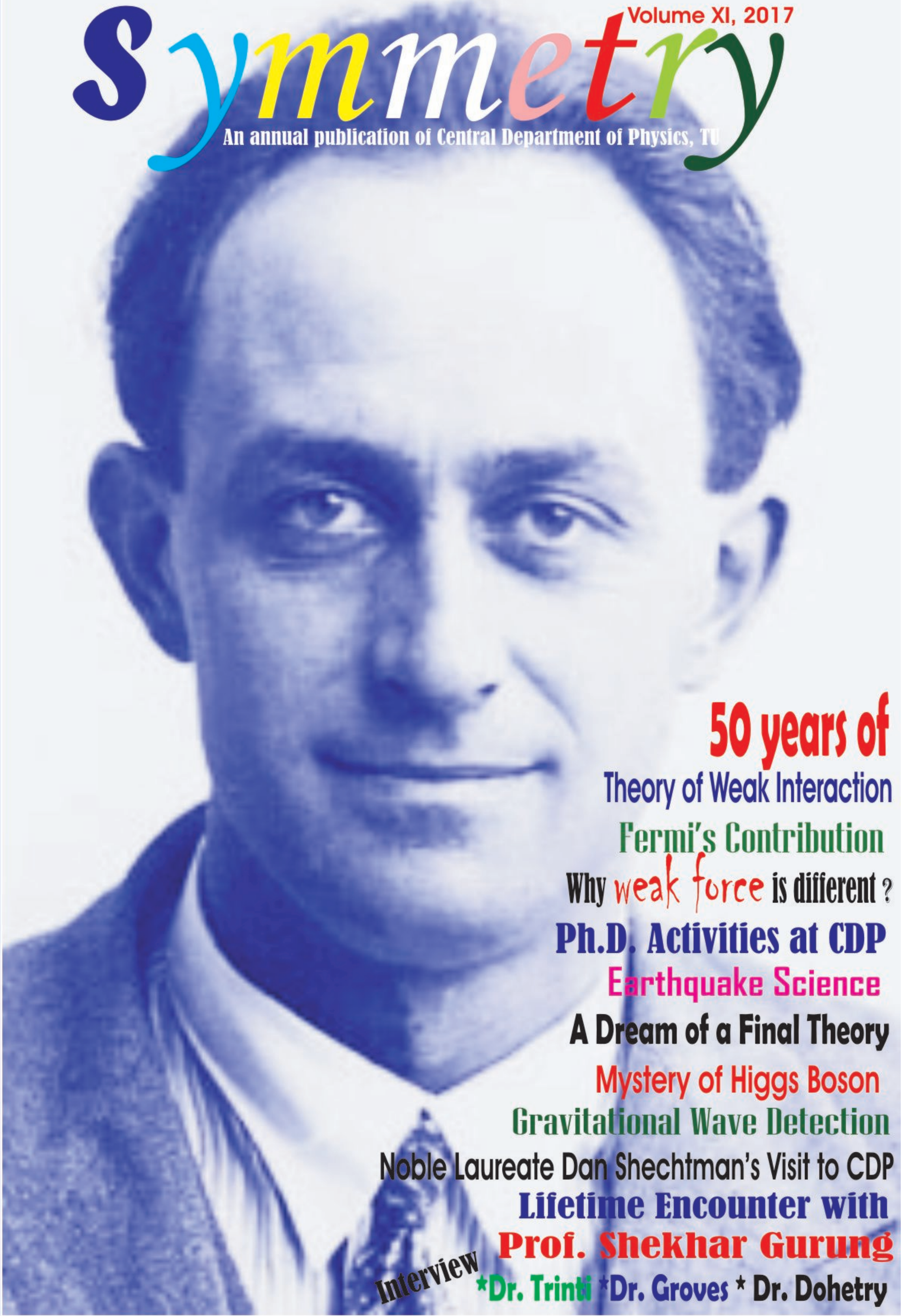
Volume XI, 2017

Symmetry

An annual publication of Central Department of Physics, TU

Dedicated to Enrico Fermi, who proposed Theory of Weak Interaction



50 years of

Theory of Weak Interaction

Fermi's Contribution

Why weak force is different ?

Ph.D. Activities at CDP

Earthquake Science

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*Dr. Trinti *Dr. Groves * Dr. Dohetry

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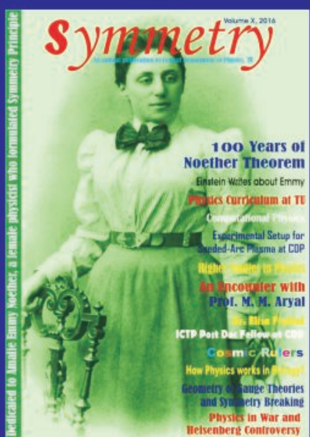

It is really surprising for me that the students of physics department of Nepal publishes a quality physics magazine named 'symmetry' regularly. I am a science journalist, never found such a broad information on Noether! Congratulation you guys! Your deep understanding bring you in front!

Isabella Rebeka, France
13 Feb 2017

I came across this magazine from facebook, forwarded to my cousin who is just 13 years old, want to be physicists in the future. After a couple of month, he thanked me for sending the magazine. This magazine helped him to understand a few abstract concepts. On his behalf I thank publisher for the effort.

Yuhan Koller, USA
23 April 2017

Second Batch of the Semester System (2015-2017)

Third Batch of the Semester System (2016-2018)

Fourth Batch of the Semester System (2017-2019)

Dedicated to

Enrico Fermi

Born: 29 September 1901, Rome, Italy
Died: 28 November 1954, Chicago, USA

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Symmetry
An annual Publication of CDP, TU

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Editorial

The 21st century is marked by two big achievements: discovery of Higg's boson at CERN and detection of the Gravitational waves by LIGO. This year, Physics Nobel Prize is awarded for the detection of gravitational wave. Apart from these, physics community has seen some breakthroughs in the field of Bose Einstein condensate (negative effective mass), time crystals, quantum computing, topological insulators, extrasolar planets, etc.

Enrico Fermi was a pioneer to give a theoretical description of the neutron beta-decay. Neutron beta-decay was the foundation of the theory of weak interactions. Enrico Fermi paved the way for the unification of two seemingly disparate phenomena, i.e., electromagnetism and weak interaction by formulating the first theory of weak interaction in 1933.

Physics is the study of matter, energy and their interactions. It has its role in enhancing the future progress of mankind. It expands our knowledge about the natural phenomena happening around us. From relativity to gravitational waves, quantum field theories to string theories, physics has always challenged our way of thinking. Physics is an essential part of the educational system and of an advanced society. National programs should be encouraged to improve physics teaching at all the academic levels.

Research plays a key role in the advancement of the society. We have seen in the history how researchers have led to great discoveries that have changed our lives forever. National issues such as energy scarcity, development of rural areas and living a sustainable life will require technical innovations that arise from research. Appropriate research can serve as solutions to many problems and also drive the economy of a country to new heights.

The ability of physicists to think analytically makes them versatile problem solvers. They are inventive and hence can contribute in developing the technological infrastructure of the country. Nepal graduates hundreds of physicists every year. These physicists have the capability of advancing the technological aspect of the country. However, our government is lagging behind in providing opportunities to the aspiring physicists within the country.

Students graduating from Central Department of Physics have performed well in international academia. Our faculties are producing high quality research papers in reputed journals. We can be sure that CDP will continue to enhance the quality of physics education in Nepal and produce high quality scholars.

Symmetry is an annual magazine of Central Department of Physics and this is the 11th volume. This magazine delivers basic theories and news related to the development and advancement in the field of physics.

This edition is dedicated to Enrico Fermi on the occasion of its 50th year of the discovery of one of the most celebrated theory, '*The Theory of Weak interaction*'. Enrico Fermi was awarded the Nobel Prize in 1938 for "*his discovery of new radioactive elements produced by neutron irradiation, and for the discovery of nuclear reactions brought about by slow neutrons.*" A scientific achievement, however small or big, is not possible with the effort of a single person only.

CDP family is highly indebted to Nobel laureate Prof. Dan Shechtman, who visited our department and delivered a very thoughtful lecture to the students. This volume of symmetry is honored by a lifetime sketch of our Prof. Dr. Shekhar Gurung, former HoD of CDP.

We aspire to inspire all the people reading this magazine towards physics and every field one is associated with.

Contents

Ph.D. Activities at CDP: Past, Present & Future

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

ABSTRACT

About five hundred Nepalese already received Ph.D. degree. About 95% of them achieved this goal in abroad (mostly in USA). The Ph.D. (Physics) program in TU has been started about 20 years back. But still it is in the process of proper shaping. Till date only 9 Ph.D. in Physics have been awarded at CDP, TU. Due to the recent research development, at present CDP have 25 Ph.D. students. In this article, a brief history of Ph.D. (Physics) program and the recent significant recommendation made by IoST and UGC will be presented and discussed.

Nepalese Graduates: Ph.D. in Abroad

Since last 22 years, about 40 M.Sc. graduates of Tribhuvan University are leaving nation every year for the higher study in Physics. Mostly our graduates are going to United States of America. In the beginning, they get enrolled for M.S. program with teaching assistanceship. After a couple or three semesters, they successfully qualify as a Ph.D. students of Physics. A few students directly get research assistanceship for Ph.D. too. A few (less than 10%) students go to other nations (western European nations, Japan, Australia, Brazil, India, China, Chile, etc).

To get teaching and/or research assistanceship, students need to have a very good percentile in '*Subject GRE*', '*General GRE*' and '*TOEFL*' tests. Our graduates prepare themselves for these tests very seriously. On an average they spend about one year for these tests. Since last few years, students have started to appear in the '*on-line courses*' offered by reputed US Universities. A few students have been receiving a very good offer directly for Ph.D. because of their excellent research work (masters' dissertation) in peer reviewed international publications.

It has been observed that our graduates complete Ph.D. in USA in four to six years. In addition, about 20% graduates turn their interest from Physics to Computer Technology and Engineering. Therefore we can easily estimate the total number of Nepalese Ph.D. in Physics. This number goes from 450 to 600. It means there are about a 500 Nepalese Ph.D. (Physics) who are in USA and other countries. This is a very big number. Author of this article have heared that the Nepal is in Top 10 in USA because of this number. A few are doing extraordinary work related to resrarch and development in very renowned industries in USA, Europe and Japan. A large number of Ph.D. holders are doing research for post doctorate program. A few are already a faculty member in the US Universities. These faculties are now playing a positive role to enhance research activities in Nepal.

