D. P. Rai**, Physical Sciences Research Center, Pachhunga University College, Aizawl, India delivered a talk entitled ***'Theoretical Investigation of New Class of Thermoelectric Materials among the Family of half-Heusler compounds***' on 26 Dec 2018.
3. **Dr. Michael S. Kirk**, Research Scientist, Heliophysics Science Division, Goddard Space Flight Center, NASA, USA, delivered a talk entitled **'Measurements of Polar Coronal Holes**' on 14 Nov 2018.
4. **Dr. Michael S. Kirk**, Research Scientist, Heliophysics Science Division, Goddard Space Flight Center, NASA, USA, delivered a series of three talks during 15-18 November, 2018. In the talks, Dr. Kirk described the theory regarding few issues of ***Solar Physics*** and about ***NASA's freely available database and software***. CDP hold a discussion with Dr. Kirk and decided to organize 2 weeks workshop in the next year.
5. **Dr. Krishna Neupane**, Dept of Physics, University of Alberta, Canada delivered a talk entitled ***'Direct observation and characterization of transition paths during the folding of Biomolecules'*** on 25 October 2018.
6. **Dr. Fernando Quevedo**, Director of International Centre for Theoretical Physics (ICTP) visited our department on 14 October, delivered a speech on ***'Impotance of fundamental science for the development***'.
7. **Dr. Amod Pokhrel,** Lecturer, Department of Environmental Health Sciences, University of California, Berkeley delivered a talk entitled ***'Maximizing the environment and health benefits of clean air in urban Nepal***' on 16 August 2018.
8. **Dr Rajan Chhetri**, Postdoctoral Researcher, International Centre for Radio Astronomy Research (ICRAR), Curtin University, Australia & also at ARC Centre of Excellence for All-sky Astrophysics (CAASTRO) delivered a talk on ***'Studying low frequency sub-arcsecond radio source populations with the Murchison Widefield Array***' on 21 March 2018.
9. **Dr. Madhav Prasad Ghimire**, Post Doc Scholar, IFW Dresden, Germany delivered a talk on ***'Chemical gating of a weak topological insulator & cleavage energies of layered materials***' on 29 April 2018.
10. **Prof. Dr. Kazuo SHIOKAWA**, Institute for Space-Earth Environmental Research (ISEE), Nagoya University, Japan, delivered a talk entitled ***'Introduction to the Solar-Terrestrial Physics***' on 3 May 2018.
11. **Dr. Bandan Chakraborty** of Plant Developmental Biology, Wageningen University, The Netherlands, delivered a talk entitled ***'Microtuble-based mechanism for cell division orientation in plant embryogenesis***' on 4 September 2018.
12. **Dr. Chetan Dhital**, Post Doctorate Fellow, Louisiana State University, USA delivered a talk entitled ***'Controlling Topological spin Textures in Metallic Magnets***' on 6 July 2018.
13. **Dr. Amba Datt Pant**, Post Doc Scholar, College of Science, Ibaraki University, Japan & Muon Science Laboratory, Institute of Materials Structure Science, High Energy Accelerator Research Organization (KEK), Ibaraki, Japan, delivered a talk on ***'Ultra slow Muon and its Applications***' on 7 May 2018.
14. **Dr. Nirmal J. Ghimire**, Director's Postdoctoral Fellow, Materials Science Division, Argonne National Laboratory, USA delivered a talk entitled ***'A Materials-Driven Approach to Condensed Matter Physics***' on 10 July 2018.
15. **Dr. Iswar Koirala**, Associate Professor, CDP, TU delivered a talk on ***'ORDERING AND SEGREGATION IN BINARY LIQUID ALLOYS***' on 10 May 2018.
16. **Prajwal Niraula**, Ph D Candidate, MIT, USA delivered a talk on ***'Planet Hunting and Characterization*** with K2' on 13 July 2018.
17. **Ramesh Mainali**, Ph.D. Candidate, Steward Observatory, University of Arizona, USA, delivered a talk entitled ***'Spectroscopy of galaxies in the first billion years of cosmic time***' on 24 May 2018.
18. **Prof. Dr. Jaichan Lee**, School of Advanced Materials Science and Engineering, Sungkyunkwan University, Suwon, Korea, delivered a talk entitled ***'Defects in Functional Oxides***' on 25 April 2018.
19. **Dr. Hem Raj Sharma**, The University of Liverpool, the United Kingdom delivered a talk entitled ***'Quasicrystals with Crystallographic Rotational Symmetry***' on 30 March 2018.

2017

1. **Dr. M. K. Radhakrishnan**, Vice-President, IEEE Electron Device Society, Founder Director, NanoRel, Bagalore, India delivered a talk entitled ***'Semiconductor Technology Progression and 50 years of Moore'*** on 15 September, 2017.
2. **Dr. Yuwaraj Kshetri**, Post-Doc Scholar of SMU, Korea delivered a talk on ***'Near infrared to visible upconversion in Alfa-SiAlON and first principles study of electronic properties of Er-alfa-SiAlON*** ' on 4 August 2017.
3. **Dr. Mim Lal Nakarmi**, Associate Professor and Chairperson, Department of Physics, Brooklyn College of the City University of New York (CUNY), Brooklyn, New York, USA delivered a talk on "***Resonant optical properties of AlGaAs/GaAs multiple-quantum-well based Bragg structure at the second quantum state***" on 25 July 2017.
4. **Dr. Akhilesh Singh**, Sr. Scientist, Princeton LightWave, NJ, USA delivered a talk on ***'Nanoengineered mid-IR plasmonics with single-layer Graphene for optoelectronic applications***' 28 June 2017.
5. **Dr. Prem Chapagain,** a post doctorate fellow of Florida International University, USA is delivering a talk on ***'Transformer-like molecular nanomachines'*** on 19 June 2017.
6. **Dr. Santosh K.C.** of Oak Ridge National Observatory, USA delivered a talk entitled ***'First-principles investigation of surface, interface, and interlayer couplings of van der Waals materials***' on 5 May 2017.
7. **Dr. Biplab Sanyal**, Docent, Associate Professor (Universitetslektor), Division of Materials Theory, Department of Physics and Astronomy, Uppsala University delivered a talk on ***'Molecular magnetism – a theoretical perspective***' on 31 Jan 2017.
8. **Dr. Matteo Marsili**, Senior Research Scientist, Quantitative life sciences, Abdus Salam ICTP, Trieste, Italy delivered a talk entitled ***'On the Importance of Being Critical***' on 4 Jan 2017.

CDP News

Masrers' Dissertation at CDP: 1990 to 2018

Central Department of physics compiled a database of masters' dissertation of last 28 years. This was done by listing the hard copies of masters' dissertation that we have at our departmental library. There are 1023 masters' dissertations at the library. A complete list with the title of dissertation, name of students, name of supervisor and the year of viva examination are compiled. Now it is available at the official webpage of CDP (https://tucdp.edu.np/thesis/).

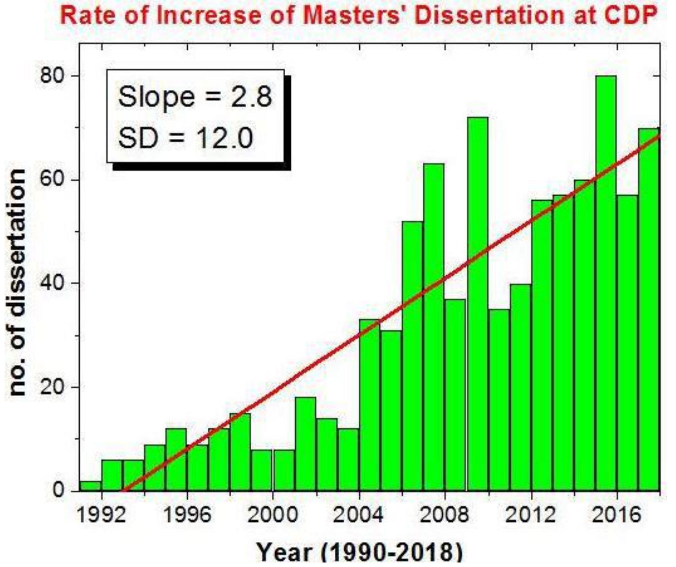


Figure 1: *Rate of increase of masters' dissertation from 1990 to till date. The slope is found to be 5.5. The average number of masters' dissertation is found to be 32 per year.*

Thity nine supervisors and more than 25 co-supervisors have been found to involve in the dissertation supervision of M.Sc. (Physics) students in last 28 yearsOut of this, nine supervisors supervised more than 40 masters' dissertation. These are Prof. Dr. Devendra Raj Mishra, Prof. Dr. Lok Narayan Jha, Prof. Dr. Shekhar Gurung, Prof. Dr. Shesh Kant Aryal, Prof. Dr. Uday Raj Khanal, Prof. Dr. Jeevan Jyoti Nakarmi, Prof. Dr. Binil Aryal, Prof. Dr. Raju Khanal and Prof. Dr. Narayan Pd Adhikari. Electronic files (pdf) of about 50% dissertations are available. The rest 50% dissertations need to be dizitised. CDP is trying to make all dissertations available electronically. CDP have begun scanning dissertations. Mr. Sagar Rawal, a third semester students and his team has done remarkable work in compiling the database. Till date, only the front page, abstract page and evaluation page has been scanned and made it available for all.

. Dissertation is not compulsory in M.Sc. (Physics) till date, mainly because of less number of supervisors in the central department as well as in colleges. The ratio of number of students per faculty at CDP is about 17. In other colleges, this ratio is even larger. Therefore, more research faculty is needed to fulfil this demand.

Table 1: List of supervisors who supervised masters dissertation of CDP students. The last column shows the number of students supervised. The grey shaded shows the supervisor's who supervised more than 40 M.Sc. (Physics) students.

SN	Supervisor's Name	No. of thesis
1	Dr. Ajay Kumar Jha	2
2	Dr. Bal Ram Ghimire	10
3	Dr. Balkrishna Sapkota	11
4	Dr. Bhadra Prasad Pokharel	18
5	Dr. Bidyapati Jha	2
6	Dr. Bimal Prasad Karki	4
7	Dr. Binil Aryal	161
8	Dr. Binod Kumar Bhattarai	10
9	Dr. Buddha Ram Shah	8
10	Dr. Deepak Raj Pant	2
11	Dr. Devendra Raj Mishra	57
12	Dr. Devi Dutta Paudyal	18
13	Dr. Gopi Chandra Kaphle	27
14	Dr. Hari Bahadur Karki	6
15	Dr. Hari Prasad Lamichhane	24
16	Dr. Jeevan Jyoti Nakarmi	88
17	Dr. Kedar Nath Khanal	5
18	Dr. Lok Narayan Jha	52
19	Dr. Mukunda Mani Aryal	28
20	Dr. Nanda Bahadur Maharjan	8
21	Dr. Narayan Pd Adhikari	132
22	Dr. Nurapati Pantha	11
23	Dr. Pradeep Kumar Bhattarai	14
24	Dr. Rajendra Parajuli	4
25	Dr. Raju Khanal	54
26	Dr. Ram Prasad Regmi	38
27	Dr. Sanju Shrestha	15
28	Dr. Shankar Prasad Shrestha	12
29	Dr. Shanta Lall Shrestha	2
30	Dr. Shekhar Gurung	47
31	Dr. Shesh Kanta Aryal	59
32	Dr. Sita Ram Joshi	2
33	Dr. Sitaram Prasad Byahut	14
34	Dr. Surendra Raj Kafle	2
35	Dr. Triratna Bajracharya	2
36	Dr. Uday Raj Khanal	47
37	Dr. Yagya Prasad Dhungana	4
38	Mr. Rajendra Prasad Koirala	12
39	Mr. Tika Ram Lamichhane	7
Total		1023

According to the list at the administration, there should be around 1130 masters' dissertations. About 110 masters' dissertation are not found in the library. The most of them are old one (before 1992). Probably, because of the shift from old building to the new, these dissertations were lost. Now CDP is trying to collect it from individuals and Central Library. A few dissertations are found and added. We hope to compile hard copy as well as soft copy of our M.Sc.(Physics) dissertation within a year.

CDP News

CDP Alumni: BS 2022-2075

The aim of the formation of CDP Alumni database is to bring together all the old students and the faculty to share their experiences with each other. In addition, CDP intend to utilize the rich experiences of old students for the benefit and progress of the present students. A compilation of M.Sc.(Physics) students enrolled from BS 2022 to till date in the Central department of physics has been completed. A complete list of CDP Alumni is given in the CDP webpage (https://tucdp.edu.np/std/main/). In the database, name of CDP Alumni, enrolled year, their district, e-mail and mobile number has been added.

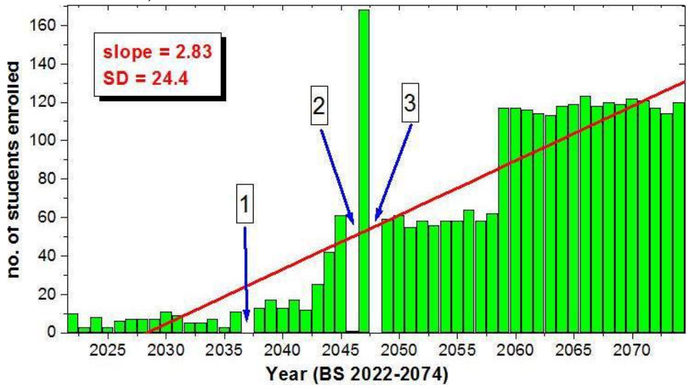


Figure 1: *Distribution of enrolled students at CDP during last 53 years. There were no enrollment in the year BS 2037, 2046 and 2048 because of public movements named 'Janmat Sanghra' and 'Democracy'.*

The gender distribution is shown in Figure 2. Only 118 (4.2%) female students studied physics at CDP.

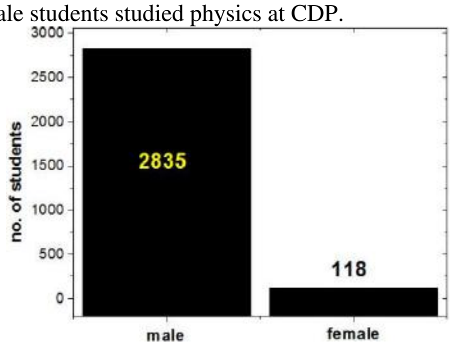


Figure 2: *Female enrollmenmt in M.Sc. (Physics) is rather low.*

Table 1 shows district-wise distribution of CDP Alumni members. List shows that CDP remained a common platform for the study. Students from almost all district of the nation studied physics at CDP.