Figure 1 shows a histogram of Nepali students studying either graduate or doing 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., Physics and Biological sciences), a large number of Ph.D. students are carrying out their research work.

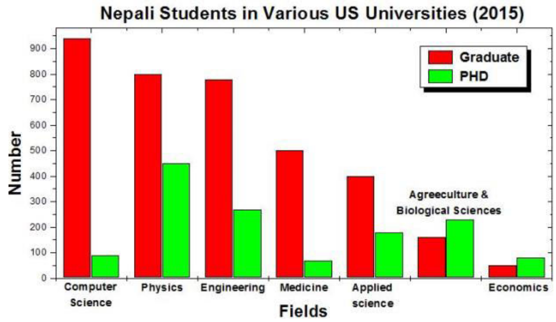

Figure 1: *A large number of Nepalese students are studying in USA, mostly in computer science, Physics and Engineering. Number of Ph.D. students is the largest in Physics.*

The return rate of our experts is rather low. The quality of University can not be improved without having a strong research faculties and research program. In this scenario, we need to develop Ph.D. research activities in the nation too. Tribhuvan University has made several attempts to enhance research in natural scinces. These attempts are just by means of law and principles. Implementation part is simple hopeless.

Ph.D. (Physics) Program in TU

In the year 1980, the first Ph.D. in Physics is registered in Tribhuvan University under the supervision of Prof. Dr. Kedar Lal Shrestha. The first Ph.D. scholar was Prof. Kedar Nath Baral (Amrit College, recently retired). The Ph.D. title of his thesis is '*A Study of the Electrical Behaviors of Kathmandu Thunderstorms*'.

Old building of CDP: where first Ph.D. has enrolled and awarded.

The contribution of Prof. Dr. Lok Narayan Jha in activating research activities in the department is noticeable. He has enforced authorities for the guidelines and knocked the door of then RONAST and later UGC for providing Ph.D. fellowship to the students. He motivated physics faculties of constituent colleges of TU for Ph.D. Because of this, a large number of senior faculties attempted for research but only a few came up with Ph.D. proposal. According to him, it was difficult to activate/convince supervisor (those who had Ph.D. from abroad) than that of the students. Because of this, he himself had begun to supervise Ph.D. scholars. He has supervised two Ph.D. students namely Prof. Dr. Jeevan Jyoti Nakarmi (CDP Faculty) and Dr. Kanchan Pd Adhikari (Bir Hospital) in the field of plasma physics and medical physics. The last Ph.D. project was collaborative in nature. Research collaboration has been initiated during 1990s. A list of physicists who completed Ph.D. in Nepal is shown in Table 1.

Prof. Dr. Kedar Nath Baral, first Ph.D. awarded by TU in Physics.The supervisor Prof. Kedar Lal Shrestha.

Table 1: *List of Ph.D. holders, awarded by the Institute of Science & Technology, Tribhuvan University 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

The role of International Centre for Theoretical Physics (ICTP) is very important particularly for the advanced courses and research activities. Prof. Dr. Narayan Pd Adhikari has extended and accelerated this academic connection through collaborations.

Dr. Shanju Shrestha, first women Ph.D. in Physics. Then Dean of IoST, Prof. Dr. Bishal Nath Upreti (black suit) and supervisor Prof. Dr. Pradeep K. Bhattarai (white Sweter) can be seen.

At present, CDP have a very dedicated research activity in the computational condensed matter physics.

Recently, experimental plasma physics lab has been established with the collaboration with India. A couple of students are involved in this laboratory for their Ph.D. research.

This year, Dr. Shiv Narayan Yadav and Mr. Nurapati Pantha received Ph.D. degree in Physics. Their work was under a research collaboration project with Institute of Astrophysics, Innsbruck University, Austria and ICTP, Italy. In between only nine scholars are awarded with Ph.D. degree. The noticeable thing is that the five Ph.D. are awarded since 2014. Therefore Ph.D. actvities have been significantly increased in these days.

Increasing Research Collaboration and Publication Rate

During 2005-2008, about half a dozon Ph.D. holder physicists (Dr. Narayan Chapagain, Dr. Raju Khanal, Dr. Hari Lamichanne, Dr. Narayan Pd Adhikari, Dr. Lekh Nath Misra, Dr. Balram Ghimire, Dr. Bhawani Dutta Joshi and the author of this article) returned back from abroad and joined Central Department of Physics and other TU constituent colleges. They have started taking classes at the masters' level and begun supervising masters' thesis. They brought new ideas with advanced technology through computers, softwares and of course the proper use of internet in order to access the Journals and database. Before this, access to the Journals, new books and computer softwares were very limited. In addition, they have begun research collaboration with their professors, colleagues, students abroad. This was the beginning of modern research collaboration. A frequent visit of collaborators, their talks/seminars, training classes encouraged the students and faculties. The publication rate has been significantly increased. Since last 4 years, about 15-20 papers have been publishing per year in the peer review Journals (Impact Factor > 1.5). A list of international publications during 2016-17 is listed in this volume of symmetry.

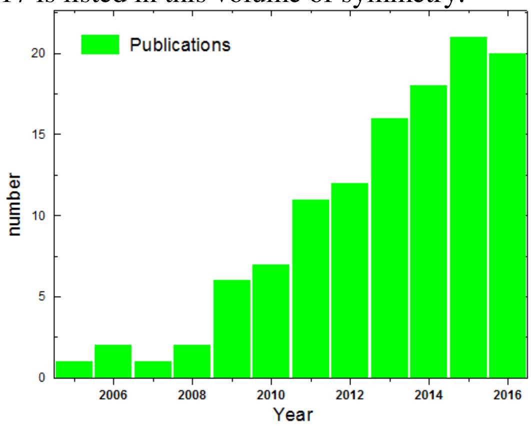

Figure 2: *Increasing rate of publications in the peer reviewed Journal by CDP faculties and students in last 12 years.*

The publication of symmetry (this magazine) has started in the year 2006. The Latex writing tool has been introduced in the department. Because of this activity, not only the quantity, quality of masters' dissertation has been significantly improved. These were the indicaters due to which Ph.D. projects begin to immerse at the surface.

Table 2 shows a list of Ph.D. scholars who already submitted their Ph.D. thesis fulfilling necessary criteria of IoST. Their thesis is in the process of final evaluation. After this, a final VIVA examination will be held in order to award Ph.D.

Table 2: *List of Ph.D. scholars who alresdy submitted thesis to the Institute of Science & Technology, TU. Their research works are in the evaluation stage.*

S.N.	Name	Supervisor
1	Mr. Prem Raj Dhungel	Prof. Dr. Uday Raj Khanal
2	Mr. Sanat Kumar Sharma	Prof. Dr. Uday Raj Khanal
3	Mr. Krishna Raj Adhikari	Prof. Dr. Shekhar Gurung
4	Mr. Shashit Kumar Yadav	Prof. Dr. Devendra Adhikari

Ph.D. Scholars at CDP

CDP has 25 Ph.D. students these days (see Table 3). They are working in various areas: from condensed matter to astrophysics, from plasma physics to atmospheric physics, from bio-medical physics to radiation physics. Out of 25 Ph.D. scholars, 17 (68%) are permanent faculty of Tribhuvan University. Two scholars are from other Universities (Kathmandu University and Mid Western University).

Table 3: *List of on-going Ph.D. scholars at the Central Department of Physics, TU.*

S.N.	Name	Supervisor
1	Mr. Ajay Kumar Jha	Prof. Dr. Binil Aryal
2	Mr. Bhanu Bhakta Saphota	Prof. Dr. Binil Aryal
3	Mr. Arjun Gautam	Prof. Dr. Binil Aryal
4	Mr. Janak Ratna Malla	Prof. Dr. Binil Aryal
5	Mr. Kisori Yadav	Prof. Dr. Jeevan J. Nakarmi
6	Ms. Neema P. Gongal	Prof. Dr. Jeevan J. Nakarmi
7	Mr. Lok Bahadur Baral	Prof. Dr. Jeevan J. Nakarmi
8	Mr. Bhisma Karki	Prof. Dr. Jeevan J. Nakarmi
9	Mr. Suresh Kumar Gupta	Prof. Dr. Raju Khnal
10	Mr. Bhesh Raj Adhikari	Prof. Dr. Raju Khnal
11	Mr. Ghanshyam Thakur	Prof. Dr. Raju Khnal
12	Ms. Anita Mishra	Prof. Dr. Raju Khnal
13	Mr. Saran Lamichanne	Prof. Dr. Narayan Pd Adhikari
14	Mr. Sunil Pokhrel	Prof. Dr. Narayan Pd Adhikari
15	Mr. Shyam Khanal	Prof. Dr. Narayan Pd Adhikari
16	Mr. Rajendra Pd Koirala	Prof. Dr. Narayan Pd Adhikari
17	Mr. Bhogendra Khathayet	Dr. Narayan Pd Chapagain
18	Mr. Drabindra Pandit	Dr. Narayan Pd Chapagain
19	Mr. Tika Ram Lamichanne	Dr. Hari Pd Lamichanne
20	Mr. Pitri Bhakta Adhikari	Prof. Dr. Kedar Nath Baral
21	Mr. Vijay Kumar Jha	Dr. Lekh Nath Mishra
22	Mr. Shankar Pd Chimauriya	Dr. Balram Ghimire
23	Mr. Tarini Kumar Yadav	Dr. Gopi Chandra Kaphle
24	Mr. Salika Ram Bhandari	Dr. Gopi Chandra Kaphle
25	Mr. Manoj K Chaudhary	Dr. Bhawani Dutta Joshi

Central Department Research Committee (CDRC) has been publishing Ph.D. calendar every year. Biannual Ph.D. progress report presentation has been begun in the department. All scholars need to present their progress in front of CDRC members, supervisors, evaluators and other Ph.D. scholards. Ph.D. scholars are regular in the department. Their attendance is must for the official purposes. The plagiarism checking has been started in the departments. Six credit hour compulsory coursees has introduced and implemented by the CDRC since 2016.

Ph.D. Operational Guideline, IoST, TU

There is a clear policy and guideline to complete Ph.D. work within five academic years in IoST, TU. If not completed within this time period it can be extend two times upto 7 years. But the policy is so flexible that some candidate get study leave and they engage in private colleges, there is no strong monitoring plan on progress report. Because of this, a large number of Ph.D. students did not complete their works.

Ph.D. award at CDP. Dean of IoST Prof. Dr. Ram Prasad Khatiwada announced the award for Shiv Narayan Yadav.