SN	District	Number
1	Achham	6
2	Arghakhanchi	28
3	Baglung	34
4	Baitadi	20
5	Bajhang	10
6	Bajura	4
7	Banke	24
8	Bara	24
9	Bardiya	30
10	Bhaktapur	26
11	Bhojpur	8
12	Chitwan	74
13	Dadeldhura	6
14	Dailekh	4
15	Dang	62
16	Darchula	6
17	Dhading	24
18	Dhankuta	4
19	Dhanusha	22
20	Dolakha	18
21	Doti	8
22	Gorkha	30
23	Gulmi	66
24	illam	18
25	jajarkot	6
26	Jhapa	110
27	Kailali	48
28	Kalikot	4
29	Kanchanpur	38
30	Kapilvastu	28
31	Kaski	60
32	Kathmandu	76
33	Kavre	24
34	Kavrepalanchwok	12
35	Khotang	4
36	Lalitpur	16
37	Lamjung	20
38	Myagdi	16
39	Mahottari	36
40	Makwanpur	24
41	Morang	86
42	Nawalparasi	36
43	Nuwakot	12
44	Okhaldhunga	4
45	Palpa	48
46	Panchthar	8
47	Parbat	44
48	Parsa	14
49	Pyuthan	20
50	Ramechaap	10
51	Rasuwa	4
52	Rautahat	12
53	Rolpa	8
54	Rukum	4
55	Rupendehi	76
56	Salyan	8
57	Sankhuwasabha	14
58	Saptari	18
59	Sarlahi	14
60	Sindhuli	8
61	Sindhupalchowk	12
62	Solukhumbu	4
63	Siraha	12
64	Sunsari	22
65	Surkhet	22
66	Syangja	64
67	Tanajun	38
68	Taplejunj	4
69	Tehrathum	14
70	Udayapur	12

CDP aims to form a formal body of CDP alumni in near future. CDP seeks to get the valuable advices of the Alumni for the overall development physics education and research. In addition, we need to arrange cultural and social welfare programs to the society as well.

CDP News

Curriculum of Ph.D. (Physics) Second Semester

Central Department Research Committee (CDRC) approved curriculum for Ph.D. second semester courses prepared by the suoervisors of Ph.D. (physics) projects. These courses are forwarded to the faculty board through subject standing committee of Physics Subject Committee. IoST, TU have implemented compulsory 18 CH courses to the Ph.D. students since 2017, as per Ph.D. Operational Guideline, UGC, 2016. The nature of the courses, course title, code and credit hour (CH) are a follows:

Nature of the course	Course Title	Course Code
Compulsory	Advanced Research Methodology in Physics	PHY751
Elective	Advanced Astrophysics	PHY761
Elective	Materials Thermodynamics A	PHY762
Elective	Vibrational Spectroscopy and Quantum Mechanical Methods	PHY763
Elective	Advanced Solid State Physics	PHY764
Elective	Advanced Plasma Physics	PHY765
Elective	Atmospheric Physics and Energy	PHY766
Elective	Space Physics	PHY767
Elective	Materials Thermodynamics B	PHY768
Elective	Material Science and Computational Physics	PHY769

The curriculum of compulsory course 'Advanced Research Methodology in Physics' is as follows:

PHY751 Advanced Research Methodology in Physics

Full Marks: 75 Pass Marks:37.5
Nature: **Practical/Computational**
Credit Hours: **3** Semester: **II**

Course Description:
The aim of the course is to impart some fundamental knowledge of advanced research methodology in physics.

Course Objectives:

- *To train the students in the methods of research in physics*
- *To provide students basic ideas of experimental physics research*
- *To provide students basic ideas of computational tools*
- *To train students to apply the tools to solve the real problems in their research work*

Course Content:

1. **Research Methodology:** 1.1 Scientific research – Aim and motivation, 1.2 Principles and ethics, plagiarism; 1.3 Identification of research problem, Current status; 1.4 Literature survey, Abstraction of a research paper, 1.5 Access using Internet web tools, Journals, 1.6 Processing of experimental data, 1.7 Errors in experimental data, 1.8 Interpretation of data. [15 hours]
Note: *Students are encouraged to analyze data on any two of experiments like (i) Measurement of background radiation using gamma ray spectrometer, (ii) Solar UV measurements using UV meter, (iii) Measurement of solar radiation using pyranometer, (iv) Estimation of Carrier concentration of a Semiconductor measuring Hall Coefficient (v) Determination of band gap in phonon spectrum of diatomic solid. Students are expected to need to prepare a report with required error analysis.*

2. **Computational Methodology:** 2.1 Introduction- Error, Precision, and Stability in Computational Science; Limitations of Computational Physics 2.2 Operating Systems – MS Windows and Linux, 2.3 Editors in Linux 2.4 Latex, Plotting programs – Gnuplot/Xmgrace, fitting of data, estimation of errors 2.5 Mathematica, 2.6 High performance computing basics: Elements of Fortran 90, Constants and variables, Arithmetic expressions, I/O statements, Logical expressions, Conditional and control statements, Arrays, Functions and subroutines, Format statements 2.7 Numerical methods- Interpolation by cubic spline, Monte Carlo Integration, One-Dimensional Schroedinger equation (example with anharmonic potential) 2.9 Applications of Software and Libraries: LAPACK, BLAS (Basics only) 2.10 Monte Carlo Simulation of Ising model. [30 hours]
Note: *Students should be able to write fortran code for a given project. Each student must carry on a project different than others. At the end they should write a report and present in seminar. The projects may include but not limited to solution of (i) Laplace equation (ii) Diffusion equation (iii) Harmonic oscillator (iv) Damped harmonic oscillator (v) Force on a charged particle in a constant magnetic field (vi) angular momentum of planetary motion (vi) total cross-section for Rutherford scattering (vii) motion of particle in static electric field (viii) three body problem (ix) Morse potential of diatomic molecules (x) anisotropic harmonic oscillator (xi) projectile with air resistance (xii) phase space trajectories of N identical, independent harmonic oscillators (say N=20) (xiii) trajectories of logistic map (xiv) bifurcation diagram (xv) relativistic motion.)*

Suggested Books/literatures:

1. Computational Physics, K.N. Anagnostopoulos, National Technical University, Athens, 2014
2. Computational Methods for Physics, J. Franklin, Cambridge University Press, Cambridge, 2013
3. S. Rajasekar, P. Philominathan, V. Chinnathambi; arXiv:***physics***/0601009v3 (2013)

Evaluation:

1. Report writing and presentation of seminar by each student will be the modality for evaluation of this course.
2. A student must submit report for unit 1 (within 7th week of the semester) & 2 (within 15th week of the semester) separately.
3. Report of unit 2 has to be presented by each student during 16-18th week of the semester.
4. All examination will be conducted by CDRC.

List of Our Graduates Leaving for Ph.D. during 2018-19

SN	Name of Student	University	Email Address
1	Anish Dhungana	Texas state University	ad_akkyog@gmai.com
2	Aditya Lamichhane	Arizona State University	lamichhance.aditya@gmail.com
3	Arjun Subedi	University of Nebraska Lincoln	arjubedi@gmail.com
4	Ashok Shrestha	Ohio University	ashoksth76@gmail.com
5	Bibash Sapkota	University of Illinois at Chicago	sapkotabibash@gmail.com
6	Bibek Tiwari	University of Nebraska Lincoln	tiwaribibek@live.com
7	Bikash Panthi	University of Houston	bikash.sanjit@gmail.com
8	Bikram Dhoj Shrestha	University of Miami, Florida	bikramdhojshrestha@gmail.com
9	Deepa Devkota	Texas state University	Dipa.dvk@gmail.com
10	Ek Narayan Paudel	University of Delaware	narayan@udel.edu
11	Esha Mishra	University of Nebraska Lincoln	eshamishra.92@gmail.com
12	Ganesh Pandey	University of Illinois at Chicago	pandeyganeshg@gmail.com
13	Gokul Acharya	University of Arkansas	mailgokul7@gmail.com
14	Govinda Kharal	University of South Carolina, Columbia	gkharal@email.sc.edu
15	Hem Prasad Bhusal	University of California, Santa Cruz	hemprasadbhusal@gmail.com
16	Kamal Thapa	Kent State University	kthapa@kent.edu
17	Keshav Bhattarai	University of Louisiana at Lafayette	keshab_aavi@yahoo.com
18	Kushal Rijal	University of Kansas	kushalko85@gmail.com
19	Laxman Sharma Poudel	University of South Dakota	laxmansharmapaudel@gmail.com
20	Paras Regmi	Louisiana State University	parasregime2073@gmail.com
21	Pawan Giri	University of Nebraska Lincoln	iampawangiri@gmail.com
22	Pradip Adhikari	University of Tennessee, Knoxville	adhprdp@gmail.com
23	Prakash Sharma	Florida State University	ps18f@my.fsu.edu
24	Pramod Ghimire	Texas state University	pramodghimire625@gmail.com
25	Prawin Rimal	Not finalized yet (MS)	cosmicprawin@gmail.com
26	Romakanta Bhattarai	The University of Memphis	romakantabhattarai88@gmai
27	Sagar Adhikari	Clemson University, South Carolina	adhikaree.sagar@gmail.com
28	Sapan Luitel	Mississippi State University	sl2008@msstate.edu
29	Sarad Gautam	Texas state University	sarad.g321@gmail.com
30	Saraswati Shrestha	Oklahoma State University	sara.shrestha649@gmail
31	Sijan Regmi	Ohio University (MS)	sijanregmi4444@gmail.com
32	Subash Poudel	University of South Carolina	subashpoudel43@gmail.com
33	Sudip Shiwakoti	Baylor University,Waco, Texas	shiwakotisudip1993@gmail.com
34	Suvechhya Lamichhane	University of Nebraska Lincoln	subekxal@gmail.com
35	Upama Karki	The University of Alabama, Tuscalosa	ukarki@crimson.ua.edu
36	Amar Thakuri	ICTP, Trieste, Italy	thakuriamar07@gmail.com
37	Anish Dahal	Beihang University, China	anishextra9@gmail.com
38	Prakash Timsina	ICTP, Trieste, Italy	renewableprakash2013@gmail.com

Note: *Symmetry family congratulates all students and wishes for the success in the future study. There might a few missing in the list. Those who are missing in the list are requested to send information so that the updated list can be added in the CDP webpage.*

Faculties: Central Department of Physics, TU, Kirtipur

Prof. Dr. Binil Aryal

Designation : Head
(since 2070/09/07)
Mailing Addres : CDP, TU, Kirtipur
Address : Jorpati – 2, KTM
Phone (+977) 9803228105
Email :aryalbinil@gmail.com
Date of Birth :2024-06-13
Place of Birth :Saptari

Field of Research : ***Galaxy evolution, dark Matter & dark energy, ISM interaction, etc.***

Members : TU Assembly (Senator)
: Academic Council, TU
: Standing Committeete, Faculty Board
: Board, BPKM-DB, MoST, Govt. Nepal
: Research Committee, IOE, TU
: Research Committee, SOS, KU
: Subject Committee, IOE, TU
: Managing Committee, RECAST, TU
: Subject Standing Committee, CDES, TU
: Board member, CDC, TU.

Qualification

Post Doctorate :Institute of Astrophysics, Innsbruck University, Innsbruck, Austria (May 2002 –April 2004)
:University of Washington Seattle, USA (May 2004- April 2005)
Ph. D. :Institute of Astrophysics, Innsbruck University, Innsbruck; Austria (2002)
M. Sc. :Central Dept of Physics, T.U., Kirtipur (1994)
Post Doc Project :*A new kind of interaction in the ISM*
Ph.D. Thesis :*Spin vector orientation of galaxies in 40 Abell clusters*
M. Sc. Thesis :*Estimation of uranium & thorium collected from central Nepal using gamma-ray spectrometry*

International Project Experience

(1) **Galileo Observatory**, Canery Island, Spain (one observational run – as a Ph.D. student, during 2001)
(2) **Asiago Observatory**, Padua University, Italy (five observational run – as a expert astronomer, during 2002-2004)
(3) **KEK Observatory**, Mauna Kea, Hawaii, USA (four observational run – as a expert Astronomer, during 2005-2009)
(4) **IRAM Observatory**, Spain (two observational run – as a expert Astronomer, during 2004-2005)

Ph.D. Supervision (completed):

(1) Dr. Shiv Narayan Yadav
(2) Dr. Ajay Kumar Jha
(3) Dr. Arjun Kumar Gautam

M.Sc. Dissertation (completed) : 218 (till March 2019)

National Level Committee:

(1) National Policy for University Affiliation
(2) Higher Education Policy: STEM (8^{th} Chapter)

University Level Committee:

(1) Credit Transfer Policy
(2) Improving Grading System in TU
(3) Fast Track Recruitment Process/policy
(4) Improving Teaching Learning in TU
(5) Question Format and Model Question for Assistant Professor, TU Service Commission

Selected Publications in the International Journals:

1. A. K. Jha, **B. Aryal**, Dust color temperature distribution of two FIR cavities at IRIS and AKARI maps, Journal Astronomy & Astrophysics (JAA), **107**, 216 (2019).
2. Arjun Kumar Gautam & **Binil Aryal**, A study of four low-latitude ({\mid } l{\mid }<10°) far-infrared cavities, Journal of Astrophysics and Astronomy, Springer, 40, 2, 116-125 (2019). DOI: 10.1007/s12036-019-9578-1
3. Binod Adhikari, Niraj Adhikari, **Binil Aryal**, Narayan P. Chapagain, Ildiko Horvath, Impacts on proton fluxes observed during differennt interplaneray conditions, Journal of Solar Physics, Springer, 295(3), 163 (2019). DOI: 10.1007/s18217-03482
4. A. K. Jha, **B. Aryal,** R. Weinberger, A study of dust color temperature and dust mass distributions of four far infrared loops Revista Mexicana de Astronomía y Astrofísica (RxMAA), **53**, 467-476 (2017).
5. A.K. Jha, **B. Aryal** & R. Weinberger, A Study of Far-Infrared Loop at Galactic Latiude -12^{o} , ISST Journal of Applied Physics, **8** (1), 85-91 (2017).
6. S. N. Yadav, **B. Aryal**, W. Saurer, Preferred alignments of angular momentum vectors of galaxies in six dynamically unstable Abell clusters, RAA, **17**, 7, 64 (2017).
7. **B. Aryal,** H. Bhattarai, S. Dhakal, C. Rajbahak & W. Saurer, Spatial Orientation of Galaxies in Six Rotating Clusters, Monthly Notice of Royal Astronomical Society (MNRAS), 434, 1339 (2013)
8. **B. Aryal,** S.N. Yadav & W. Saurer, Spatial orientation of galaxies in the Zone of Avoidance, Bulletin of Astron. Astron. Soc. Ind. (BASI), **40**, 65 (2012)
9. **B. Aryal,** R. R. Paudel, W. Saurer, Spatial orientation of angular momentum vector of galaxies in three merging binary clusters, Astrophysics & Space Science Journ. (Springer), **337**, 313 (2012)
10. **B. Aryal**, Winding sense of galaxies around the Local Supercluster, Journ. Research in Astronomy & Astrophysics (RAA) **11**, 293 (2011)
11. **B. Aryal**, C. Rajbahak, R. Weinberger, A giant dusty bipolar structure around planetary nebula NGC 1514, Monthly Notice of Royal Astronomical Society (MNRAS) **402**, 1307 (2010)
12. **B. Aryal**, C. Rajbahak, R. Weinberger, Planetary nebulae NGC 6826 and NGC 2899: early aspherical mass loss?, Journ. Astrophysics & Space Science, **323**, p. 324-331 (2009)
13. **B. Aryal**, P. Kafle & W. Saurer, Radial velocity dependence in the spatial orientations of galaxies in and around the local supercluster, Monthly Notice of Royal Astronomical Society (MNRAS) **389**, 741 (2008)
14. **B. Aryal,** D. Nupane & W. Saurer, Morphological dependence in the spatial orientations of galaxies around the Local Supercluster, Astrophysics & Space Science (Ap&SS) **314**, 177 (2008)
15. **B. Aryal**, S. Paudel & W. Saurer, Coexistence of chiral symmetry restoration and random orientation of galaxies, , Journ. Astronomy & Astrophysics (A&A) **479**, 397 (2008)
16. **B. Aryal,** S. Paudel & W. Saurer, Spatial Orientation of galaxies in 7 clusters of BM type II, Monthly Notice of Royal Astronomical Society (MNRAS) **379**, 1011 (2007)
17. **B. Aryal,** S. R. Acharya & W. Saurer, Chirality of spiral galaxies in the Local Supercluster, Journ. Astrophysics & Space Science, **307**, p. 369-380 (2007)
18. **B. Aryal,** S. M. Kandel & W. Saurer, Spatial orientation of galaxies in the core of the Shapley Concentration: The cluster Abell 3558, Journ. Astronomy & Astrophysics **458**, 377 (2006)
19. **B. Aryal** & R. Weinberger, A new high latitude cone like far-IR nebula, Journ. Astronomy & Astrophysics **446**, 213 (2006)
20. **B. Aryal** & W. Saurer, Spin vector orientation of galaxies in ten clusters of BM type II-III, Monthly Notice of Royal Astronomical Society (MNRAS) **366**, 438 (2006)
21. **B. Aryal** & W. Saurer, Spin vector orientation of galaxies in the region $19^h 26^m 00^s < \alpha (2000) < 20^h 19^m 00^s$, $-68^o < \delta (2000) < -65^o$, MNRAS **360**, 125 (2005)
22. R. Weinberger & **B. Aryal,** A Gaint Dusty Bipolar Structure Around the Planetary Nebula NGC 1514, Monthly Notice of Royal Astronomical Society (MNRAS) **348**, 172 (2005)
23. **B. Aryal** & W. Saurer, Spin vector orientation of galaxies in seven Abell clusters of BM type III, Journ. Astronomy & Astrophysics 432, 841-850 (2005)
24. **B. Aryal** & W. Saurer, Morphological dependence in the spatial orientation of Local Supercluster galaxies, Journ. Astronomy & Astrophysics **432**, 431-442 (2005)
25. **B. Aryal** & W. Saurer, Spin vector orientation of galaxies in seven Abell clusters of BM type I, Journ. Astronomy & Astrophysics 425, p. 871-879 (2004)

26. R. Weinberger & **B. Aryal**, Huge Dust Structures and Cavities Around PNe: NGC 6826 and NGC 2899, Edited by Margaret Meixner, Joel H. Kastner, Bruce Balick and Noam Soker, ASP Conf. Proc., Vol. **313**. San Francisco: Astronomical Society of the Pacific, 2004., p.112-115 (2004)
27. R. Weinberger & **B. Aryal**, Asymmetric mass-loss on the AGB: examples from IRAS data, Edited by Y. Nakada, M. Honma and M. Seki. Astrophysics and Space Science Library, Vol. **283**, Dordrecht: Kluwer Academic Publishers, ISBN 1-4020-1162-8, p. 103-106 (2003)
28. **B. Aryal** & W. Saurer, The influence of selection effects on the isotropic distribution curve in galaxy orientation studies, Edited by José G. Funes, S. J. and Enrico Maria Corsini. San Francisco: Astronomical Society of the Pacific. ISBN: 1-58381-063-3, ASP Conf. Ser., Vol. **230**, p. 145-156 (2001)
29. **B. Aryal** & W. Saurer, Comments on the expected isotropic distribution curve in galaxy orientation study, Journ. Astronomy & Astrophysics Letters **364**, L97-L100 (2000).

Prof. Dr. Om Prakash Niraula

E-mail : niraula@yahoo.com
Telephone : 977-1-4429383

M.Sc. Thesis : Laser absorption in inertial confinement fusion plasma, CDP, TU (1988)

PhD Thesis : The analysis of steady thermal stresses in thermopiezoelastic body with an edge crack, Shizuoka University, Hamamatsu, Japan (2002)

Selected Publications

1. Niraula, O. P. and Jha, L. N, Laser absorption in inertial confinement fusion plasma, 1992, Shangai International Symposium on Quantum Optics, Academia, Sinica, Shangai, China, 29 March- 2 April 1992, edited by Wang, Y., Wang, Y. and Wang, Z., SPIE - International Society for Optics and Photonics, Volume 126, Pages 402-407, 1992
2. Niraula, O. P. and Noda, N., Thermal stress intensity factor i thermopiezoelastic semiinfinite material, The Fourth International Congress on Thermal Stresses, Osaka, Japan, (FICTS 2001), June 8-11, 2001, edited by Tanigawa, Y. , Pages 257-260, June 2001
3. Niraula, O. P., Noda N., The analysis of thermal stresses in thermopiezoelastic semiinfinite body with an edge crack, Archive of Applied Mechanics, Volume 72, Pages 119-126, 2002
4. Niraula O. P., and Noda N., Thermal stress analysis in thermopiezoelastic strip with an edge crack, Journal of Thermal Stresses, Volume 25, Pages 389-405, 2002
5. Ishihara, M., Niraula, O. P. and Noda, N. The analysis of transient thermal stresses in piezothermoelastic semi-infinite body with an edge crack, IUTAM Symposium on Dynamics of Advanced Materials and Smart Structures, Yonezawa, Japan, May 20-24, 2002, edited by Watanabe, K, and Zigler. F., Pages 137-146, 2003
6. Niraula, O. P. and Wang, B. L, Thermal stress analysis in magneto-electro-thermoelasticity with a penny-shaped crack, Journal of Thermal Stresses, Volume 29, Pages 423–437, 2006
7. Niraula O. P. and Wang B. L., A magneto-electro-elastic material with a pennyshaped crack subjected to temperature loading, Acta Mechanica, Volume 187, Pages 151-168, 2006 Wang, B. L. and **Niraula, O. P.,** Transient analysis of thermal fracture in transversely isotropic magneto-electro-elastic material, Journal of Thermal Stresses, Volume 30, Pages 297-317, 2007
8. Wang B. L, Mai Y-W, **Niraula, O. P.**, A horizontal shear surface wave in magnetoelectroelastic materials. Philosophical Magazine Letters, Volume 87, Pages 53-58, 2007
9. Wang, B. L., Zhang, H. Y. and **Niraula, O. P.** , An internal crack subjected to a thermal flow in magnetoelectroelastic solids: exact fundamental solution, Mathematics and Mechanics of Solids, Volume 13, Pages 447-462, 2008
10. Wang, B. L., Zhang, H. Y. and **Niraula, O. P.** , A moving screw dislocation in transversely isotropic magnetoelectroelastic materials, Philosophical Magazine Letters, Volume 88, Pages 153-158, 2008
11. Wang, B. L. and **Niraula, O. P.,** Two collinear antiplane cracks in functionally graded magnetoelectroelastic composite materials, Mechanics of Composite Materials, Volume 45, Pages 585-596, 2009 (A translation of Russian Language Journal- Mekhanika Kompozitnykh Materialov, Volume 45, Pages 843-862, 2009
12. **Niraula, O.P.,** Solution of wave propagation in magneto-electro-elastic plate, Second Asian Conference on Mechanics of Functional Materials and Structures (ACMFMS 2010), October 22-25, 2010, Nanjing, China, Pages 375-378, 2010
13. **Niraula, O. P.** and Noda, N, Derivation of material constants in non-linear electromagnetothermo-elasticity, Journal of Thermal Stresses, Volume 33, Pages 1011-1034, 2010
14. **Niraula, O. P.** and Chao, C. K., Thermodynamic derivation in magneto-electroelasticity, Journal of Thermal Stresses, Volume 35, Pages 448-469, 2012
15. **Niraula, O. P.,** A Mathematical model for magneto-electro-elasticity and thermodynamics, Asian Conference on Mechanics of Functional Materials and Structures, Department of Applied Mechanics, Indian Institute of Technology Delhi, New Delhi, India, (ACMFMS 2012) December 5 -8, 2012, edited by Kapuria, S., Pages 99-102, 2012

Prof. Dr. Ram Prasad Regmi

E-mail : regmi_rp@hotmail.com
Field of interest : Atmospheric transport processes over the Himalayan complex terrain.

Qualifications :Doctor of Engineering (Environmental and Life Engineering) (March 2003), Graduate School of Engineering, Toyohashi University of Technology (TUT), Japan.
:Masters Degree in Physics (1991), CDP, TU.

PhD Thesis :Study on Meteorological Flows and Air Pollution Transport over the Kathmandu Valley, Nepal: Observation and Numerical Simulation, Japan. 2003.

M Sc Thesis :High Field Behaviors of Electrons in Semiconductor Surface Inversion Layer, CDP, TU (1991)

Selected Publications

1. Kitada T. and **R. P. Regmi** (2003): Air Pollution Distribution and Their Dynamics over the Kathmandu Valley, Nepal: As Revealed with Numerical Simulation and Observation. Journal of Applied Meteorology, American Meteorological Society, Vol. 42, No 12, pages 1770-1798.
2. **Regmi R. P.** and T. Kitada (2003): Human-Air Pollution Exposure Map of the Kathmandu Valley, Nepal: Assessment Based on Chemical Transport Simulation. Journal of Global Environment Engineering, JSCE, Japan, Vol. 9, pages 89-109.
3. **Regmi R. P.**, T. Kitada, and G. Kurata (2003): Numerical Simulation of Late Wintertime Local Flows in the Kathmandu Valley, Nepal: Implication for Air Pollution Transport. Journal of Applied Meteorology, American Meteorological Society, Vol. 42, No 3, pages 389-403.

Reports

- Ram P. Regmi (2009): “A Study of the Local and Regional Flow in the Kathmandu Valley” submitted to Pacific Northwest National Laboratory, USA.
- Ram P. Regmi (2009): “A Study on Atmospheric Conditions Leading to Decoupling of Surface Air from the Regional Flows in the Kathmandu Valley” submitted to Pacific Northwest National Laboratory, USA.
- Ram P. Regmi (2008), “Energy Sector Overview of Nepal: Country Report”, Wind Energy International 2007/2008, World Wind Energy Association.

Prof. Dr. Raju Khanal

Designation : Professor
Mailing Address : CDP TU
Kirtipur, Nepal

Phone : (+977) 9841411951
Email : plasmanepal@hotmail.com
Date of Birth : Thursday; 12 June 1969 (2026 Jestha 30 B.S.)
Place of Birth : Sakrantibazar-6, Terhathum, Nepal

Field of Interest :*Plasma Physics (Plasma–wall transition, plasma seath)*

Qualification
M.Sc. : CDP, T. U., Kirtipur (1994)
Ph.D. : Institute for Theoretical Physics, Innsbruck University, Austria (2003)
M. Sc. Thesis :*Plasma Wake-Field Accelerator and its Transformer Ratio.*
Ph.D. Thesis : *A Kinetic Trajectory Simulation Model for Bounded Plasmas*

Selected International Publications:

1. B. Ghimire, D. P. Subedi and **R. Khanal**, Improvement of wettability and absorbancy of textile using atmospheric pressure dielectric barrier discharge, AIP Advances 7, 085213 (2017).
2. S. P. Gupta, L. K. Jha and **R. Khanal**, Study of proton and alpha particle impact double ionization of Fe, Bulletin of Pure & Applied Sciences- Physics 36D, 43 (2017).
3. G. Thakur, **R. Khanal** & B. Narayan, Determination of Plasma Parameters by using Movable Langmuir Double Probe in Copper Arc Plasma, Research Highlights: A Multidisciplinary Quarterly International Referred Research Journal IV, 20 (2017).
4. S. P. Gupta, L. K. Jha and **R. Khanal**, Electron impact single and double ionization of Fe atom, Bulletin of Pure & Applied Sciences - Physics 36D, 53 (2017).
5. G. Thakur, **R. Khanal** and B. Narayan, Production of Copper Arc Plasma and its Characterization using a Movable Langmuir Probe, Varanasi Management Review III, 27 (2017).
6. P. Gautam, **R. Khanal**, S. Heoh Saw and S. Lee, Measurement of Model Parameters versus Gas Pressure in High Performance Plasma Focus NX1 and NX2 Operated in Neon, IEEE Transactions on Plasma Science 45, 2292 (2017)
7. S. H. Saw, D. Subedi, **R. Khanal**, R. Shrestha, S. Dugu and S. Lee, J., Numerical Experiments on PF1000 Neutron Yield, Fusion Energy 33, 684 (2014)
8. P. Gautam and **R. Khanal**, Comparison of Measured and Computed Neutron Yield Versus Pressure Curve on NX2 at Different Operating Voltages, KUSET **10**, 1 (2014)
9. B. Ghimire, **R. Khanal** and D. P. Subedi Diagnostics of Low Pressure DC Glow Discharge Using Double Langmuir Probe, KUSET **10**, 20 (2014)
10. Comparison of Measured Neutron Yield Versus Pressure Curves for FMPF-3, NX2 and NX3 Plasma Focus Machines Against Computed Results Using the Lee Model Code, S. H. Saw, P. Lee, R. S. Rawat, R. Verma, D. Subedi, R. Khanal, P. Gautam, R. Shrestha, A. Singh and S. Lee, J. Fusion Energy 34, 474 (2015)
11. "Comparison of Measured Soft X-Ray Yield versus Pressure for NX1 and NX2 Plasma Focus Devices against Computed Values Using Lee Model Code", P. Gautam, R. Khanal, S. H. Saw and S. Lee, J. Fusion Energy 34, 686 (2015)
12. "Self-consistent one dimension in space and three dimension in velocity kinetic trajectory simulation model of magnetized plasma-wall transition", Roshan Chalise and Raju Khanal, Physics of Plasmas 22, 113505-1 (2015)
13. Electron Impact Single Ionization of Kr and Xe, Suresh Prasad Gupta, L. K. Jha, Raju Khanal and Akhilesh Kumar Gupta, Bulletin of Pure & Applied Sciences- Physics 34d, 71 (2015)
14. Roshan Chalise and Raju Khanal, The Study of Kinetic Energy of Ion ond Sheath Thickness in Magnetized Plasma Sheath, Journal of Materials Science and Engineering A 5, 41 (2015).