Till 2010, according to an official document of IoST [3], about 25% Ph.D. students could not complete their degree within the extended period and their Ph.D. enrollment get expired. The reasons behind it are i) some students find better opportunities in other universities, ii) some did not receive any scholarships and could not able to spend field expense personally, iii) retirement of supervisors and conflict with supervisors iv) lack of strong research plan of data collection and analysis, v) supervisor(s) easily accept PhD candidates with poor quality of PhD synopsis but no strong plan of supervisor(s) to guide students, vi) intentional enrollment just to get leave and engage in other private colleges. In Physics, three student's Ph.D. enrollment has been expired in the past. This is a very small number if we compare it with other disciplines.

IoST Ph.D. Operational Guideline is considered as one of the best in this region. The highlights of this guideline are as follows:

1. **Publication:** Students should publish at least a paper as a first author in the peer reviewed international (other than the Journals published in Nepal) index Journal. The total number of publications should be not less than two.
2. **Conferences:** Students should attend at least one international meeting/conference and present the result.
3. **Pre-submission Seminar:** Students should obey the rule and regulations of concerned CDRC and

give pre-submission seminar after submitting thesis. CDRC should forward Ph.D. thesis to the Dean Office for the final evaluation.

4. **External Examiners:** Ph.D. thesis should be approved by the three external (national, regional and international) examiners before the final VIVA examination.
5. **Regular Evaluation:** Student should be regular and present progress report at least once in a semester.

Latest Ph.D. at CDP: Dr. Nurapati Pantha with supervisor and HoD.

UGC Guideline for Ph.D. Program

Recently University Grant Commission, Nepal (2017) recoommended '*Minimum Standard for Ph.D. Operational Guideline*' and circulated to all Universities of Nepal saying to modify their existing rules and regulations regarding Ph.D. program as per the guideline. There are three major recommendations, which are as follows:

1. **Entrance Test:** Students should pass entrance test to quality as a Ph.D. student. The modality of this test can be fixed by concerned institutes or departments.
2. **Compulsory Course:** Ph.D. students should complete at least *18 CH course* in two semesters. They should be regular in these semesters. They should give all exams to earn these credits.
3. **Plagiarism Clearance Certificate:** Before the final VIVA examination, Ph.D. students should submit plagiarism clearance certificate to the concerned institute or faculty of University.

IoST, TU has reviewed UGC guideline critically, hold a discussion with UGC authorities. Author of this article was also in that committee. IoST has revised guideline and conducted first entrance examination on 2 December 2017 for the Ph.D. program. Figure 3 shows a flow chat describing the Ph.D. procedure for the future. There were 58 applicants in the Ph.D. entrance examination, including 16 in physics only.

From now, students need to pass entrance examination held by IoST, TU. After this, students need to find supervisors themselves and wrote a proposal. The proposal should contain extensiove literature review and the problem with a very specific objective. A method to solve that objective should be described in the proposal. The proposal should be presented orally in front of CDRC/experts and should be approved. After this students should immediately begin to take following compulsory courses:

First Semester:

(1) **Research Methodology (3CH):** This course will be commen for all IoST Ph.D. students. The examination will be held as per semester operational guideline of TU.

(2) **Philoshophy (3CH):** This course is also the commen for all IoST Ph.D. students. The examination will be held as per semester operational guideline of TU.

(3) **Seminar (3CH):** The modality of the seminar will be fixed by IoST, TU. To earn 3 CH, students need to deliver two or 3 seminars as per requirement. One of the seminars should focus on research methodoly that the Ph.D. students going to apply to solve his/her research problem. The CDRC will evaluate this course.

Second Semester:

(1) **Advanced Research Methodology (3CH):** This course will be prepared by concerned CDRC focusing on their subject's demand. The examination will be held as per semester operational guideline of TU.

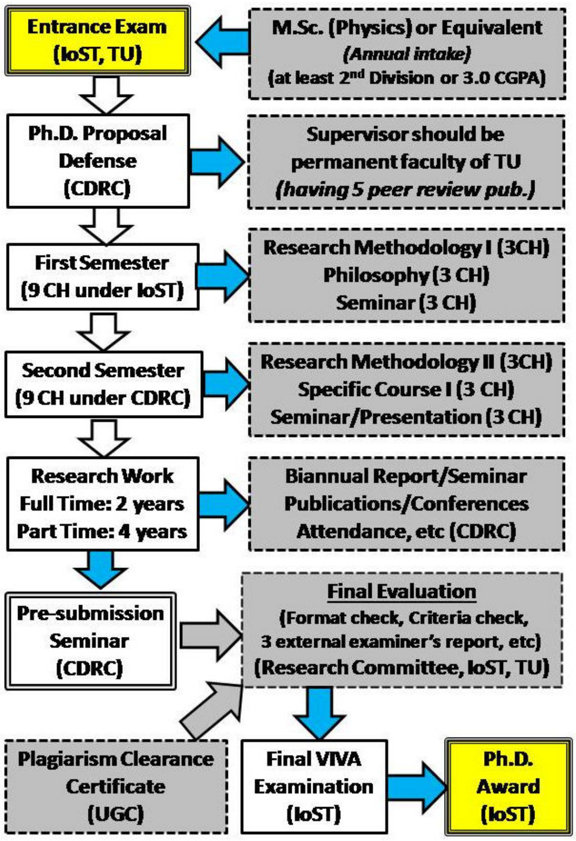

Figure 3: *Flow chart of newly modified Ph.D. procedure at the Institute of Science & Technology (IoST), TU.*

Second Semester:

(2) **Advanced Research Methodology (3CH):** This course will be prepared by concerned CDRC focusing on their subject's demand. The

examination will be held as per semester operational guideline.

(3) **Specific Course (3CH):** This course should be recommended by the supervisor to the students. Any M.Sc. (Physics) courses can be the specific course. In case a new course is needed, supervisor should prepare the curriculum and forward it to CDRC for necessary process. This course will be handled by the supervisor. The examination will be held as per semester operational guideline of TU.

(4) **Seminar (3CH):** Three seminars (each of one hour) should be presented by the Ph.D. students covering his research interest and problems. CDRC will evaluate this course.

Credit Transfer in TU

Tribhuvan University is going to introduce policy regarding the Credit Transfer. This will help Ph.D. program significantly. Credit transfer refers to a procedure of granting credit to a student for educational experiences or courses undertaken at another institution. Tribhuvan University introduces following policies in order to facilitate credit transfer to the national and international students:

(1) Tribhuvan University grant credit to a student for his/her educational experiences or courses undertaken at other Universities or degree awarding institutions.

(2) Tribhuvan University transfer credit of own student for his/her educational experiences or courses undertaken within the institutes or faculties or from one institute to faculty and vice versa.

An exchange of Ph.D. students from one to other institute or faculty for taking required courses will be important. The highlights of general guideline for 'credit transfer' are as follows:

(1) For the credit transfer, the content of theoretical, computational and practical courses taken by the students in other Universities or in other Institutes/Faculties of Tribhuvan University should match up to 80% to that of the courses of Tribhuvan University. The remaining 20% flexibility will be covered by additional courses. The Subject Committees of the respective disciplines/subjects will decide the nature of such additional courses.

(2) In any case, the maximum percentage of transferred credit should not exceed 50% of total credit hours of that degree at Tribhuvan University. Students should complete remaining 50% credit hour in Tribhuvan University. These 50% required courses should cover the core courses of that discipline or subject. The concerned Subject Committee will decide their core courses.

(3) Credit transfer is not applicable to that academic program which is not described in the 'Higher Education Qualification Framework' recommended by University Grants Commission, Nepal (2016).

Conclusion

Time has come to upgrade the quality of research work in Physics in TU. The introduction of 6 CH course, Ph.D. annual calendar and the initiation of '*biannual progress report presentation program*' at CDP are initial steps towards the goal. For the future, following steps should be carried out:

(1) Establishment of research laboratory.
(2) Enhance research collaboration.
(3) Increase the number of research faculties.
(4) Publication in the reputed Journal.

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The term 'Ph.D.' stands for 'Doctor of Philosophy'.

A PhD

- Is an advanced postgraduate degree involving three or more years of independent research on an original topic.
- Is carried out with the support of one or more expert academic supervisors.
- Results in a thesis that offers a significant original contribution to knowledge.
- Confers the title 'Doctor' upon successful candidates.
- Is the highest academic degree a student can achieve and is considered the de facto entrance qualification for a career in academia.

COVER STORY - 1

Enrico Fermi: A Brief Story

Khagendra Katuwal
M.Sc. (Physics), Fourth Semester, CDP, TU, Kirtipur

ABSTRACT
This article provides information about Enrico Fermi, who is a pioneer of modern physics.

Enrico Fermi was born in Rome of Italy on 29 September 1901. He was only 14 years old when there was the death of his brother Giulio during minor surgery. Then, he became interested in his study of physics and studied rigorously in the grief of his own brother. He graduated with a doctorate from Sculoa Normale Superiore University-College at the age of 21. He was awarded a scholarship from Italian government in 1923 so he spent several months with Professor Max Born in Gottingen. After a year, he moved to Leyden to work with P. Ehrenfest under a Rockefeller Fellowship. It was the great opportunity for him to enhance his study. In fact, after that year he returned to Italy as a lecturer in Mathematical Physics and Mechanics at the University of Florence.

Receiving Nobel Prize

In 1926, Fermi discovered the statistical laws which is also known as '*Fermi statistics*', governing the particles subject to Pauli's exclusion principles that is known as '*fermions, in contrast with bosons, which obey the Bose-Einstein statistics*'. He was elected as a professor of Theoretical Physics at the University of Rome in 1926 and worked in that post until 1938. He married to Laura Capon in 1928 and had a son, Giulio and a daughter, Nella. Then, he migrated to USA, to escape Mussolini's fascist dictatorship. In 1938, he was awarded the Nobel Prize in Physics for the demonstrations of the existence of new radioactive elements produced by neutron irradiation and for the discovery related to nuclear reactions brought about by slow neutrons. In early career, he gave focus on electrodynamic problems and theoretical investigations related to spectroscopic phenomena and later he gave attention towards the atomic nucleus. He evolved the beta-decay theory by joint work on radiation theory with Paul's idea of the neutrino. In addition, influencing from the discovery of Curie and Joliot of artificial radioactivity, Fermi demonstrated that nuclear transformation occurs in almost every element subjected to neutron bombardment. This work helped to the discovery of slow neutrons that led to the discovery of nuclear fission and the production of elements lying beyond what was until then the Periodic Table. Fermi was appointed as a Professor of Physics at Columbia University of New York in 1930 and worked until 1942. During this time, his experience led to the atomic pile (nuclear reactor) and the first controlled nuclear chain reaction that took place in Chicago on 2nd December 1942. Because of it, he became one of the prominent leaders of the team of physicists on Manhattan Project.