Prof. Dr. Narayan Pd Adhikari

Mailing Address : P.O. Box: 24354, Kathmandu, Nepal.
Phone : 01-4335958 (R)
: 9841-500796 (M)
Email : npadhikari@gmail.com
Date of Birth : 10th March, 1970
Place of Birth :Chapakot –7, Kaski

Field of Interest :***Nanoscience, Condensed Matter Physics, Computational Physics, Biophysics***

Qualification : Ph. D. Martin-Luther University, Halle/Saale, Germany (2001)
: M.S. The Abdus Salam International Center for Theoretical Physics, Trieste, Italy (1998)
: M.Sc. Central Department of Physics, T.U. (1996)

Ph.D. Thesis : *Interfacial properties and phase behavior of unsymmetric polymer blends*

M.S. Thesis : *Calculations of the energy in two weakly coupled Bose- Einstein Condensates*

M. Sc. Thesis : *Size effects in metal clusters*

Post Doctoral Experiences
: October 2001 – August 2002, Rice University, Houston, Texas, USA
: September 2002 – May 2004 : Rensselaer Polytechnic Institute, Troy, New York,
: October 2004 – December 2005: Max-Planck Institute for Polymer Research, Mainz, Germany

Selected Publications

1. M. M. Aryal D. R. Mishra D. D. Paudyal S. Byahut N. B. Maharjan **N. P. Adhikari ·** R. H. Scheicher · Junho Jeong S. R. Badu R. H. Pink Lee Chow T. P. Das "*First–Principles Study of Binding Energies and Nuclear Quadrupole Interactions in Molecular Solids-Halogens"* Hyperfine Interactions, Volume **176**, page 51-57 (2008) (Springer, Germany)
2. V. A. Harmandaris, **N. P. Adhikari**, N. F. A. van der Vegt, K. Kremer, B. A. Mann, R. Voelkel, H. Weiss, and Chee Chin Liew **"***Ethylbenzene Diffusion in Polystyrene: United Atom Atomistic Coarse Grained Simulations and Experiments*", Macromolecules, **40**, 7026 (2007)
3. V.A. Harmandaris, **N.P. Adhikari**, N.F.A. van der Vegt and K. Kremer, "*Hierarchical modeling of Polystyrene: From atomistic to coarse-grained simulations*", Macromolecules, **39**, 6399 (2006
4. **N.P. Adhikari**, X. Peng, A. Alizadeh, S. Nayak and S.K. Kumar "*Multiscale modeling of the synthesis of quantum nanodots and their arrays*" Theoretical and computational chemistry, volume **18**, Nanomaterials:Design and simulation**,** Chapter 4, Page 85, editors: P.B. Balbuena and J. M. Seminario, Elsevier, 2006
5. **N.P. Adhikari**, X. Peng, A. alizadeh, S. Ganti, S.K. Nayak and S.K. Kumar, "*Multiscale modeling of the surfactant mediated synthesis and supramolecular assembly of cobalt nanodots*", Phys. Rev. Lett., **93**, 188301(2004)
6. **N.P. Adhikari** and J.L. Goveas, "*Effects of slip on the viscosity of polymer melts*", Journal of Polymer Science: Part B: Polymer Physics, **42**, 1888(2004).
7. **N.P. Adhikari** and E. Straube, "*Interfacial properties of asymmetric polymer blends*", Macromolecular theory and simulations, **12**, 499(2003).
8. **N.P. Adhikari**, R. Auhl and E. Straube, "*Interfacial properties of flexible and semiflexible polymers blends"*, Macromolecular theory and simulations, **11**, 315(2002).
9. **N. P. Adhikari** and E. Straube, "*Interfacial properties of mixtures of flexible and semiflexible polymers*", Modeling Complex systems, AIP conference proceedings, volume **574**, page 252, year 2001
10. **N.P. Adhikari** and D.R. Mishra, "*Electronic structure in metal clusters*", Journal of Nepal Physical Society, **15**,13(1998).
11. **N.P. Adhikari** and D.R. Mishra, "*Thickness dependence of Fermi wave vector in thin bismuth films*", Journal of Nepal Physical Society, **13**, 23(1996).
12. S. Pokharel, N. Aryal, B..R. Niraula, A. Subedi, **N..P. Adhikari**,

Transport properties of methane, ethane, propane, and n-butane in water, *Journal of Physics Communications* 2 (6), 06500. DOI: 10.1088/2399-6528/aabc45

Prof. Dr. Ishwar Koirala

Designation : Associate Professor
Mailing Address : CDP T, Kirtipur
Phone : 9849073009
Date of Birth : 2021–04–18
Place of Birth : Dharan –14, Sunsari
Field of Interest :*Solid State Physics, Material Science*
Qualifications :M.Sc., CDP, TU
Experience :tauhght B.Sc. (three year system) for about 14 years and M.Sc. (Physics) since last 6 years

Selected International Publications

1. **I. Koirala**, I.S. Jha, B.P. Singh, D. Adhikari, Thermodynamic, transport and surface properties in In-Pb liquid alloys, Physica B 423 (2013) 49: Elsevier
2. **I. Koirala**, B.P. Singh, I.S. Jha ,Theoretical Investigations on Mixing Properties of Liquid Ga-Zn Alloys,Journal of Science and Technology (JOST) 18:2(2013)37-43
3. **I. Koirala**, B.P. Singh, I.S. Jha, Theoretical assessment on segregating nature of liquid In-Tl alloys, J. Non-Cryst.Solids 398(2014) 26-31: Elsevier
4. B.P. Singh, **I. Koirala**, I.S. Jha, D. Adhikari, The segregating nature of Cd-Pb liquid binary alloys, Phys. Chem. Liq., 52:4(2014)457: Taylor and Francis
5. I.S.Jha, **I. Koirala**, B.P.Singh, D.Adhikari, Concentration dependence thermodynamic, transport and surface properties in Ag-Cu liquid alloys, Applied Physics A,116:3(2014)1517-1523: Springer Link
6. **I. Koirala**, I.S. Jha, B.P. Singh, D. Adhikari ,Theoretical investigations of mixing properties in Ni-Pd liquid alloys,Chem. Xpress 4:1(2014)75-79: Global Scientific Inc
7. **I. Koirala** ; B.P.Singh ; I.S.Jha, Theoretical investigation of mixing behaviors on Al-Fe alloys in the molten stage, The African Review of Physics 10 (2015)0040
8. B. Singh and **I. Koirala**, Size sensitive transport behavior of liquid metallic mixtures , Journal of Science and Technology (JIST) 20:2 (2015) 140-144
9. **I. Koirala**, B. P. Singh, I.S. Jha , Theoretical investigation of energetic and its effect on Cd-Hg amalgam Journal of physical society 3-1(2015), 60-64

Dr. Hari Pd Lamichhane

Designation : Associate Professor
Contact Addres : CDP TU, Kirtipur
Telephone :977 -1- 4332694 (H)
e-mail : hlamichhanel@gmail.com
Permanent Address :Tarkughat -1, Lamjung,
Education : B.Sc. in Physics, 1990, TU, Nepal
: M.Sc. in Physics, 1994, TU Nepal
: Ph. D. in Physics (December, 2011), Georgia State University, Atlanta
Ph.D. Title : Calculated Vibrational properties of Quinones in Photosynthetic Reaction Centers M.S. in Physics, August 2008, Georgia State University, Atlanta

Selected Publications

1. **Hari Prasad Lamichhane** and Gary Hastings, "Calculated Vibrational Properties of Pigments in Protin Binding Sites", Proceedings of the National Academy of Science (2011), 108, 10526-10531.
2. **Hari Lamichhane**, Ruili Wang, Gary Hastings, "Comparison of calculated and experimental FTIR spectra of specifically labeled ubiquinones" Vibrational Spectroscopy (2011), 55, 279-286.
3. Gary Hastings, Peter Krug, Ruili Wang, Jing Guo, **Hari Lamichhane**, Tian Tang, Yu-Sheng Hsu, John Ward, David Katz and Julia Hilliard (2009) "Viral Infection of Cells in Culture Detected Using Infrared Microscopy", Analyst (2009) 134, 1462-1471. DOI: 10.1039/b902154j.
4. **Hari Lamichhane**, "A general Technique of Finding Roots by the Method of Division" Published in the proceedings of IInd National Conference in Science and Technology organized by Royal Nepal Academy of Science and Technology, Kathmandu, Nepal, June 8-11, 1994.

Dr. Bal Ram Ghimire

Designation : Associated Professor
Mailing Address : CDP TU
Phone : 9848848733
e-mail: : balramghimire@gmail
Field of interest : Condensed matter
Education : M.Sc. in Physics, Southern Illinois Univ., USA
: Ph. D. University of North Dakota, USA
Any Other : Member of the Optical Society of America, American Physical Society and Life member of Nepal Physical Society.

Selected International Publications

1. **Bal Ram Ghimire**, Shanker Prasad Chimouriya, Ju H. Kim, Collective Phase Frustrationand Time Reversal Symmetry Broken on Single Long Josephson JunctionBased on MgB2Superconductor, *Journal of Applied Physics (IOSR-JAP)*, iosrjournals.org, **10**, 5 Ver. II, 38-44 (2018). DOI:10.9790/4861-1005023844.
2. Shanker Prasad Chimouriya, **Bal Ram Ghimire**, Ju H. Kim, Phase Dynamics of SingleLong Josephson Junctionin MgB2Superconductor, *AIP Conference Proceedings, American Institute of Physics*, **1953**, 120074-1-1200744 (2018). DOI:10.1063/1.5033139.
3. J. H. Kim, **B. R. Ghimire**, and H. Y. Tsai, Phys. Rev. B **85**, 134511, (2012).

Dr. Ajay Kumar Jha

Designation : Associate Professor
Mailing Address : CDP TU
Date of Birth : 2022/04/16(B.S.)
Place of Birth : Janakpur Dham
Contact Number : +977- 9848722897
Email : astroajay123@gmail.com
Qualification : M.Sc. Physics, CDP, TU (1992)
Ph.D.(submitted) : Interaction Between Pulsar wind and the ambient Interstellar Medium
Experience :tought B.Sc. (three year system) for about 12 years and M.Sc. (Physics) since last 3 years

Selected Publications:

1. **A. K. Jha**, B. Aryal**,** R. Weinberger, A study of dust color temperature and dust mass distributions of four far infrared loops Revista Mexicana de Astronomía y Astrofísica (RxMAA), **53**, 467-476 (2017).
2. **A. K. Jha**, B. Aryal & R. Weinberger, A Study of Far-Infrared Loop at Galactic Latiude -12^{o} , ISST Journal of Applied Physics, **8** (1), 85-91 (2017).
3. **A. K. Jha** & B. Aryal, A Study of Pulsar Driven Structure in Far-Infrared IRAS map at Latitude of -10^{o} . Journal of Institute of Science and Technology, JIST, **22** (1): 12-20 © IOST, Tribhuvan University (2017).
4. **A. K. Jha** & B. Aryal, A Study of Cavity Nearby Pulsar at -60^{o} Latitude in the Fra-Infrared Map, Journal of Nepal Physical

Society, JNPS, **4** (1), 33-41 (2017).

5. **A.K. Jha**, Systematic Search of Interacting Pulsar in the IRAS Survey, Nepalese Journal of Integrated Sciences, **3**, 38-43 (2013).

Dr. Gopi Chandra Kaphle

Designation : Associate Professor
Mailing Address : CDP, TU
Permanent Address :Butwal-14, Tamnagar, Rupandehi
Email :gck2223@gmail.com
Phone: :+014479927(Home) / 9849000975(Mobile)
Phone : 9848848733

Field of interest : Electronic and Magnetic properties of clusters, nanosystems and disordered solids

Education : M.Sc. in Physics, CDP
: Ph.D. in Physics, CDP, TU

M.Sc. Thesis :Dipole Potential Characteristics of the metal vacuum interface of the selected metals

Ph. D. Thesis :Study of electronic structure of clusters and disordered solids

Selected Publications

1. P. Sharma and **G. C. Kaphle**, Electronics and Magnetic properties of Half-Metallic Heusler Alloy:Co2MnSi:A first Principles Study, Journal of Nepal Physical Society **4**(1), 60-66 (2017).
2. R. P. Sedhain and **G. C. Kaphle**, Structural and Electonic properties of Transition Metal Di-Calcogenides(MX2) M=(Mo, W) and X=(S,Se) in Bulk State: A First-principles Study, Journal of Institute of Science and Technology, **22**(1), 41-50 (2017).
3. S. Paudel, S. Dandeliya, R. Chaurasiya, A. Srivastava, **G. C. Kaphle**; Magnetism in zigzag and armchair CuO nanotubes: Ab-initio study, J. Magnetism and Magnetic Materials **406**, 8 (2016).
4. **G. C. Kaphle**, N. P. Adhikari, and A. Mookerjee, Adsorption and Dissociation of Nitrogen and Hydrogen Molecules on Platinum (Pt) Clusters, Quantum Matter, 5(3), 348-355 (2016).
5. S. Lamichhane, **G. C. Kaphle**, N. P. Adhikari, Electronic Structures and Magnetic Properties of NiAl and Ni3Al, Quantum Matter, **5**(3), 356-361 (2016).
6. R. Poudel and **G. C. Kaphle**, Study of electronic and Magnetic properties of Fe, Cr, FeCr and FeCr3: TB-LMTO -Approach, Patan Gyansagar, **2**(1), 80 (2016).
7. S. Lamichhane, B. Aryal, **G. C. Kaphle**, N. P. Adhikari, Structural and Electronic Properties of Perovskite Hydrides ACaH3 (A=Cs and Rb), BIBECHANA 13, 94-99 (2016).
8. B. Aryal, **G. C. Kaphle**; Study of Electronic Structure and Magnetic Properties of Bulk (Pb & Ti) and Perovskite (PbTiO3), Asian Academic Research Journal of Multidisciplinary (AARJMD), **3**(2), 47 (2016).
9. **G. C. Kaphle**, N. Adhikari, A. Mookerjee, Study of Spin Glass Behavior in Disordered Pt x Mn1− x Alloys: An Augmented Space Recursion Approach, Advanced Science Letters, **21**(9), 2681, (2015).
10. Study of morphology effects on magnetic interactions and band gap variations for 3d late transition metal bi-doped ZnO nanostructures by hybrid DFT calculations. The Journal of chemical physics,**143** (8), O84309 (2015)
11. Structural and electronic properties of Perovskite Hydrides AcaH3 (CaH3), BIBECHANA **13**, 94-99 (2015)
12. A study of magnetism in disordered Pt–Mn, Pd–Mn and Ni–Mn alloys: an augmented space recursion approach. Journal of Physics: Condensed Matter **24**(29), 295501 (2012).

Dr. Madhav Prasad Ghimire

Designation : Associate Professor
Contact no. : 9851127345
E-mail : ghimire.mpg@gmail.com
Date of Birth :10th April, 1981
Place of Birth : Rupandehi, Nepal

Field of Research: Weyl semi-metals, topological phase transition in kagome systems, topological insulators, Magnetic anisotropies, Surface and interfacial properties of 2D materials, thermoelectric, electronic and magnetic properties of complex materials, etc.

Qualification:

Post Doc 1: Leibniz Institute for Solid State and Materials Research, IFW- Dresden,Germany (1stNov., 2015 – 8th August, 2018)

Project title: Magnetic doping of weak Topological insulators

Post Doc 2.: National Institute for Materials Science (NIMS), Tsukuba, Japan *1st Feb., 2012 – August, 2014*

Project title: Exploring novel materials of half metallic antiferromagnet and application to spintronics

Ph. D. : Ph.D. in Physics, Department of Physics, Mizoram University, Aizawl, India (November, 2010)

Ph. D. thesis: Theoretical study of Photofield emission and band structure calculations

M. Sc.(Physics) : Solid State Physics, Department of Physics, Banaras Hindu University, Varanasi, India (June, 2003)

M. Sc. Thesis: Series analysis and critical phenomena

Selected Publications

1. J. Zeisner, A. Alfonsov, S. Selter, S. Aswartham, **M. P. Ghimire**, M. Richter, J van den Brink, B. Büchner, & V. Kataev, Magnetic anisotropy and spin-polarized two-dimensional electron gas in the van der Waals ferromagnet Cr2Ge2Te6, Physical Review B, APS,99, 165109 (2019) DOI: 10.1103/PhysRevB.99.165109
2. **M. P. Ghimire**, J. I. Facio, J.-S. You, Linda Ye, J. G. Checkelsky, S. Fang, E. Kaxiras, M. Richter & J. van den Brink, Creating Weyl nodes and tuning their energy by magnetization rota-tion in a metallic ferromagnet, Bulletin of the American Physical Society, MAR19, B04.6 (2019)
3. Bishnu P. Belbase, Dinesh K. Yadav, Shalika R. Bhandari, Gopi C. Kaphle, and **Madhav P. Ghimire**, Investigations of electronic and optical properties of double perovskite Ba2BiSbO6, Bulletin of the American Physical Society, MAR19, P33.14 (2019)
4. **M. P. Ghimire**, and M. Richter, "Chemical gating of a weak topological insulator: Bi14Rh3I9" ACS Nano Letters, 17, 6303 (2017).
5. Sandeep, D.P. Rai, A. Shankar, **M.P. Ghimire**, R. Khenata, S. B. Omran, S.V. Syrotyuk, and R.K. Thapa "Investigation of the structural, electronic and optical properties of the cubic RbMF3 perovskites (M=Be,Mg,Ca,Sr & Ba) using modified Becke-Johnson exchange potential" Mater. Chem. Phys. 192, 282-290 (2017).
6. D.P. Rai, Sandeep, A. Shankar, A. P. Sakhya, T.P. Sinha, P. G.-Gallardo, H. Cabrera, R. Khenata, **M. P. Ghimire**, and R.K. Thapa "Electronic, optical and thermoelectric properties of bulk and surface (001) CuInTe2: A first principles study" Jour. Alloys. Comp. 699, 1003-1011 (2017).
7. H. L. Feng, S. Calder, **M. P. Ghimire***, Y.-H. Yuan,Y. Shirako,Y. Tsujimoto, Y. Matsushita, Z. Hu, C.-Y. Kuo, L. H. Tjeng, T.-W. Pi, Y.-L. Soo, J. He, M. Tanaka, Y. Katsuya, M. Richter, and K. Yamaura "Ba2NiOsO6: A Dirac-Mott insulator with ferromagnetism near 100 K" **Phys. Rev. B** 94, 235158 (2016).
8. **M. P. Ghimire**, L.-H. Wu, and X. Hu "Possible half-metallic antiferromagnetism in an iridium double-perovskite material" **Phys. Rev. B** 93, 134421 (2016).
9. D. P. Rai, Sandeep, A. Shankar, A. P. Shakya, T. P. Sinha, R. Khenata, **M. P. Ghimire**, and R. K. Thapa "Electronic and magnetic properties of X_2YZ and XYZ Heusler compounds: a comparative study of density functional theory with different exchange-correlation potentials" **Mater. Res. Express**3, 075022(2016).
10. Sandeep, D. P. Rai, A. Shankar, M. P. **Ghimire**, A. P. Sakhya, T. P. Sinha, R. Khenata, S. B. Omran, and R. K. Thapa "Band-gap engineering of $La_{1-x}Nd_xAlO_3$ (x=0.0, 0.25, 0.5, 0.75, 1) perovskite using density functional theory: A modified Becke Johnson potential study" **Chinese Physics B** 25, 067101 (2016).
11. A. Shankar, D. P. Rai, Sandeep, R. Khenata, **M. P. Ghimire**, and R. K. Thapa "FP-LAPW study of energy bands and optical properties of the filled skutterudite $CeRu_4As_{12}$ with spin–orbit coupling" **J. Comp. Elec.** 15, 721 – 728 (2016).
12. Sandeep, D.P. Rai, A. Shankar, **M.P. Ghimire** , R. Khenata, and R.K. Thapa "A first principles study of Nd doped cubic LaAlO3 perovskite: mBJ+U study" **J. Magn. Magn. Mat.** 417, 313–320 (2016).
13. Sandeep, D. P. Rai, A. Shankar, R. Khenata, **M. P. Ghimire**, R. K.

Thapa and S. Bin Omran "GGA+U and mBJ+U study of the optoelectronic, magnetic and thermoelectric properties of the $SmAlO_3$ compound with spin-orbit coupling" **Int. Jour. Mod. Phys.**30, 1650078 (2016).

14. A. Shankar, D. P. Rai, Sandeep, H. Joshi, R. Khenata, **M. P. Ghimire**, and R. K. Thapa "Energy band structure, elastic and optical constants of the filled skutterudite $CeRu_4Sb_{12}$" **Mat. Sci. Semicond. Proc.**46, 10-16 (2016).
15. Y. Yahua, H. Feng, **M. P. Ghimire**, Y. Matshushita, Y. Tsujimoto, J. He, M. Tanaka, Y. Katsuya, and K. Yamaura "High-pressure synthesis, crystal structure, and magnetic properties of 5d double perovskite oxides Ca_2MgOsO_6 and Sr_2MgOsO_6" **Inorg. Chem.** 54, 3422-3431 (2015).
16. D. P. Rai, A. Shankar, Sandeep, **M. P. Ghimire**, R. Khenata, and R. K. Thapa "Study of the enhanced electronic and thermoelectric properties of $Zr_xHf_{1-x-y}Ta_yNiSn$: a first principles study" **RSC Advances** 5, 95353 (2015).
17. **M. P. Ghimire***, and R. K. Thapa "Ferromagnetic Mott-insulating state in double perovskite Gd_2MgIrO_6"**Adv. Sci. Lett.** 21, 2727-2729 (2015).
18. Sandeep, D. P. Rai, A. Shankar, **M. P. Ghimire**, R. Khenata, and R. K. Thapa "Study of electronic and magnetic properties in 4f electron based cubic $EuAlO_3$: A first-principles calculation" **PhysicaScripta**90, 065803 (2015).
19. Sandeep, D. P. Rai, A. Shankar, **M. P. Ghimire**, R. Khenata, and R. K. Thapa "A systematic study of $LaAlO_3$ with variation of Nd doping, case of bandgap tuning: A first principles method" **Mod. Phys. Letts. B** 29, 1650028 (2015).
20. D. P. Rai, A. Shankar, Sandeep, **M. P.Ghimire,** and R. K. Thapa "A comparative study of a Heusler alloy Co_2FeGe using LSDA and LSDA+U" **Physica B** 407, 3689 (2012).
21. D. P. Rai, A. Shankar, Sandeep, **M. P.Ghimire,** and R. K. Thapa "Electronic structure and magnetic properties of Co_2YZ (Y=Cr, Z=Al, Ga) type Heusler compounds: A first principles study" **Int. J. Mod. Phys. B** 26, 1250071 (2012).
22. **M. P.Ghimire***, Sandeep, T. P. Sinha, and R. K. Thapa "Ground state electronic and magnetic properties of $RCrSb_3$ (R= La, Ce, Sm, Gd, Dy): A first principles study" **Sol. Stat. Commn.** 151, 1224-1227(2011).
23. **M.P. Ghimire***, Sandeep, T.P. Sinha, and R.K. Thapa "First principles study of the electronic and optical properties of SbTaO4" **Physica B** 406, 3454–3457 (2011).
24. Sandeep, **M. P.Ghimire,** and R. K. Thapa "Electronic and magnetic properties of $SmCrSb_3$ and $GdCrSb_3$: A first principles study" **J. Mag. Mag. Mat.** 323, 2883-2887 (2011).
25. Sandeep, **M. P.Ghimire,** and R. K. Thapa "Electronic and magnetic properties of $NdCrSb_3$: A first principles study" **Physica B** 406, 1862-1864 (2011).
26. **M. P.Ghimire*,** Sandeep, T. P. Sinha, and R. K. Thapa "First principles study of the electronic and magnetic properties of semi-Heusler alloys NiXSb (X=Ti, V, Cr and Mn)" **J. Alloys Compds.** 509, 9742-9752 (2011).
27. D. P. Rai, **M. P. Ghimire,** Sandeep, and R. K. Thapa "Study of energy bands and magnetic properties of Co_2CrSi Heusler alloy" **Bull. Mat. Sc.**34, 1219-1222 (2011).
28. R. K. Thapa, Sandeep, **M. P. Ghimire,** and Lalmuanpuia "Study of DOS and energy band structures in beryllium chalcogenides" **Indian J. Phys.**85, 401-409 (2011).
29. **M. P.Ghimire,** Sandeep, and R. K. Thapa "Study of the electronic properties of CrO_2 using density functional theory" **Mod. Phys. Letts.** *B*24, 2187-2193 (2010).

Dr. Nurapati Pantha

Designation : Assistant Professor
Mailing Address : CDP, TU
Kirtipur, Kathmandu, Nepal
Phone : +977-1-4336326 (R)
Email : mrnurapati@yahoo.com
Place of Birth : Baletaksar -8, Gulmi
Field of Interest : Solid State Physics and Atmospheric Physics.
Qualifications : M.S. Norwegian University of Science and Technology (Norway)
Thesis entitled :Surface Ultraviolet Radiation in Nepal, [ground-based measurement, satellite information and modeling] (2007)
: M.Sc., TU (1999)
M. A. in Population Studies, T.U. (2001)
Thesis entitled : Gender Inequality in Nepal: A case study for Lumbini Zone
Ph.D. Thesis Title : First-principles and classical atomistic study of interactions between methane and other substances.

Selected Publications

1. S. Pokhrel, **N. Pantha** and N. P. Adhikari, Diffusion coefficients of Nitric Oxide in water: a molecular dynamics study. Int. J. Mod. Phys. B **30**, 1650205-1-20 (2016).
2. S. Lamichhane, P. Lage, G. B. Khatri, **N. Pantha**, N. P. Adhikari, and B. Sanyal.First-Principles Study of Adsorption of Halogen Molecules on Graphene-MoS2 Bilayer Hetero-system. J. Phys.: Conf. Ser., **765**(1), 012011-1-10 (2016).
3. **N. Pantha**, N. P. Adhikari, and S. Scandolo, Decomposition of methane hydrates: a density-functional theory study, High Presure Research **35**(3), 231-238 (2015).
4. **N. Pantha**, A. Khaniya, and N. P. Adhikari, Hydrogen storage on palladium adsorbed graphene: a density functional theory study, , Int. J. Mod. Phys. B **29**(20), 1550143-1-14 (2015).
5. **N. Pantha**, K. Belbase, and N. P. Adhikari, First-principles study of the interaction of hydrogen molecular on Na-adsorbed graphene, Appl. Nanosci **5**, 393-402 (2014).
6. Surface UV Radiation in Nepal: Satellite Retrieval System, *Journal of Nepal Physical Society*, Vol. **23** (1), pp 27-31, June (2007).