Fermi with peace freedom fighter, M. K. Gandhi (1943)

He accepted a professorship at the Institute for Nuclear Studies of the University of Chicago after World War II and that position he held until he died from stomach cancer on 28th November 1954. Element 100 was named Fermium (Fm) for his contribution and honor. Therefore, his contributions in Physics would be inspirations for us to follow his path.

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COVER STORY - 2

Fermi's Overall Contribution to Physics

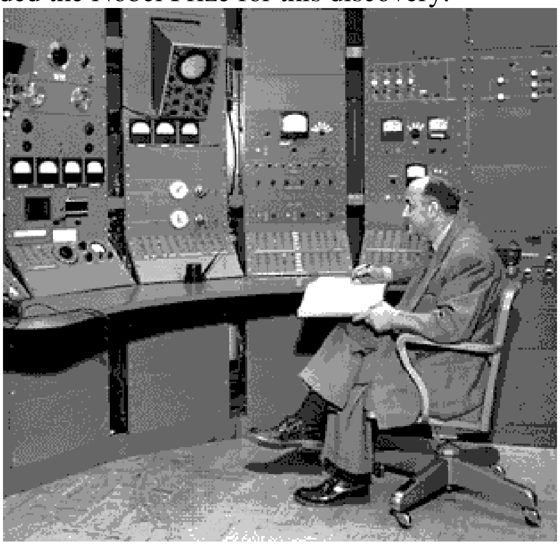
Esha Mishra
M.Sc. (Physics), Fourth Semester, CDP, TU, Kirtipur

ABSTRACT
This article describes the information regarding Enrico Fermi's contribution to physics.

Enrico Fermi – the "*architect of the nuclear age*" and the "*architect of the atomic bomb*", a prominent physicist, excelled both the arenas of theories and experiments in the 20th century. Not only did Fermi have an outstanding contribution to nuclear energy and physics, but also in the formation of one of the most powerful military weapons in history, the atomic bomb. Born in Rome on 29th September 1901, he possessed a keen interest in mathematics since his early age. From the Scuola Normale Superiore in Pisa, Fermi received his undergraduate and doctoral degree.

During the early years of Fermi's career in Rome, his work was concerned with electrodynamics problems. Fermi and his group made important contributions to many practical and theoretical aspects of physics, especially in the quantization of the electromagnetic field. When he directed his attention from the outer electrons towards the atomic nucleus itself, he was able to apply the Pauli Exclusion Principle to systems of multiple electrons not attached to atoms. In 1926, Fermi discovered the statistical laws, today known as the Fermi statistics. The Fermi statistics govern the particles subjected to Pauli's exclusion principle.

One of the great contributions of Fermi to physics was his theory of weak interactions. Henri Becquerel's discovery of radioactivity in 1896 led to the starting of weak interactions. Subsequently, after the discovery, it was classified into alpha, beta and gamma decay of the nucleus. Beta decays of nuclei and the decays of most of the elementary particles are known to be due to weak interaction. Enrico Fermi in 1934, invented a physical mechanism for the theory of weak interaction. It still serves as a core part of the Standard Model of High Energy Physics. Wolfgang Pauli suggested that during the beta decay, along with the electron, an almost massless neutral particle is also emitted. Fermi successfully incorporated Pauli's suggestion and thus was born the theory of weak interactions. Fermi drew an analogy with the electromagnetic interaction and pictured the weak interaction to be responsible for the beta decay of the neutron as the emission of an electron. Fermi developed the ß-decay theory and was able to demonstrate the occurrence of nuclear transformation in almost every element subjected to neutron bombardment. This work was followed by the discovery of slow neutrons that same year which led to the discovery of nuclear fission. Fermi conducted a series of experiments inducing radioactivity with neutrons and concluded that slow electrons were more easily captured than the fast ones. He developed the Fermi age equation to illustrate this phenomenon. Enrico Fermi received the Nobel Prize in 1938 for "*his discovery of new radioactive elements produced by neutron irradiation, and for the discovery of nuclear reactions brought about by slow neutrons.*" Upon the bombardment of thorium and uranium with slow electrons, Fermi discovered new elements and was awarded the Nobel Prize for this discovery.



Enrico Fermi at the controls of the synchrocyclotron at the University of Chicago, (1951)

The discovery of fission, by Hahn and Strassmann, early in 1939, induced Fermi to see the possibility of emission of secondary neutrons and of a chain reaction. In 1940, Fermi and his team examined the absorption of a neutron by a uranium nucleus and found that the nucleus to split into two nearly equal parts, releasing numerous neutrons and huge amounts of energy which eventually led to the atomic pile and the first controlled nuclear chain reaction. This took place in Chicago on December 2, 1942 - on a squash court situated beneath Chicago's stadium. In 1944, Fermi became an American citizen and served as a professor at the Institute for Nuclear Studies of the University of Chicago. There he worked on high-energy physics and led investigations related to the pion-nucleon interaction. Fermi played a deterministic role in solving the problems connected with the development of the first atomic bomb which was detonated at Alamogordo Air Base on July 16, 1945.

During the last years of his life, Fermi turned his attention to the problem of the mysterious origin of cosmic rays. He developed a theory, accounting for the energies present in the cosmic ray particles. According to his theory, a universal magnetic field-acting as a giant accelerator- governs the energies of the cosmic ray particles. From the Universities of Utrecht, Heidelberg, Washington University, Columbia, Yale and Rockford (Illinois) College, Fermi received his honorary degrees. He was awarded the Franklin Medal by the Franklin Institute in 1947 and the Barnard Gold Medal from Columbia University in 1950. He was an elected member of the Royal Society of England. Likewise, he was also a member of the American Philosophical Society, American Physical Society, and Sigma Xi. Fermi was the most demanded lecturer of his time and many of his lectures are still in print. Enrico Fermi was the first recipient of a special award of $50,000, which now bears his name for the work on an atom.

Fermi's outstanding contributions to the development of quantum theory, nuclear and particle physics, and statistical mechanics recognized him to be one of the prolific scientists of the 20th century.

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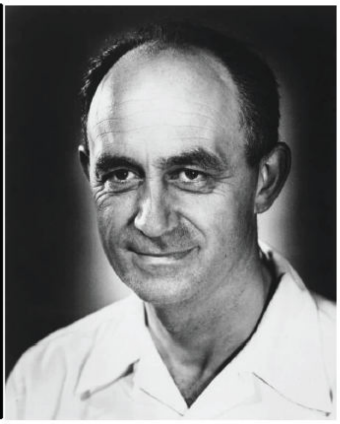
Enrico Fermi Quotes

I remember my friend Johnny von Neumann used to say, 'with four parameters I can fit an elephant and with five I can make him wiggle his trunk'.

There are two possible outcomes: if the result confirms the hypothesis, then you've made a measurement. If the result is contrary to the hypothesis, then you've made a discovery.

It is no good to try to stop knowledge from going forward. Ignorance is never better than knowledge.

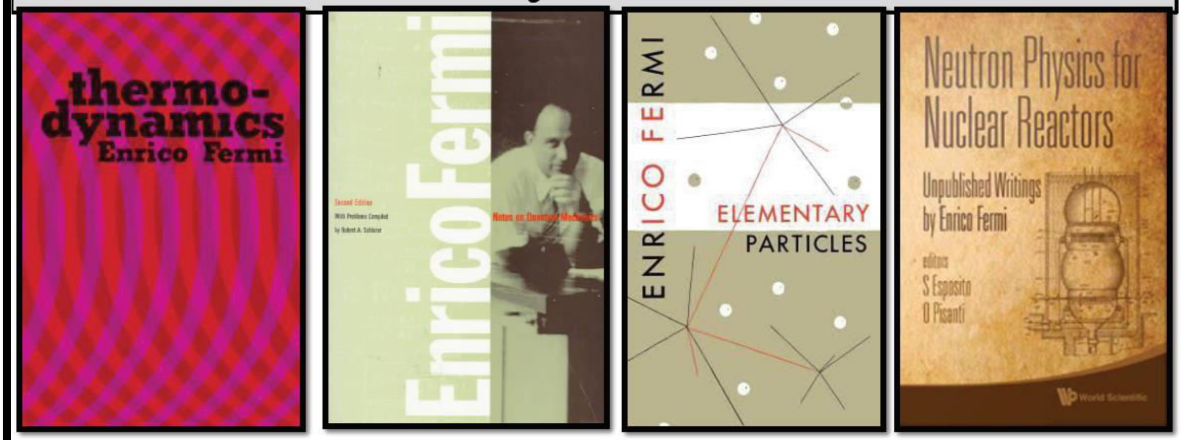


The fundamental point in fabricating a chain reacting machine is of course to see to it that each fission produces a certain number of neutrons and some of these neutrons will again produce fission.

When asked what characteristics Nobel prize winning physicists had in common - I cannot think of a single one, not even intelligence

Experimental confirmation of a prediction is merely a measurement. An experiment disproving a prediction is a discovery.

Books *by* Enrico Fermi



COVER STORY - 3

The Electroweak Theory: A Brief Introduction

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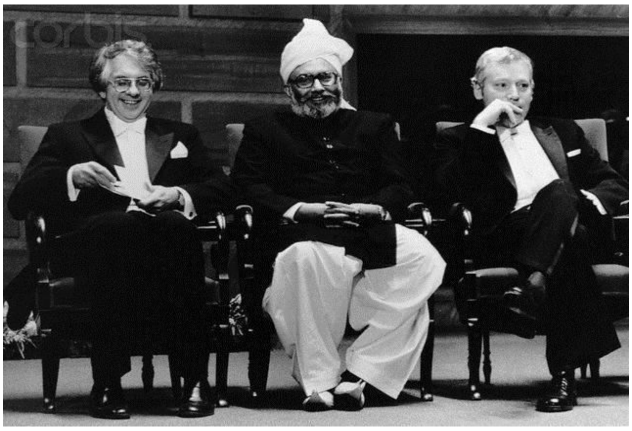
ABSTRACT

This article traces out the historical development of the electroweak unification and problems encountered during the unification process. It also aims to provide the basic outline of electroweak theory.