Dr. Sanju Shrestha

Designation : Assistant Professor
Mailing Address : Devnagar, Sankhamul-9, Lalitpur, Bagmati, Nepal
Telephone : (+977)-1-5006507 (R)
: 9841-406928 (M)
Email : sanju12np@yahoo.com
Field of Interest : Electronics
Ph. D. : Low Dimensional Devices (TU 2006)
M.Sc. : CDP, T.U. (1994)

Selected Publications

1. Comparative studies on electronic transport due to the reduced dimensionality at the heterojunctions of $GaAs/Al_xGa_{(1-x)}As$ and $Ga_xIn_{(1-x)}As/InP$ systems at low temperatures: **S. Shrestha** & C. K. Sarkar, Microelectronics Journal **37**, 8, 735-7 (2006).
2. Low-field electrical and thermal transport in lattice-mismatched n-GaN grown on sapphire: Two-layer model calculations: **S. Shrestha**, C. K. Sarkar & A. Chakraborty, J. Appl. Phys. **100,** 013705 (2006).
3. Low fiB. Sen & C. K. Sarkar, pg. 377, Proceeding of International conference on Communications, Devices and intelligent Systems (CODIS 2004)
4. The effect of band structure on the thermoelectric figure of merit of n-HgCdTe (MCT) under magnetic quantization at low temperatures: **S. Shrestha**, A. Chakraborty & C. K. Sarkar, pg.324, Proc. of International conference on Communications, Devices and intelligent Systems (CODIS 2004)
5. Effect of carrier confinement on photoelectric emission from magnetically and geometrically confined sub-two-dimensional semiconductor systems: P. K. Das, C. Bose, **S. Shrestha** & C. K. Sarkar, pg.381, Proc. of International conference on Communications, Devices and intelligent Systems (CODIS 2004)
6. The effect of reduced dimensionality on low field transport at low temperatures: **S. Shrestha**, P. Samanta & C. K. Sarkar, pg.1074, Proceedings of the XIIth International Workshop on the Physics of Semiconductor Devices (IWPSD 2003)
7. Study of thermoelectric power of GaN grown on sapphire using two layer model: A. Chakraborty, **S. Shrestha** & C. K. Sarkar,

pg.1071, Proceedings of the XIIth International Workshop on the Physics of Semiconductor Devices (IWPSD 2003)

8. Effect of reduced dimensionality on low field AC Mobility at low temperatures: **S. Shrestha**, P. Samanta & C. K. Sarkar, pg.133, IEEE Conference on Electron Devices and Solid-State Circuits (EDSSC'2003)
9. Hot-phonon effect on hot electron transport in narrow gap semiconductors under a quantizing magnetic field at low temperature: **S. Shrestha** & C. K. Sarkar, pg. 409, Phonons in Condensed Materials editors: S P Sanyal and R K Singh (2002)
10. Low field AC mobility in one dimensional electron gas at low temperatures: **S. Shrestha**, P. Samanta & C. K. Sarkar, pg. 414, Phonons in Condensed Materials editors: S P Sanyal and R K Singh (2002)
11. Breakdown of Gate Dielectrics of EEPROM Devices in VLSI Circuit during High-field Stress: P. Samanta, **S. Shrestha** & C. K. Sarkar Pg. 110, 28th Annual Convention and Exhibition of IEEE India Council (ACE-200)
12. Longitudinal Magneto-Seebeck coefficient in degenerate and nondegenerate n-HgCdTe in the Extreme Quantum Limit at low temperatures: **S. Shrestha**, K. Santra, P. K. Bhattarai & C. K. Sarkar, pg.1367, XIth International Workshop on the Physics of Semiconductor Devices (IWPSD 2001)
13. Study of magneto-millimeter and microwave hot electron conductivities in narrow band gap n-HgCdTe: **S. Shrestha**, P. K. Bhattarai, A. Chakraborty & C. K. Sarkar,IVth National Conference on Science & Technology, Royal Nepal Academy of Science and Technology (RONAST 2004)
14. Combined figure of merit for GN: grown on sapphire: **S. Shrestha**, A. Chakraborty, C. K. Sarkar & P. K. Bhattarai IVth National Conference on Science & Technology, Royal Nepal Academy of Science and Technology (RONAST 2004).

Mr. Pramod Kumar Thakur

Designation : Assistant Professor
Contact Address : CDP TU Kirtipur,
Telephone : 031-522887 (H)
: 9841721700 (M)
E-mail : thakur_pramod2001@yahoo.com
Date of Birth : 2035 – 02 – 10
Place of Birth : Rajbiraj –9, Saptari
Field of interest ***:Experimental work in Physics, Molecular Physics***
Qualification : M. Sc., CDP, TU, Kirtipur
M Sc Thesis :Theoretical study on absorption of light due to effect of Ponderomotive Force
Experience :tought M.Sc. (Physics) since last 12 years

Ms. Sangeeta Maharjan

Designation : Teaching Assistant
Contact Address : CDP,T.U., Kirtipur
Telephone Number : 9841652075
E-mail : sangeetamaharjan@gmail.com
Place of Birth : Kathmandu
Field of Interest : Atmospheric Physics
Qualification : M. Sc., CDP, TU, Kirtipur

Publications:

1. **S. Maharjan** and Ram P. Regmi, Numerical Weather Prediction for Himalayan Complex Terrain: Prospects of Variational Data Assimilation. JNPS, **2 (1)**, 63-68 (2015).
2. **S. Maharjan**, Springtime Meteorology of Damauli valley, Nepal: Implication for Climatic Comfort and Environmental Hygiene. *JIST* , **19 (2)**, 24-29 (2014).
3. **S. Maharjan** and Ram P. Regmi, Grid Based Temperature and Relative Humidity Distribution Map of The Kathmandu Valley. *JIST*, **19 (1)**,7-13 (2014)
4. Ram P. Regmi and **S. Maharjan**, Wind Power Density over the Kathmandu Valley and its Surrounding Areas. *JIST,* **18 (1)**, 43-49 (2013).
5. **S. Maharjan** and Ram P. Regmi, Mechanism of Intrusion and Channeling of Regional Air Mass Over Kathmandu Valley. *JIST*, **18 (2)**, 77-83 (2013).

Supporting Staffs

Sargaman Maharjan
Administrator
9803736846

Mina Manander
Head Assistant
9813040374

Mohan Bd Shrestha
Lab Assistant
9849087874

Govinda Maharjan
S. Lab Boy
9860811494

Gautam Thapa
T. Technician
9841400142

Shreedhar Pd. Subedi
S. Lab Boy
9841401776

Laxmi Pandey
Lab Boy
01-4336315

Mangal S. Maharjan
Office Assistant
01-4330705

Sharmila Shrestha
Office Assistant
01-4330625

Lalit Bd Gurung
Office Assistant
01-4331054

Gyanendra Maharjan
Gardener
9841468167

Raj Deula
Office Assistant
9841862681

CDP Webpage Address:

https://tucdp.edu.np/

CDP Telephone:

0144331054

Ph.D. Students (2018)

Anita Misra
Mahottari
S: Prof. Raju Khanal

Bhanu B. Sapkota
Kathmandu
S: Prof. Binil Aryal

Basu Dev Ghimire
Kathmandu
S: Prof. N. Chapagain

Bhishma Karki
Jhapa
S: Prof. JJ Nakarmi

Bhogendra Kathayet
Morang
S: Prof. N. Chapagain

Daya Nidhi Chhatkuli
Kathmandu
S: Prof. B. Aryal

Dinesh K Chaudhary
Kathmandu
S: Prof. Leela Pradhan

Drabindra Pandit
Rautahat
S: Prof. N. Chapagain

Indra Bd Bhandari
Kathmandu
S: Prof. Ishwar Koirala

Janak R. Malla
Nepalgunj
S: Prof. Binil Aryal

Jiwan Regmi
Pokhara
S: Prof. Khem N. Paudyal

Manoj K Chaudhary
manojkc054@gmail.com
S: Dr. Bhawani D. Joshi

Prakash Man Shrestha
Kathmandu
S: Prof. Khem N. Paudyal

Raj Kumar Rai
Kathmandu
S: Prof. Om P. Niraula

Rajendra P. Koirala
Syangja
S: Prof. N. P. Adhikari

Rajesh K Bachchan
Birgunj
S: Prof. Binil Aryal

Ram Babu Roy
Kathmandu
S: Dr. G. C. Kaphle

Ramesh K Gohiwar
Biratnagar
S: Prof. D. Adhikari

Salika Ram Bhandari
Rupandehi
S: Dr. G. C. Kaphle

Shankar P Chimauriya
KU, Dhulikhel
S: Dr. Bal Ram Ghimire

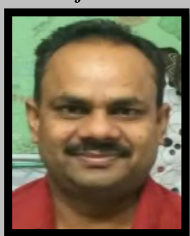
Shyam P. Khanal
Gulmi
S: Prof. N. P. Adhikari

Suresh Basnet
Kathmandu
S: Prof. R. Khanal

Tarini Kumar Yadav
Kathmandu
S: Dr. G. C. Kaphle

Taraun Chaudhary
Mahendranagar
S: Prof. B. D. Joshi

Tika R. Lamichanne
Syangja
S: Dr. H. P. Lamichanne



Upendra Meheta
Biratnagar
S: Prof. D. Adhikari

Usha Joshi
Kathmandu
S: Prof. Khem N. Paudyal

Vijay K. Jha
Mahottari
S: Dr. Lekhnath Misra

Second Semester (Fifth Batch of the Semester System)