Introduction:

Nature is elusive. The phenomena appearing disparate at first sight might be the manifestations of the same aspect. There was a time when electricity and magnetism were considered fundamentally different. In 1820, Oersted discovered that an electric current could deflect a magnetic compass needle. And a decade later, Faraday found that electricity can be produced from magnetism. After the unification of these two properties by Maxwell, Electricity and Magnetism became two aspects of a single subject: Electromagnetism. [1]

Unification of four fundamental forces has been a dream of many scientists, including Einstein. Glashow, Weinberg, and Salam were few who were inspired by the similar vision and who got success. They unified the weak and electromagnetic forces. According to GWS (Glashow-Wienberg-Salam) theory, even though electromagnetic and weak interaction appear different at low energies encountered at daily life, above certain energy, called unification energy, they are essentially same.



Sheldon Glashow, Abdus Salam and Steven Weinberg

Initial Development

The path towards the unification was first laid out by V-A theory.V-A theory was developed by Feynman and Gell-Mann and by Sudarshan and Marshak, according to which the interaction factors in a weak decay are a mixture of vector and axial-vector quantities. It accounted for the parity violation in weak interactions. This led Schwinger to suggest a gauge theory of weak interactions mediated by W^+ and W^-. He even suggested the idea of the unified theory of weak and electromagnetic interaction involving three gauge bosons: W^+, W^-, and photon. But the Electromagnetic interactions are long-range whereas weak interactions are short-range forces. Additionally, weak force violates parity but electromagnetic force is parity conserving force. These asymmetries posed the serious threat towards the goal of unification of these two forces.[2]

The SU(2)×U(1) Model

To rectify the problem of symmetry, Glashow (in 1961) by proposed an extended model with a larger symmetry group, SU(2) × U(1) but he did not know how to give mass to the W and Z bosons without breaking the gauge symmetry.

A model similar to SU(2) x U(1) model was proposed by Salam and Ward and by Wienberg, independently. The model described the weak interaction of Leptons. At that time, the weak interactions of the hadrons were not completely understood. The Gauge group SU(2) × U(1) has four vector fields, three of them($W^{\pm}$ and Z^0) are associated with SU(2) group and one is associated with U(1) group. But there were some problems with this model. Leptons have mass but the SU(2) × U(1) symmetry does not allow lepton mass terms. Also since weak force is a short range force, exchange particles must also be massive. A massless exchange particle would give rise to a parity violating long-range force.[3]

One possible solution to this problem would have been adding the mass terms manually even if it violated the gauge symmetry. But the theory resulting from that approach would be non-renormalizable. So that was not an option. [3]

Spontaneous Symmetry Breaking

The problem of mass was solved by introducing Higgs field. Higgs field permeates all the space and interacts with nearly all other particles thereby giving rise to mass. The mass depends on the coupling between Higgs and the particle. Bigger the coupling, greater is the mass. Photons do not interact with Higgs field but W and Z-bosons do so that photon is massless but W and Z are massive. This process is called spontaneous symmetry breaking.[4]

Salam wrote his Nobel Prize winning paper in November 1967. It was ignored at first and remained in oblivion until a copy of the paper was sent to Wigner.

Although Wienberg and Salam developed their theories independently, they were fundamentally same.

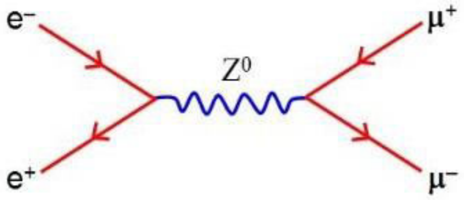


Figure 1: *An example of neutral current reaction:* $e^{+}+e^{-} \rightarrow \mu^{+}+\mu^{-}$

Final Unification

Wienberg-Salam model was incomplete. It explained only the interaction of leptons but failed to explain the electromagnetic and weak interactions of hadrons. In 1964, Glashow (with Bjorken) had proposed the idea of fourth quark i.e., charmed quark (until then there were only three quarks: up, down, strange). In 1969, Glashow, now working with John lliopoulos and Luciano Maiani (the 'GIM' model) found that introduction of charmed quark can explain the natural suppression of strangeness-changing neutral currents. [4]

The unification of the weak and electromagnetic interaction was now almost complete. Wienberg and Salam had unified these two forces for leptons. And GIM four-quark model had extended that to hadrons. The only problem that remained was the renormalization. [4]

Renormalization

The renormalizability of this theory baffled the scientists for some time. Although Salam and Weinberg were confident that their theories are renormalizable, it was established by 'tHooft and Veltman only in 1971 and were awarded the Nobel Prize for this in 1999. Renormalization allowed the precise calculation of carrier particles thereby leading to widespread acceptance of the theory.[3]

Experimental Verification

In 1973, the existence of neutral current interaction was confirmed at CERN. The reactions mediated by Z^0–bosons are called neutral current reactions. Before electroweak theory, weak interactions were believed to be mediated by $W^{\pm}$ bosons only. This provided the experimental evidence for Electroweak Model. Glashow, Salam, and Weinberg were awarded the Nobel Prize in 1979. In 1983, W and Z-bosons were discovered at CERN. This further strengthened the validity of the theory.[2]

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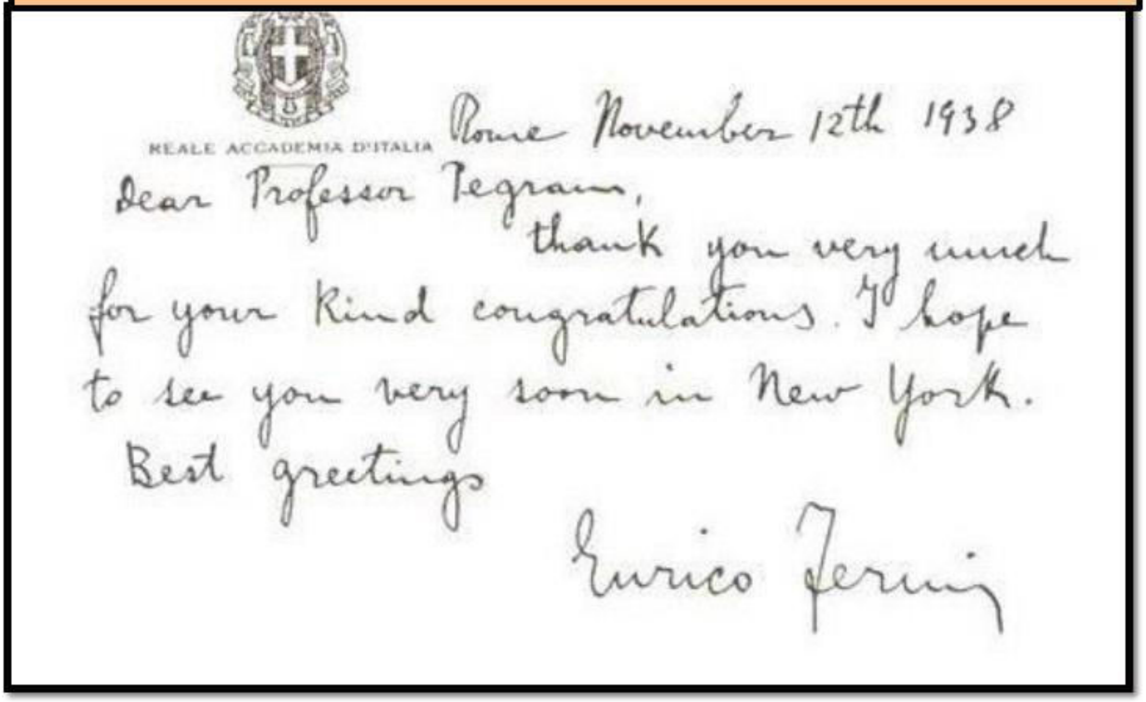
Fermi's Hand-written Letter to his Colleague



REALE ACCADEMIA D'ITALIA

Rome November 12th 1938

Dear Professor Segrain,
thank you very much for your kind congratulations. I hope to see you very soon in New York.
Best greetings

Enrico Fermi

COVER STORY - 4

Toughest Trial of Weak Interaction

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ABSTRACT

How the riddle of beta decay was solved by Fermi? How weak interaction appeared in the realm of modern physics? Why weak interaction faced series of amendments and how the problem was solved? I would try to find answer to these questions.

It has been more than eighty years since Enrico Fermi informed the world that there exists a weak interaction by his famous nuclear beta decay theory, yet its importance has not faded. Various changes and modifications have been made to Fermi's weak interaction theory during the process of formulation of Standard Model but still the fundamental idea of Fermi serves as a core part of this model. Now it is known that not only beta decay, most of the elementary particles such as muons, kaons, pions and hyperons decay via weak interaction.

Years of Conundrum

By the end of 1920, it was evident that there was something strange about beta decay. Alpha and gamma rays, which were also the nuclear by product like beta rays, had discrete energy but beta rays were observed to have continuous energy spectrum.When energy available for beta decay was calculated, as this can be easily done by calculating the difference of masses of parent and daughter nuclei, it seemed to violate energy conservation. If the beta decay was simply the emission of electron from the nucleus then from the energy momentum-conservation one would expect the well defined value of energy for emitted beta particle. However, the observed continuous beta decay spectrum suggested that there was something wrong with this assumption.

Many scientists were working on the theory of beta decay but it was a tough job to create an electron in the nucleus. Heisenberg uncertainty principle ruled out the existence of nuclear electron and there was not a clear idea how such particles can be bound within nuclear orbits. In 1930, to explain this anomaly Wolfgang Pauli proposed the third particle neutrino (originally called "*neutron*" by him) so that it would not violate the conservation of momentum and energy.On the basis of this assumption, in 1934 Fermi proposed the the theory of beta decay.

Assumptions and formulation of the theory

During the formulation of the theory of beta decay following assumptions were made by Fermi.

- During the process of beta decay, along with the emission of beta particle, another quasi- particle called neutrino is also emitted. The mass of the neutrino is of the order of the electron or less than that and it is charge less.
- In quantum theory of electromagnetic radiation, photons are absorbed or emitted by an atom. Drawing an analogy from this one can assume that the electrons, as well as neutrinos, can be created or annihilated and hence the total number of electrons (or neutrinos) is not necessarily constant.
- The nucleus consists of two heavy particles i.e neutron and proton and they may be treated as the two internal state of the same particle. One can assign intrinsic coordinate to the particle to differentiate one from another. The value of intrinsic coordinate is unity and takes positive sign if the particle is neutron and negative sign if the particle is proton.
- To ensure the conservation of charge, the Hamiltonian function is chosen such that each transition from neutron to proton is associated with the creation of electron and neutrino and the reverse process is associated with the annihilation of an electron and a neutrino.