Akash Subedi
Rolpa
subediakash52@gmail
9814471157


Amir Wagle
Jhapa
wagleamir74@g
9845568566


Amit Tharu
Banke
ameetchy2049@gmail
9848255559


Amrit Gurung
Lamjung
emailamrit7@gmail
9846181777


Amrit Naharki
Dhading
anaharki53@gmail
9860719556


Arjun Dumre
Syangja
arjundumre799@gmail
9843379567


Arjun Gaire
Palpa
arjungaire03@gmail.com
9867172723


Arjun
LamaNawalparasi
gurungarjun1994@gmail
9805411773


Arun Shrestha
Kathmandu
eeshanstha@gmail.com
9843536794


Ashish Bhattarai
Morang
bhattaraiashish422@gmai
9842282466


Bhairab Sundar
Singh
ThakuriSurkhet
bhairabsinghthakuri0@
g9860690310


Bhawana Sharma
Dang
sharmaanima50@gmail
9844967689


Bhishma Neupane
Rupandehineupanebh
ishma@yahoo
9847555130


Bijay Nath Baniya
Rupandehi
9847258600


Bikash Shrestha
Rupandehi
9847258600


Bikram Pandey
Palpa
pandeybikram193@gmail.co
9847169877


Bimal Thapa
Parbat
bimalthapa444@gmail.co
m
9817170279


Bishal Paudel
Nawalparasi
paudelbishal565@gmail.co
m9805485800


Bishnu N. Shrestha
Ramechhap
bishnunarayan50@gmail
9803086018


Chandra P. Bhatta
Kailali
chandrabhatta883@gmail
9843879456


Chandra Singh Aidi
Dadeldhura
9858745424


Chandrashekhar
Bhagat
Rajbiraj
bhagatchandrashekhar99@
9804792498


Chhabi Lal
Bhandari
Baglungchakendra16@
yahoo.com
9846750382


ChiranjibiDhakal
Kailali
chiranjibi.dhakal1@gma
il9812777576


Deepa
Lamichhane
Syangja


Dharma Raj Dhakal
Surkhet
dhakaldharma605@gma
9866538814


Dhiraj Ghimire
Jhapa
dhirug2@gmail.com
9806049372


Dilip Gautam
Rukum
dilip004678@gmail.com9
849004678


Dinesh G.C.
Morang
Brijsingh707@gmail.co
9844114464


Dipak Chaulagain
Jumla
chaulagaindipak2075@g
9841567153


Dipesh Kumar Sah
Sunsari
kumardipeshsah@gmail
9804335146


Durga P Bhandari
Achham
bhandaridurgaprasad501
@g
9863344019


Ganesh Pr. Joshi
Gorkha
ganeshjoshi930@gmail
9863451432


Geeta Pandey
Dailekh
geetapandey2053@gmail
9844030213


Gopal Bhusal
Dang
bhusalgopal89@gmail9
863451351


Gopal B.K.
Mahottary
gbk367@gmail.com
9841311925


Gyan Pr. Neupane
Palpa
neupanegyan61@gmail
9847417361


Hari Pr. Kurmi
Kapilvastu
harichaudhary44496@g
9867217065


Hari Timsina
Jhapa
haritimsina351@gmail.co
m9844661766


Homchandra Adhikari
Udyapur
homchandra123@gmail.
9842480315


Homnath Dulal
Morang
homnathdulal2049@gm
ail 9862024436


Imran Khan
Kathmandu
daimrankhan@gmail.co
m9818371089


Indra Bahadur K.C.
Salyan
kcindra3@gmail.
9840022148


Indira Adhikari
Kathmandu
adh_indu2045@gmail
9865091956

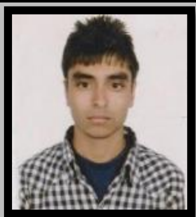

Jeevan Bhattarai
Kailali
jeevanvai45@gmail.com9
865777998


Kamal DhamalaAdhikari
Okhaldhunga
dhamalakamal@gmail.co
9849181008


Kamal Pandey
Syangja
kp885193@gmail.com
9867010002


Khil P. Timalsina
Lalitpur
timalsinakhilprasad@g
m
9849877072


Krishna Oli
Salyan
olikrishna98@gmail.com
9866911724


Krishna P Bhurtel
Parbat
krishnabhurtel10@gmail
9846462586


Kshitij Pangeni
Syangja
pangenikshitij3@gmail
9846557900


KshitizKshetri
Kathmandu
kshetrik16@gmail.com
9814888264


Kula Jaishi
Kalikot
jaishikula@gmail.com9
848321317


Kumar K.C.
Kathmandu
kumaarkc47@gmail.co
m9860009409


Kumar Neupane
Kathmandu
kumarneupane4344@gm
9849434472


Lalit Dhami
Baitadi
dhamilalit555@gmail.co
9868896658


Lalit Singh Karki
Kanchanpur
karkilalitsingh@yahoo.co
m 9868403342


Laxman Bhandari
Palpalaxmanbhandari03
9@gmail
9844767404


LiladharBohara
Doti
liladharbohara0411@gm
9848558132


Lokendra S. Dhami
Kanchanpur
lokendra.dhami@gmail
9840502838


Madan Rawal
Achham
rawalmadan25@gmail
9848780755


Mahendra Rawat
Surkhet
mahendrarawal682@gm
ail9848239461


Mahesh Giri
Jajarkot
maheshgiri200@gmail.co
9860015990


Manoj K. Shrestha
Sindhupalchok
stha.manoj018@gmail.co
9886157009


Mausam N Limbu
Sunsari
limbumausam0416@gm
9810506747


Mohan Datta Bhatt
Darchula
bhattm316@gmail.com9
863468447


Nabin
BhagatKathmandu
smartnrn23@gmail.com
9804266333


Narayan Basnet
Lamjung
narayanbasnet75@gmai
9846544419


Nirab Sharma
Kathmandu
nirab1234@gmail.com98
49035900


Nirmala Kuikel
Jhapa
kuikelnirmala13@gmail
9842755021


Nirmala Regmi
Parbat
regmi.nirmala1@gmail
9846619680


Niroj Humagain
Kavre
humagainniroj71@gmail
9808904058


Nishchal Paudel
Jhapa
nishchalpaudel1@gmail
9861293363


PhanindraDevkota
Salyan
pd152207@gmail.com9
868620282


Pintu Shah
Rautahat
shahpintu574@gmail.com
9845552818


Prabin Katuwal
Myagdi
katuwalprabin100@gmail
9843917841


Prajapati Dahal
Morang
prazz.pd@gmail.com
9862957413


Prajwal Shrestha
Sunsari
prajal.drn15@gmail.com
9817353986


Prakash B Thakur
Janakpur
prakashbhushan018@gm
9814844243


Prakash Dawadi
Makawanpur
bkprakashdawadi@gma
9845733856


Prakash Joshi
Kailali
brokenheartprakash@gm
9843556775


Pratibha Khanal
Gulmi
pratibhakhanal77@gmail
9847233601


Prem Pr. Ghimire
Syangja
premgh730@gmail.com
9846225878


Pushkar Saud
Kanchanpur
pushkarsaud1995@gma
9868772979


Rabin Bhattarai
Chitwan
rabinbhattarai667@gmail
9845440599


Rabindra N.
Yadav
Janakpur
rabindranathyadav8@g
9824870545


Radha Krishna
JoshiKanchanpur
joshiradhakrishna11@gm
9848997942


Rajeeb Kunwar
Lalitpur
punkrajeeb76@gmail.com
9849534187


Rajendra Silwal
Dhading
rajendra.silwal89@gmail
9849000956


Raju Lamsal
Tanahun
rlamsal777@gmail.com
9849005879

Ramesh D. Bhatt
Baitadi
bhattrameshbaitadi@gm
9848714700

Ravi Pandey
ravipandey1792@gmail
9804012821

Sandeep Chaudhary
Kapilvastu
chaudharysandeep620@g
9815467290

Sandesh Devkota
Chitwan
9845208799

Sangat Sharma
Syangja
9856014219

Santosh Bhandari
Chitwan
bhandarisantosh7518@
9845519149\

Santosh K.C.
Tanahun
santoshkc6588@gmail
9846162982

Santosh Panth
Rupandehi
santoshpanth555@gmai
9867420826

Sarita Bhatt
Kanchanpur
bhattsarita11@gmail.com
9848993994

Saroj K. Mandal
Saptari
sarojkumarandal661@gm
9804781113

Satyanand Gupta
Nawalparasi
iamsatyagupta@gmail
9868185205

Sharup Sheikh
sharupsheikh33@gmail
9818038147

Shiva Bikram Thapa
Kathmandu
9818038147

Shusan
NepalRupandehi
nepal.shusan@gmail.co
m9811405898

Sudhanand Mandal
Kathmandu
nandasudha215@gmail
9861785960

SujanPokhrel
Nawalpur
wedantpokhrel@gmail.co
m9863833883

SujanSubedi
Parbat
sujansubedi1995@gmail
9840011485

Suman Adhikari
Dhankuta
smartsumanadhikari@g
9803692293

Suraj Rai
Sankhuwasabha
raisuraj732100@gmail
9843689576

Surakshya Bhattarai
Kathmandu
9860205949

Surendra Bajagain
Lalitpur
bajsurendra12345@gmail
9851089439

Suresh K. Chaudhari
Rautahatsc044548@g
mail.com9860044548

Sushil C. Gautam
Bhaktapur
sushilgtm123@gmail.co
9842214166

Tibendra Adhikari
Jhapa
tbndhkr@gmail.com
9844688290

Tika Ram Bhandari
Dang
bhandaritikaram1996@g
9847838930

Tirth Bhatta
Kathmandu
tirthbhatta666@gmail.co
9865630273

Uchit Chaudhary
Morang
uchitchaudhary1992@gm
9862304181

Umesh Karki
Taplejung
umeshkarki675@gmail.co
9816091474

Yagya Bhattarai
Jhapa
yagyabhattarai29@gmai
9816006551

YubrajNiroula
Jhapa
niroulayubraj96@gmail
9818710608

Third Semester (Fourth Batch of the Semester System)


Ajay shakya
Bhaktapur
shakyajey@gmail.com
9803816811


Alisha Budhathoki
Kathmandu
alishabudhathoki9@gmail
9808971337


Amar Thagunna
Baitadi
Thagunnaamar47@gmail.com
9848844244


Amit Kumar Shah
Morang
amitsahb123@gmail.com
9803258399


Anil Yadav
Kapilvastu
Anilyadavp267@gmail.com
9814427627


Anina Mahat
Siraha
Aninamahat9@gmail.com
9849659183


Ashwin T. Magar
Syangja
-
9846526193


Ashish Mukhin
Kailali
aasismukhia@gmail.com
9804638624


Babita Gyawali
Dang
Babeeta209nk@gmail.com
9809779367


Baburam Sapkota
Chitwan
baburam.sapkota94@gmail
9845543395


Balaram Regmi
Gorkha
Regmibalaram3@gmail.com
9849664290


Bandana Shrestha
Tanahun
Bandu7864@gmail.com
9843540545


Basanta Acharya
Chitwan
achchirangeebi@gmail.com
9845522987


Basudev Yadav
Kapilvastu
Yadavprem2135@gmail.com
9860236796


Bhishm Shankar Joshi
Darchula
bhishmjoshi1995@gmail.com
9848781802


Bhuwan Ahikari
Ramechaap
Adhikaribhuban68@gmail
9860811643


Bhuwan Ahikari
Pyuthan
pdlbhuwan@yahoo.c
om
9851270282


Bhuwan Upreti
Dhading
Bhuwanupreti072@gmail
9841064462


Bibandhan Poudyal
Morang
bibandhanpoudyal@gmail
9843435822


Bibek Shrestha
Morang
livevilifeshrestha@gmail
9862232511


Bibek Subedi
Morang
Vivek13.bs@gmail.com
9817395443


Bidya Wagle
Tanahu
Vidyawagle74@gmail
9843296836


BikalpaLamsal
Kapilvastu
lamsalbikalpa@gmail.com
9811990220


Bikash Sapkota
Jhapa
Bikash.sapkota000@gmail
9842631419


Binaya K. Mahato
Dhanusha
swamibinay@gmail.com
9844125938


Binita Shah
Dang
thakuribini@gmail.com
9847884492


Bishnu Bushal
Kapilvastu
Bishnubhusal789@gmail.com


Bishnu Karki
Rupandehi
Bishnukarki724@gmail.co
9849329262


Bishnu P.Belbase
Rupandehi
Bishnupdbelbase89@gmail
9867331743


Chandra Bd Nepali
Kavrepalanchok
Nepalichandra2071@gmail
9849577860


Chandra S. Chaudhary
Sarlahi
Sekharchaudhary292@gmail
9818060147


Chiranjibi Shrestha
Dhading
Shresthachiran540@gmail
9849245141


Devraj K.C.
Dolakha
Kcdevraj849@gmail.com
9843626996


Dhurba R Jaishi
Bajura
Dhurbajaishi7@gmail.com
9843150358


Dipendra Kr. Raut
Saptari
rautdipendra12@gmail.com
9840017632


Durga Ghimire
Rupandehi
Quantumghimire1990@gmail
9805468030


Ependra Tamang
Morang
Ependra.tamang123@gmail
9817355161


Ganesh Shrestha
Tanahun
Goonyes680@gmail.com
9846705241


Ganesh Subedi
Baglung
Subediganesh961@gmail.com
9843934968


Gaurab Regmi
Jhapa
Gaurab11dimension@gmai
9862638600


Gopi Mahato
Chitwan
Joe.jonesme99@gmail.com
9845838598


Hari Pokhrel
Parbat
Pokhrelhari734@gmail.co
9840010451


Ishwor Guragai
Makawanpur
Guragainsir666@gmail.com
9843072983


Ishwori Nepal
Sindhupalchok
Ishunepal222@gmail.com
9849640426


Janak Basel
Nawalparasi
Janam.basel@gmail.com
9847121863


Jeevan Shrestha
Nuwakot
Shresthajeev82@gmail.co
9843117632


Kamal Khanal
Nawalparasi
addkaruna@gmail.com
9847270157


Kamal Khatiwada
Jhapa
Khatiwadakamal901@gml
9844641197


Keshab Subedi
Kapilvastu
subedikeshab2012@gmail
9840073617


Kisan Khatri
Pyuthan
Kisankhatri891@gmail.com
9844703893


Kishor Sijapati
Dhangadi
Kishorsijapati50@gmail.com
9848486713


Krishna Khadka
Achham
Krishnakhadka7313@gmail
9848587313


Laxmi Bhurtel
Kaski
Laxmibhurtel246@gmail.com
9846528711


Madan Somai
Gulmi
Madan.somai1.ms@gmail
9844706780


Madhav Pokhrel
Dang
Pokhrelmadhav2012@gmail
9857821732


Madhukar Pd.Yadav
Parsa
jmdmadhukar@gmail.com
9865222869


Mahesh Aryal
Gorkha
9846742992


Manoj Pokharel


Milan Gurung
Syangja
Meelangrg1@gmail.com
9826128265


Mukesh Pd Chauhan
Mpchauhan789@gmail.co
9816291158


Nagendra karki
Jhapa
indranagendra27@gmail
9818840042


Natwar Joshi
Kanchanpur
natwar230@gmail.com
9848790329


Nileema S. Paudel
Parbat
neleemasharma012@gmail
9867683867


Niraj K Shah
Dhanusha
Niroseshah3@gmail.com
9807883719


Niranjan Bhatta
Doti
Bhatta.niranjan400@gmail
9848582490


Nirmal Saud
Kailali
Saudnirmal05@gmail.com
9843610147


Philemon Pun
Dang
Punphilemon35@gmail.com
9813972481


Prabin Khadka
Morang
Prabin.shine980@gmail.com
9807000554


Prabin Thapa
Sindhupalchok
physicpract@gmail.com
9849133395


Pradip Tiwari
Parbat
Pradip.tiwari273@gmail.co


Prakash Kafle
Bardiya
Kafleprakas999@gmail.com
9848133423


Pramila Pokhrel
Sarlahi
Goodfortune94@gmail.co
9849204745


Pramod Subedi
Parbat
Subedipramod48@gmail
9849279035


Prashrit Baruwal
Parbat
prashritbaruwal@gmail.com
9849912842


Prem Chaudhary
Kailali
premchdhy@gmail.com
98488411419


Prena Chaudhary
Kailali
prenachau@gmail.com
9843160840


Puja Thapa
Palpa
9847516592


Radhika Rimal
Kathmandu
rimradhika@gmail.com
9843595601


Rajesh Chaudhary
Bardiya
Rajesh.chaudhary97@yahoo
9848236489


Rajesh kshettri
Bara
Rajukshettri51@gmail.com
9809226355


Ram chandra Nepal
Sindhupalchok
hithisismenpl@gmail.com
9849451536


Ram K. Adhikari
Banke
Raemkreeshna@gmail.com
9849670158


Ramesh Ghimire
Ramechhap
Ghimireramesh66@gmail
9860528964


Ramesh N. Yogi
Kailali
Yogiramesh185@gmail.co
9848551132


Ramila Khatiwada
Nuwakot
Khatiwada.ramila94@gmail
9861493520


Ram N Chaudhary
Rupandehi
Armanchaudhary783@gmail
9815475633


Rishiram Gyawali
Palpa
Rishiram2gyawali@gmail.com
9847437545


Rishi R. Ranabhat
Tanahun
Rishiram2074@gmail.com
9846642632


Roshan Paudel
Kaski
Foreverlove4@outlook.com
9840610040


Sagar Katwal
Sunsari
Saagarkshetri@gmail.com
9862220623

Sagar Rawal
Jumla
Searchbbc1881@gmail.com
9868336847

Sandeep phuyal
Jhapa
Phuyal69@gmail.com
9843565917

Sangeeta K.C.
Kaski
Sangeetac168@gmail.com
9815173686

Sanjeev Sapkota
Jhapa
sanjeevshapkota@gmail.co
9849107746

Santosh Shrestha
Sankhuwasabha
Santoshstha666@gmail.com
9849657069

Santosh Sodari
Gorkha
santoshsodari@gmail.com
9849218743

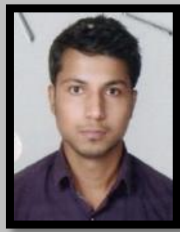
Sarita Lawaju
Bhaktapur
Sjuniper.juniper@gmail.com
9862236343

Saroj Bd Rimal
Lamjung
Sarojrimals226@gmail.com
9843701341

Saroj Paswan
Sarlahi
Sarojphysicist707@gmail.com
9865081654

Saroj Thakur
Mahottari
Thakursaroj58@gmail.com
9843520618

Shanta P Timalsina
Kavre
Sagartim2001@gmail.com
9841005049



Shishir Bhusal
Rupandehi
Shishirbhusal07@gmail.co
9867037713

Shishir Dangi
Dang
Dangi.ccr45@gmail.com
9865055745

Sidharaj Bhatta
Dadeldhura
siddhasirjan@gmail.com
9868792690

Sita Dawanse
Arghakhanchi
sitadawanse@gmail.com
9849916192

Subash Ghimire
Bharatpur
Subashghimire123@gmail
9845548384

Sudeep Jnawali
Rupandehi
lamsudeep12@gmail.com
9849595235

Sudip Acharya
Dang
Sudipacharya21@gmail.com
9847949478

Sujan Pd. Gautam
Myagdi
kroneckeer@gmail.com
9856080141

Sujan Shrestha
Gorkha
My.sujan5@gmail.com
9805888330

Sujata Dhakal
Palpa
Dhakal.sujata@yahoo.com
9849416318

Sujit Bati
Bhaktapur
sujitbati33@gmail.com
9841042900

Suman Shrestha
Kavreplanchock
sumanshresth@gmail.com
9843700617

Surendra B Tharu
Bardiya
Surendra.sangam51@gmai
9843772189

Sushil Pokhrel
Tanahun
Susheelpokhrel03@gmail
9843310874

Tara Pd Dulal
Dolakha
tarapddulal@gmail.com
9843178551

Trilochan Baral
Kaski
electronbaral@gmail.com
9846051849

Yajya Pd Limbu
Tehrathum
Subba.yogya123@gmail.co
9842208647

Yogendra Limbu
Ilam
yogendralimbu.54@gmail
9843315704

Yogendra Pun
Baglung
yog.pun100@gmail.com
9846806262

Fourth Semester (Third Batch of the Semester System)