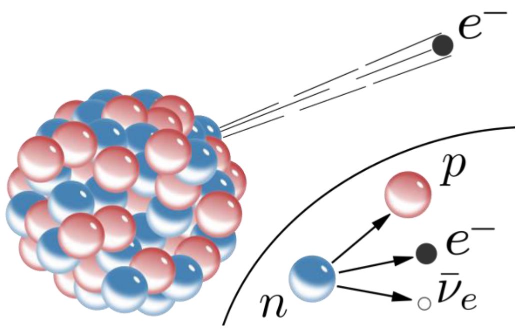

Figure 1: *Beta decay from the unstable nuclei.*

During the formulation of theory of beta decay, he made some major modification in the Lagrangian density of the proton. While doing so, he replaced electromagnetic current of proton by the term which described the transition of neutron into proton and in the place of spinor of the photon he used the term which described the production of electron and neutrino. These new terms were called Dirac currents. He also replaced the electronic charge'e' by the new coupling constant 'G', now known as Fermi coupling constant. It is important to note that these Dirac currents are '*charged*' unlike electromagnetic currents, leading one's to think that beta decay was something completely new. In this way, long before the W and Z bosons were known and quark model formulated, he successfully discovered the new forces of nature.

Fermi first send this work to the the Nature but the editorial board rejected his paper saying "*it contained abstract speculations too remote from physical reality to be of interest to the reader*". They did not like four particle interactions that created an electron and neutrino out of nothing and more importantly they did not take neutrino seriously. Later he submitted slightly revised versions of the paper to less prestigious Italian and German journal, which published them quickly in their languages. Though Fermi's weak interaction was a great intellectual leap and a significant step towards the right direction, it would face series of challenges and amendments with the passage of time.

Years of trial

a) Universal Fermi interaction

In the mid 1930's, Japanese physicist Yukawa argued that nuclear strong force is mediated by particle with a mass of approximately 200 times that of electron. Yukawa also suggested that this particle might be responsible for the beta decay as it could decay into electron anti-neutrino pair.Few years later, Anderson and his colleague discovered the particle which had the similar properties as described by Yukawa but the problem with the detected particle was that it could traverse through thick layer of matter without any interaction. In fact, the particle was a fermion (muon) with half integer spin rather than a boson of integral spin, which would turn out to be a milestone in our story of the weak interaction.

During the research on muon, Italian physicist Bruno Pontecorvo noticed that if the mass difference between the electron and muon is taken into account one could draw an analogy between the capture of muon by nuclei and capture of electron from the innermost atomic shell. In 1947, Pontecorvo proposed the theory of muon decay. A years later, Jack Steinberg in his Ph.D thesis found that the energy spectrum of such electron is continuous as like in beta decay, which led other theoretician to propose the so called Universal Fermi theory of weak interaction. Thus it became clear that beta decay, muon captures and muon decay were different aspect of the same interaction.

b) Parity violation

The serious observation on pionic decay of K-mesons forced Lee and Yang to rethink that parity might be violated in weak interaction. In 1956, when they made a detail analysis of all previous experiment on weak interaction, they realized that there was not a clear evidence for parity conservation in weak interaction. So they proposed to reconsider the validity of this principle and suggested experiments where the assumption could be tested.In 1957, Madame Wu and her team performed an experiment by taking cobalt nuclei and established the fact that fewer electrons were emitted in the forward hemisphere than in the backward hemisphere with respect to the spins of the decaying nuclei. This striking result was a watershed in the history of weak interaction and a complete shock to the physics world. The effect of this result can be put in the words of Isador Rabi who had said "*A rather complete theoretical structure has been shattered at the base and we are not sure how the pieces will be put together*."

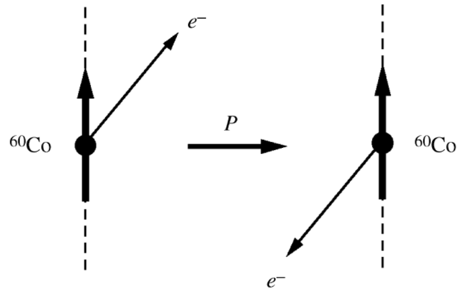

Figure 2: *The Wu Experiment: the thick arrows indicate the direction of the spin of the ^{60}Co nucleus, while the thin arrows show the direction of the electron's momentum.*

Thus the result of Wu's experiment demonstrated the fact that the weak force violates the reflection symmetry and hence the parity conservation. It also revealed that electrons are preferentially left handed. Later when the helicity of the neutrino was measured, it was found that all the neutrinos are also left handed. The consequence of these series of discovery was huge and of serious concern because an understanding of weak interaction was impossible If it was neglected.

c) A new lagrangian and V-A theory

While drawing an analogy from quantum theory of radiation, Fermi confined himself into Vector bilinear field (one of the five forms of Dirac bilinear covariant field). In Dirac's quantum field theory, these bilinear covariant fields are the different ways in which one can write a physical law so that it remains Lorentz invariant. If Fermi had not limited himself to the case of Vector field he would have written more general form of lagrangian. So one of the assumptions then on was to consider the general form of lagrangian. Now it was remained to modify this general form of lagrangian so that it would include the observed phenomena of parity violation.

It is impossible here to understand the whole theory without any mathematical expression but the main idea was to replace the full spinors of massive leptons with their left handed projection. After inserting these left handed projections into parity violating Hamiltonian, one would get a completely new Hamiltonian which would account both Fermi transitions and Gamow-Teller interaction. This general form of interaction is known as V-A theory. The V-A theory being itself a significant step towards a complete theory however possessed some serious mathematical difficulties. It would take an elegant touch of Glashow, Salam and Weinberg to lift weak interaction into completely new level.

Conclusion

Fermi's theory is one of the greatest achievements in the history of modern physics. Although peculiarities had been observed many times in the path of beta decay, it endured the trial of truth keeping its spirit intact. Fermi theory even survived the fundamental revolution. His particular form of beta interaction laid the foundation for the systematic study of other types interaction. For the first time, it introduced the concept of creation and annihilation of material particles. The importance of Fermi theory can be put in the word of Fermi's friend and associate Emilio Segre who once said, "*Fermi was fully aware of the importance of his accomplishment and said that he thought he would be remembered for this paper, his best so far.*"

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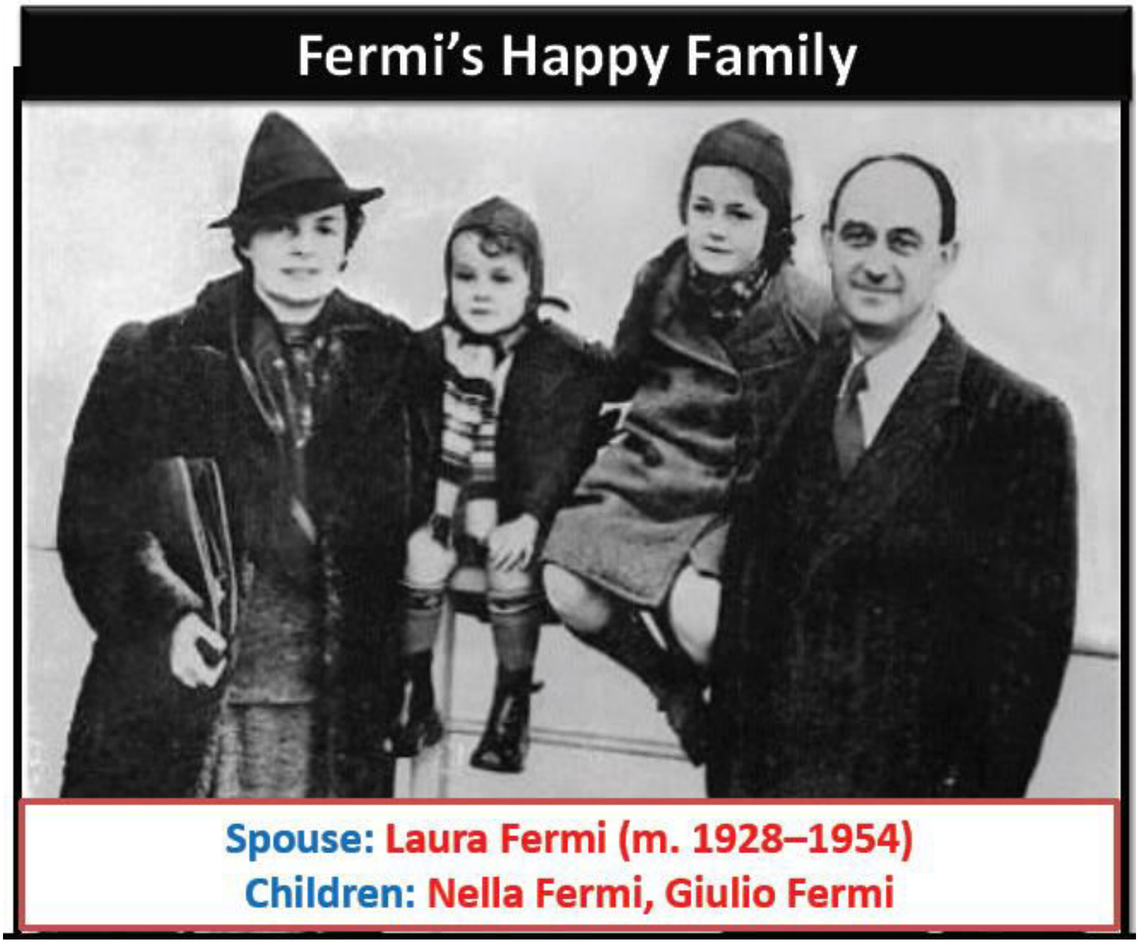
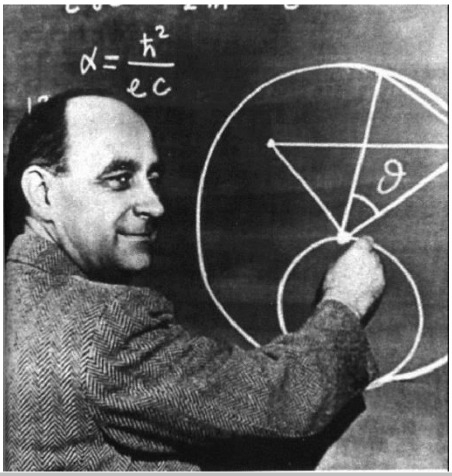


"***I knew my father was an atomic scientist,***" she said. "*I knew he was doing secret war work. I knew that all these other guys around were physicists. It didn't take any great leap of the imagination. But my mother being older and wiser . . . I think it's reasonable speculation (that she knew about the bomb).*" But, she insists, her father never told his wife or children.

"***My father came home with a bunch of gas masks one day. And that was scary. He didn't have one for (baby brother) Judd because he couldn't find one small enough.***"
She and her 3-year-old brother would see their childhoods rearranged. Their father was from a Roman Catholic peasant family; their mother was upper-middle class and Jewish. There were three reasons the Fermi family left Italy. The first was the promulgating of anti-Semitic laws by Mussolini, the second the fear of war. The third was Fermi's Nobel Prize which facilitated their escape to America via Stockholm and England.



COVER STORY - 5

Why is Weak Force Different from other Three Forces?

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ABSTRACT

The importance of the understanding of the fundamental forces (or interaction) is as obvious as is the meaning of 'fundamental' itself. The understanding of these forces in depth is very important in the sense that the proper insight into the fundamental structure of the matter and hence the whole universe is manifested through them. Here I have put the short introduction of four conventionally accepted forces and attempted to distinguish the weak one from the rest types with its special characteristics and importances.

Introduction

The terms force and interaction are almost the synonyms or at least complementary since the generation of the interaction is due to the force which also carries physical meaning contrasting to the other. Basically, as the fundamental forces of nature, the four forces: gravitational force, strong force, electromagnetic force and the weak force are taken into contemplation. The standard model, the best-known model of the particle physics till date accommodates these forces to describe how the particles and the forces are inter related to each other. We can distinguish these forces according to the characteristics like, on which properties they act upon, the particles that experience the force, carrier (or exchange) particles, strength, the range of the force, etc.

(1) Gravitational force

Gravitation is the interaction between two masses. Gravitation, according to General Theory of Relativity, has been defined as the curvature of the space-time of an object having mass. It is long ranged, purely attractive in nature and weakest in strength among all four forces. Graviton is considered to be the exchange particle.

(2) Electromagnetic force

Electromagnetism is basically the interaction between two electrically charged particles. EM force may be attractive or repulsive depending on the nature of the charges. It varies in the range. It is stronger than both the weak and gravitational force. Photon is the exchange particle.

(3) Weak force

The strength of the weak force lies in between that of gravitational and electromagnetic force. The phenomena like the beta decay are due to the weak forces. It combines with the EM force to form the electroweak force. Its shortest range force of the order of about 10-18 m. Intermediate vector boson is the particle being exchanged here.

(4) Strong force

It is the strongest of all forces as the name suggests, which makes the nucleons bound. The range of the strong force is about 10^{-15} m. Particles called gluon are the mediating particles of the strong force.

Are these forces actually different to each other?

Though looking at the different properties, four fundamental forces seem completely different, the standard big-bang-model predicts that the all these forces were in combined form to maintain the fundamental symmetry before Planck's epoch (within 10^{-43} s of Big-Bang) where the gravity was believed to be split. The effort to unify gravity with other three forces is called '*quantum gravity*', which is believed to be carried by the virtual particle 'graviton'. Later, at the end of '*inflationary epoch*' (10^{-32} s after big-bang), the strong force also got split from the electroweak force. Ultimately, the weak force also got split from electromagnetic force, at the end of the Hadron Epoch (1s after the big bang), resulting all the forces survive independently at present. However, in the last decades, the belief has grown among the scientific community that the strong, EM, weak and gravitational interactions are different aspects of a single universal interaction, which would be manifested at very high energies inaccessible by existing accelerators. The first successful attempt to unify the two interactions; electricity and magnetism by Maxwell in 1865 considering the vector field (em field) followed by the unification of EM and weak interactions into electroweak interaction by Glashow, Weinberg, and Salam with a single coupling described the elementary electric charge, e, have become the strong evidence for such the beliefs.

How weak force differs significantly?

EM force and Gravity both are the inverse-square and conservative forces hence resulting in the potential energy. The weak force, on the other hand, differs significantly from these two forces which are confined to the nuclear scale contrasting to the long range of the Gravity and EM force. In addition, the weak force is also distinct from the strong one since the former acts on both the leptons and quarks while the latter acts on the quarks and other particles composed of quarks only. The interesting property is that the other three forces act to hold the things together while the weak does play the role to make them distinct or falling apart.

The weak force, or weak interaction, is very responsible for almost all the natural radiation present in the universe. To explain the process of so-called beta decay, a theory was devised by the Enrico Fermi in 1934, which produces a proton, an electron (often called as the beta particle) and electron neutrino(later it was confirmed as anti-electron neutrino) in the expense of a neutron. He then assumed the responsible force for the beta decay was the weak force or interaction.

$$n \rightarrow p + e^- + \nu_e \qquad (1)$$

The violation of parity invariance in weak interaction can be seen from the decay

$$\pi^+ \rightarrow \mu^+ + \nu_\mu \qquad (2)$$

where the neutrino is always emitted with left-handed helicity.

Charge conjugation is also violated in

$$\pi^- \rightarrow \mu^- + \nu_\mu \qquad (3)$$

where the anti-neutrino still has left-handed helicity. But the anti-neutrino in the real world always comes out right-handed. Combining the equations (2) and (3), we get the left-handed neutrino changes to the right-handed anti-neutrino. This is similar to the mirror image of a right-handed electron being the left-handed positron. But the CP is violated here. An indication of the above reactions is the true violation of the mirror symmetry in nature. Matter dominated universe of the present is may be due to this reason. In this point, the weak force comes into the significant difference to others.

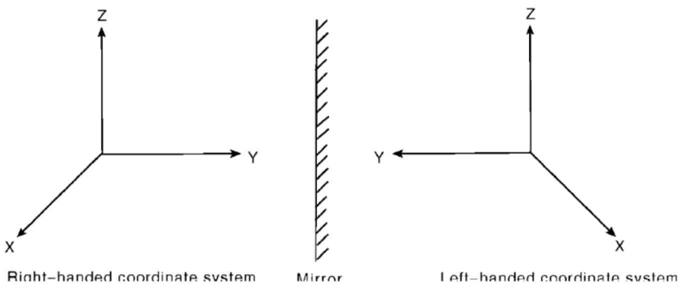

Figure 1: *Left and right handed coordinate system.*

The W and Z bosons (that are made up of bundles of energy), which were predicted by the Nobel laureates Weinberg, Salam and Glashow in the 1960s, and discovered later in 1983 at CERN are supposed to be the carrier particles of the weak force. The electrically charged W bosons, by the emission of which the weak force changes the flavor of the quark are responsible for the conversion of the proton into neutron and vice versa. The burning of the stars and the nuclear fusion are the consequences of these processes according to CERN. This burning after a long process yields the formation of the planetary system and even the lives in the earth by means of heavier elements first. There is a number of conservation laws that are valid for strong and electromagnetic interactions but broken by weak processes. The weak force is the only force that violates the conservation of the parity and CP symmetry.

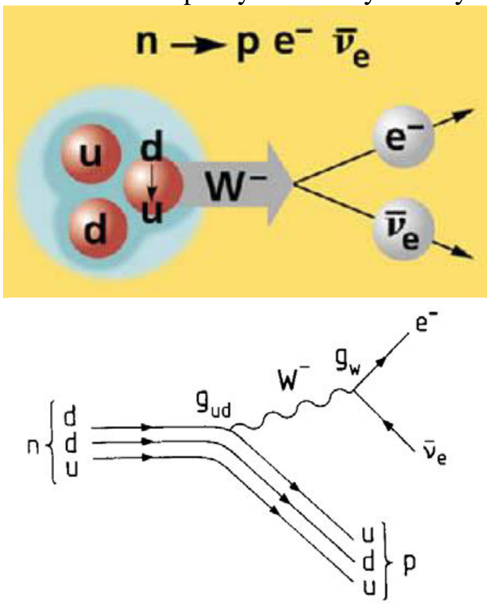

Figure 2: *Weak Interaction: Modern Quark Level Picture*

Only weak interaction changes the flavor of the quarks and leptons. $W^{\pm}$ boson transforms νe into e^-, u into d-quark by coupling to weak charge g_w of neutrino/electron or up/down quark pair. Parity violation in ^{60}Co beta decay, $^{60}Co \rightarrow {}^{60}Ni^* + e^- + \nu_e$ was first observed experimentally by Wu *et al.* in 1957 which was proposed earlier in 1956 by Lee and Yang. So, despite their slow rate and short range, weak interactions play a crucial role in the make-up of the world we observe.

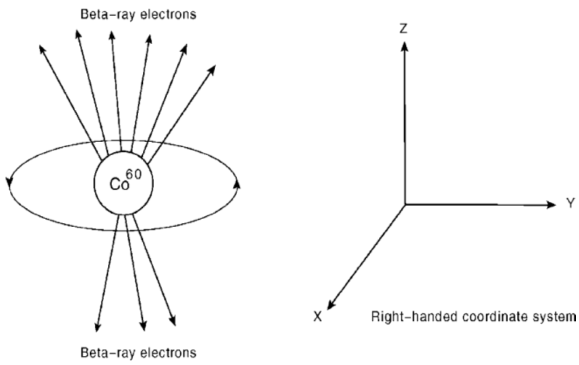

Figure 3: *Parity Violation in the Beta Decay of Co-60.*

After Fermi put the theory of β decay in 1934, several theories of weak processes came in existences as Bethe (1938) and Gamov (1946) proposed the role of weak processes in nucleosynthesis in the stars. Accordingly, the phenomenon like Type II (core collapse) supernovae was also believed to be attributed to the weak force. The processes in which the difference between a number of particles and the antiparticles of a given quark or lepton type change, is weak decay process and involves a W-boson. The ordinary stable matter contains only up and down type quarks and electrons are thus attributed by the weak decays. Also, the force carriers W and Z of the weak interaction have the masses but the gluons and photons, the carrier particles of strong and EM force, are massless.