Aakash Limbu
Morang
asubba671@gmail.com
9815911723

Abinash Pathak
Jhapa
abhipathak353@gmail.com
9807907721

Aditya Lamichhane
Kaski
lamichhane.aditya@gmail.com
9869277695

Ajay Gopali
Makwanpur
agopali24@gmail.com
9843684972

Ajay Sunar
Kathmandu
avijeet1990@redifmail.com
9860499864

Alisha Dhakal
Lamjung
alishadhakal2014@gmail.com
9849110589

Amar Thakuri
Tanahun
thakuriamar07@gmail.com
9849825703

Amrit Khadka
Surkhet
amitkhadka333@gmail.com
9843678199

Amrit Sedhain
Chitwan
sedhainamrit@gmail.com
9845114708

Anil Kumar Shah
anilshah9054@gmail.com
9844036905

Anish Maskey
alchemist_anish@yahoo.com
9807044405

Arun Kumar Karna
Morang
chitransarun1@gmail.com
9802793035

Atit Deuja
Bhaktapur
its.atitdeuja@gmail.com
9841652563

Awadesh Kumar Das
Sarlahi
awadeshdas6@gmail.com
9849120520

Barun DC
Dang
barun.dangi123@gmail.com
9840366975

Bharat Sharma
Pyuthan
bk.srm12@gmail.com
9843174437

Bharat Sunar
Arghakhachi
bsunar53@gmail.com
9847168942

Bhimsen Bhujel
Kavre
sxc.bhimsen@gmail.com
9860464734

Bibek Tiwari
Bara
tiwaribibek@gmail.com
9843409489

Bijaya Pudasaini
Makwanpur
bipuda@gmail.com
9845295655

Bijaya Kharel
Jhapa
bijayakharel78@gmail.com
9807936318

Bijaya Sharma
Chitwan
bijayasharma22@gmail.com
9845431214

Bikash Chauhan
Kathmandu
c2bikash@gmail.com
9849408378

Bimal Nepal
Rupandehi
urbimalnepal@gmail.com
9847382543

Binod Bhandari
binodbhandari.98471764
82@gmail.com

Binod Pun
Myagdi
punbinod64@gmail.com
98611113006

Binod Subedi
Chitwan
binodsubdi@gmail.com
9860028356

Bipin Khatri
Morang
khatrybipin12@gmail.com
9842089038

Bishnu Maya Acharya
Rupandehi
acharyabishnu828@gmail.com
9847585983

Bivek Pokhrel
Bara
bsiovneyk@gmail.com
9841500730

Buddhi Narayan Serma
Jhapa
Sermabuddhi@gmail.com
9817089973

Chheda Lal Chaudhary
Kailali
chhedalalchaudhary432@gmail.com
9848498864

Debit Subedi
Morang
debitsubedi@gmail.com
9842222274

Denish Poudyal
Sunsari
qrystal45@gmail.com
9849718053

Dependra Shah
Kailali
dependrashah35@gmail.com
9848679601

Devi Sapkota
Nawalparasi
devi.sapkota92@gmail.com
9843007385

Dharma Raj Mahato
Parsa
77drmahato@gmail.com
9843599034

Dindayal Sahani
Kapilbastu
dindayalsahani123@gmail.com
9807438247

Dipendra Ojha
Nawalparasi
dipendraojha49@gmail.com
984841718

Durga Pd. Adhikari
Kailali
durga400@gmail.com
984841718

Ganesh Pandey
Dhading
octganesh@gmail.com
9860319621

Gaurab Rijal
Pyuthan
gaurabrijal41@gmail.com
9860312336

Hemanta Bhujel
Dolakha
hemanta_bhujel@yahoo.com
9843609966

Hiralal Khatri
Banke
khatri_hiralal@yahoo.com
9848297960

Ishwor N. Joshi
Bajhang
ishworjoshi25@gmail.com
9840019308

Jaya P.N. Chaudhary
Kapilvastu
9807425643

Jayanti Aryal
Kathmandu
aryaljayanti50@gmail.com
9843160266

Kabita Bista
Pyuthan
kabitabista360@gmail.com
9849780360

Keshab Giri
Dang
keshabgiri699@gmail.com
9860871699

Khagendra Pd. Pokhrel
Jhapa
quasigod0@gmail.com
9842675862

Khemraj Hamal
Kailali
khemrajhamal143@gmail.com
9848502010

Khimananda Acharya
Parbat
deepakacharya649@gmail.com
9843162772

Kiran Nyaupane
Palpa
kkungai@gmail.com
9860938782

Kushal Baral
Jhapa
baralkushal.kb@gmail.com
9842648538

Krishna K. Bhandari
Baglung
krishna.bhandari91835@gmail.com
9847658918

Kshitij K. Magar
Dhankuta
x.yokchai@gmail.com
9810359235

Kushal Rijal
Nuwakot
kusshalko85@gmail.com
9841903349

Laxmi Chalise
Sindhupalchok
laxmichalise205@gmail.com
9841245687

Lila B. Gurung
Jhapa
jambalgurung@gmail.com
9862651661

Madan Prasai
Ilam
profoundphysics2010@gmail.com
9842782441

Meghraj Timsina
Kaski
timilsina@gmail.com
9746033989

Mohan Giri
Morang
mohangiri56@gmail.com
9843181557

Namuna Adhikari
Kavre
adhikaridw@gmail.com
9843250271

Narendra Basnet
Gulmi
basnetnarendra@gmail.com
9847300451

Narayan Basyal
Palpa
narayanbashyal04gmail.com
9847170576

Naresh Meuongba
Panchthar
meuongbanaresh@gmail.com
9851156532

Netra Thapa Magar
Palpa
netra.thapamagar011@gmail.com
9867204537

Phanindra Sunuwar
Sindhuli
fanindrasunuwar23@gmail.com
9849871709

Phanindra Thapa
Morang
phanindrathapaaa@gmail.com
9849385847

Pradip Adhikari
Kaski
adhprdp@gmail.com
9846058169

Prakash Bashyal
Syangja
prksbsl@gmail.com
9856051689

Prakash Timsina
Terhathum
renewableprakash@gmail.com
9842191683

Pramita Tiwari
Jhapa
pramishatiwari65@gmail.com
9843311865

Pramod Neupane
Palpa
pramodneupane.pn@gmail.com
9844794042

Prawin Rimal
Chitwan
cosmicprawin@gmail.com
9845939828

Puskar Thapa
Kapilvastu
pskrthp@gmail.com
9843561982

Radheshyam Bhattarai
Rupandehi
9860198458

Radhika Rijal
Nawalparasi
raka.jal01@gmail.com
9867223253

Rajan Ghimire
Rupandehi
mr.boyrajan@gmail.com
9847546384

Raju Khasu
Gulmi
khasuraju729@gmail.com
9847169822

Raju Paudel
Kaski
bidhan.98024@gmail.com
9846880372

Ramesh Chalise
Baglung
rameshchalise43@gmail.com
9845543397

Ravindra Aryal
Palpa
aryalrabin93@gmail.com
9847532936

Romeena Shrestha
Bhaktapur
romeenashrestha@gmail.com
9843035247

Sagar Adhikari
Chitwan
adhikaree.sagar@gmail.com
9849450188

Sagar Thapa
Nawalparasi
sagarnayan79@gmail.com
9847558771

Sailesh Dhungel
Jhapa
saileshdhungel53@gmail.com
984267845

Sandip Shah
Sunsari
sandipshah454@gmail.com
9814304174

Santosh Adhikari
Parsa
santoshadhikari890@gmail.com
9845546663

Santosh Burathoki
Baglung
shantosh.shreesh98@hotmail.com
9844723750


Santosh Thapa
Lamjung
thapa.st2049@gmail.com
9849119680


Saraswoti Dhital
Banke
9843441641


Sarman Bhurtel
Kathmandu
bhusar5510@gmail.com
9841262064


Saroj Dahal
Terhathum
dahalsaroj5465@gmail.com
9849421996


Saroj K. Thapa
Sindhuli
thapasaroj22@gmail.com
9849770678


Shiva Bhandari
Gulmi
bhandarishiva03@gmail.com
9843105041


Shivaji Tiwari
Kaski
daggar4698@gmail.com
9846260455


Shyam Pd. Kuikel
Kaski
lekiuk777@gmail.com
9846299482


Shyam S. K.Dhubedi
Parsa
shyamduvedi30@gmail.com
9806840585


Sijan Regmi
Chitwan
sijanregmi4444@gmail.com
9845182792


Sikala Tiwari
Gorkha
tiwarisikala@gmail.com
9841005404


Subash C. Gautam
Gulmi
gautamboss52@gmail.com
9847433670


Subash Poudel
Kaski
subash.poudel43@gmail.com
9846523234


Sudam Bhurtel
Kathmandu
sudambhurtel@gmail.com
9849754431


Sudip Ghimire
Lalitpur
sudip_ghimire@hotmail.com
9860981710


Sudip Paudel
Kaski
apoudel1000@gmail.com
9864318125


Suman Acharya
Baglung
9849535994


Suman Acharya
Rupandehi
acharyasuman63@gmail.com
9817576892


Suman Arghali
Palpa
ypnotiseme2@gmail.com
9847195202


Surendra Budha
Bajura
9861083418


Suresh Poudyal
poudel.suresh18788@gmail.com
9847402516


Sushmita Adhikari
Nawalparasi
susmita1498@gmail.com
9845544359


Susmita Bhattarai
Khotang
susmita1498@gmail.com
9843571498


Subeksha
Lamichhane
Kathmandu
subekxal@gmail.com
9849412861

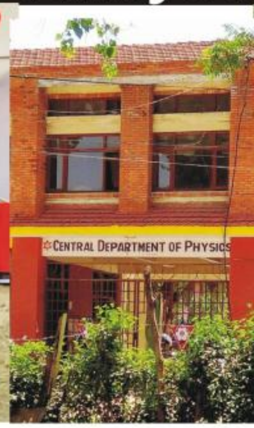

Thakur Bhandari
Dang
bhandarithakur99@gmail.com
9849785257


Youbraj Poudel
Rupandehi
poudelyoubraj100@gmail.com
9847110029


Yub Narayan Kaphle
Syangja
9846603248

Photos of CDP Family & Activities (2018)

CDP - Winner of GS-Exhibition 2019

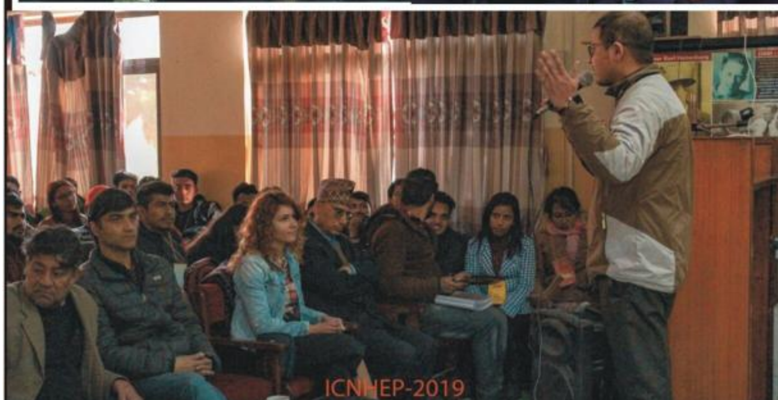


Second Sem Students

ICNHEP2019

Winter lecture series

SITARE2018



ICNHEP-2019

Sarashwati Puja 2018

Welcome & farewell program 2018

Welcome & farewell program 2018

Picnic third semester

CDP participanfs, IUCAA, Pune

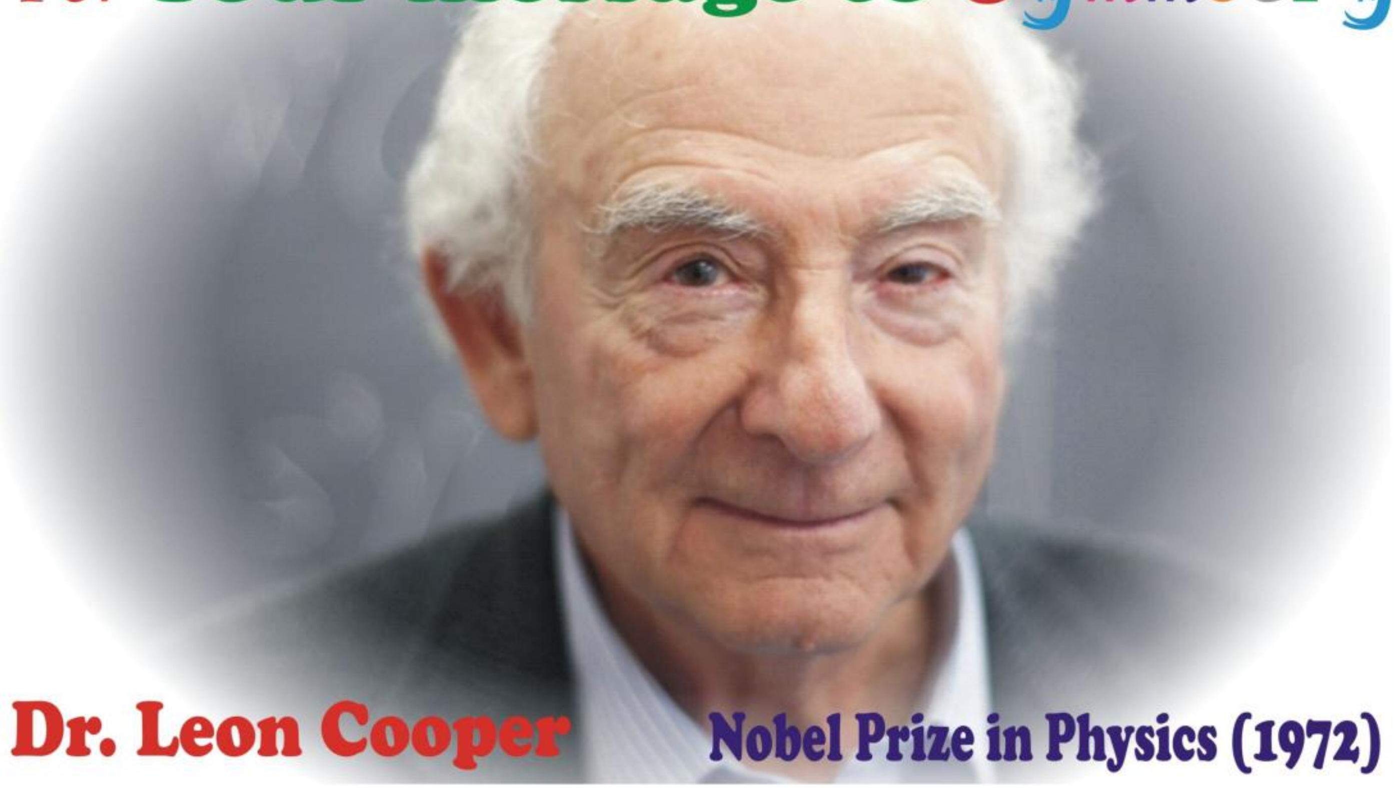
KLS sir: Interview

TU Academic Council meeting 2019

Women in physics conference

Thank you Nobel Laureate Dr. Cooper

For Your message to Symmetry



Dr. Leon Cooper **Nobel Prize in Physics (1972)**

Central Department of Physics, Tribhuvan University, Kirtipur, Nepal

Symmetry Volume XII (2018)