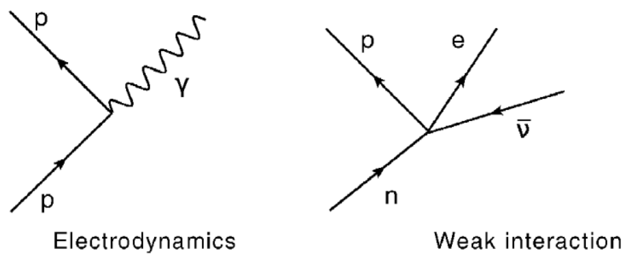

Figure 4: *Fermi's idea in sketch.*

Conclusion

The importance of the weak force is almost unexplainable since every single life in the present earth is indebted for it. Thermonuclear fusion in the stars like sun, that constitutes the fusion of four protons to form a helium nucleus emitting two positrons and two neutrinos with the release of about 27 MeV of energy as expressed $^4p \rightarrow {}^4He + 2e^+ + 2\nu_{e-} + 27$ MeV, which is regarded as the most important reaction for all lives, is ultimately the result of weak processes.

The theory of weak interactions (formulated by Enrico Fermi in 1934) after appropriate amendments and generalizations served as a core part of the Standard Model of High Energy Physics, which now is considered to be the basis of almost all of physics excluding the gravitation. In this dynamic sense, the weak interaction has the promising value different than the rest types.

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Eleven Ph.D. Supervised: 4 Won Nobel Prize!

Harold Agnew: *a scientific observer on the Hiroshima bombing mission and, later, as the third director of the Los Alamos National Laboratory.*

Edoardo Amaldi: *an talian Physicist.*

Owen Chamberlain: *an American physicist, and* ***Nobel laureate*** *in physics for his discovery, with collaborator Emilio Segrè, of the antiproton, a sub-atomic antiparticle.*

Geoffrey Chew: *American theoretical physicist*

Mildred Dresselhaus: *known as the "queen of carbon science", was the first female Professor at the Massachusetts Institute of Technology.*

Jerome Friedman: *American physicist, at the Massachusetts Institute of Technology, won the 1990* ***Nobel Prize*** *in Physics along with Kendall and Taylor, for the internal structure for protons later known to be quarks.*

Richard Garwin: *an American physicist, widely known to be the author of the first hydrogen bomb design.*

Marvin Goldberger: *a theoretical physicist and former president of the California Institute of Technology.*

Tsung-Dao Lee: *a Chinese-American physicist, known for his work on parity violation, won* ***Nobel Prize*** *in Physics with Franklin C N Yang.*

Ettore Majorana: *an Italian theoretical physicist who worked on neutrino masses.*

Arthur Rosenfeld: *Berkeley physicist and California energy commissioner, dubbed the "godfather of energy efficiency", for improving energy efficiency.*

Emilio Segrè: *an Italian-American physicist and* ***Nobel laureate****, who discovered the elements technetium and astatine, and the antiproton, a subatomic antiparticle.*

Sam Treiman: *an American theoretical physicist who produced research in the fields of cosmic rays, quantum physics, plasma physics and gravity physics.*

COVER STORY - 6

History of Success of Weak and Electro-weak Interaction

Sunil Lamichanne
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ABSTRACT

Theoretical Physicists have long dreamed of combining all the interaction of nature into a single unified theory. As a first step, Einstein spent much of his later life trying to develop a field theory that would unify gravitation and electromagnetism. He was only partly successful. In this article we discuss about brief history of experimental success of weak and electroweak interaction.

If one was to spend a few minutes observing the physical phenomena taking place all around them, one would came the conclusion that there are only two fundamental forces of nature, Gravitation and Electromagnetism. Just one century ago, this was the opinion held by the worldwide community of physicists. After many decades spent digging deeper and deeper into the heart of matter, two brand new types of interactions were identified, impelling us to add the Strong and Weak nuclear forces to this list. Of these two new forces, the Weak has done the most to shatter long-held beliefs and to ultimately guide us towards a deeper understanding of our universe. In this work, we will figure out history of our understanding of the weak force from early observations and explanations of β decay all the way to the doorstep of Electroweak unification, one of the greatest accomplishments of modern physics.

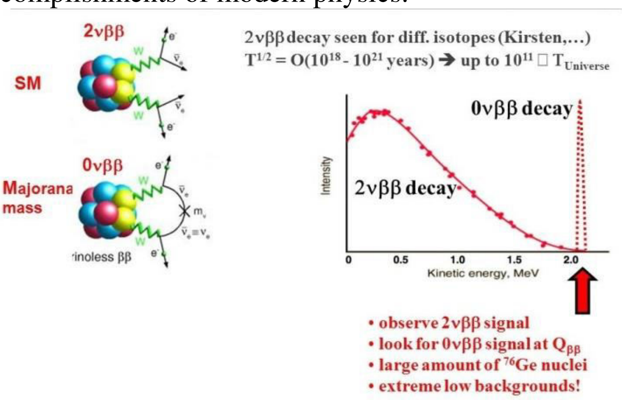

Figure 1: *The standard picture of double beta decay.*

By the end of the 1920s, it was clear that there was something peculiar about β decay. Coming off of a decade which had seen tremendous success in the development of quantum mechanics, physicists were now faced with another perplexing conundrum. Experimental evidence contradicted the prevailing ideas about β decays and desperate attempts to salvage the theory had to be made. β rays were one of the three types of radiation observed in the final years of the nineteenth century, the others being α and γ rays. The energy spectra of α and γ rays were discrete, i.e. these rays could only have certain fixed energies. Against all expectations, β rays were observed to have a continuous energy spectrum by James Chadwick in 1914. This observation would weigh on the minds of physicists for many years and would eventually lead to the Fermi Theory, the first theory of the Weak force.

In 1924, German-American physicist Otto Laporte realized that atomic states underwent photon absorption or emission always ended up, after the transition, in a final state of opposite parity. This rule is simply a statement of the law of conservation of parity. In 1927, Eugene Wigner provided a proof that Laporte's rule was a direct consequence of the reflection symmetry of the electromagnetic force.

In 1930, Wolfgang Pauli postulated the existence of the neutrino to explain the continuous nature of the β decay. By 1934, Enrico Fermi had developed a theory of beta decay to include the neutrino. This theory assumed neutrino to be massless as well as chargeless. In 1932, Anderson discovered the positron, the first identified antiparticle. For his contribution in physics, he was awarded by Nobel prize in 1936.

Considering beta decay as a transition that depends upon the strength of coupling between the initial and final states, Fermi developed a relationship which is now referred to as Fermi's Golden Rule. Chinese American physicist Chien-Shiung Wu in 1956, experimentally verified the symmetry violation in weak interaction. Lederman and his collaborators used Columbia's 385-MeV synchrocyclotron to analyze the $\pi - \mu - e$ decay chain and check for a similar asymmetry in the decay of the muon to that which was found by Wu in 60Co decays. This experiment provided an important independent confirmation of Wu's result. This result also confirms the helicity of the electrons and neutrinos.

In 1958, Gell-Mann and Richard Feynman, George Sudarshan and Robert Marshak, discovered the chiral structures of the weak interaction in physics. In 1963, Wigner received the Nobel Prize for his work on the "*discovery and application of fundamental symmetry principles*".

Abdus Salam, Sheldon Glashow and Steven Weinberg were awarded the Nobel Prize in Physics in 1979. Their contributions in Physics were the unification of the weak and electroweak interaction between elementary particles.

Figure 3: *1963 Nobel laureates in physics.*

The existence of the electroweak interaction was the the consequence of discovery of neutral currents in neutrino scattering by Gargamelle collaboration in 1973, and the second in 1983 by the UA1 and UA2 collaborations. It involved the discovery of the W and Z gauge bosons in proton-antiproton collisions at the converted Super Proton Synchrotron. In 1999, Hooft and Veltman were awarded the Nobel Prize. They verified that the electromagnetic theory is renormalizable.

In 2012, Atlas and CMS experiment at CERN's Large Hadron Collider (LHC) detect a new particle of energy around 126 GeV. This new particle is known to be Higgs Boson as predicted by standard model. The Nobel prize of 2013 was given to François Englert and Peter Higgs for the discovery of the Higgs Boson.

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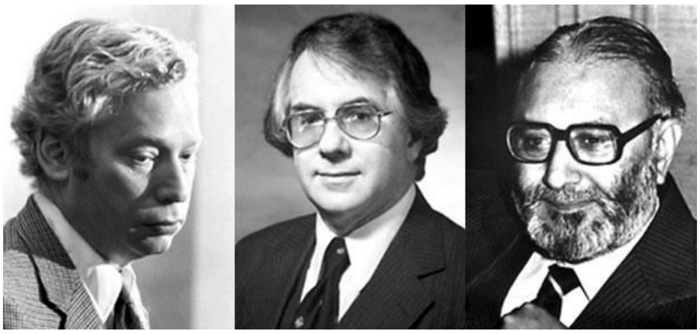
Things named in Fermi's Honour

Many things bear Fermi's name. These include the **FermiLab Particle Accelerator** and physics lab in Batavia, Illinois, which was renamed in his honour in 1974, and the **Fermi Gamma-ray Space Telescope**, which was named after him in 2008, in recognition of his work on cosmic rays. Three nuclear reactor installations have been named after him: the **Fermi 1** and **Fermi 2** nuclear power plants in Newport, Michigan, the **Enrico Fermi Nuclear Power Plant** at Trino Vercellese in Italy, and the RA-1 Enrico Fermi research reactor in Argentina. A synthetic element isolated from the debris of the 1952 Ivy Mike nuclear test was named **Fermium**, in honour of Fermi's contributions to the scientific community. This makes him one of 16 scientists who have elements named after them.

Since 1956, the United States Atomic Energy Commission has named its highest honour, the **Fermi Award**, after him. Recipients of the award include well-known scientists like **Otto Hahn**, **Robert Oppenheimer**, **Edward Teller** and **Hans Bethe**.



COVER STORY - 7

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

Biography of 1979 Nobel Laureates: Sheldon Glashow, Abdus Salam & StevenWeinberg

ABSTRACT

A brief biography of 1979 Nobel laureates Sheldon Glashow, Abdus Salam & Steven Weinberg will be discussed.

Sheldon Lee Glashow (born December 5, 1932), Mohammad Abdus Salam (Jan 29, 1926- Nov 21, 1996) and **Steven Weinberg** (born May 3, 1933) shared the 1979 Nobel Prize in Physics for their ground breaking insight in the unification of the weak force and electromagnetic interaction between elementary particles, including inter alia, the prediction of the weak neutral current.

Birth and Education:

Sheldon Glashow was born in New York City. He received his Bachelor of Arts degree from the Cornell University in 1954 and a Ph.D. degree from Harvard University in 1959 under the tutelage of Julian Schwinger, Nobel Prize winner in Physics in 1965. Like Glashow, Weinberg was also born in New York City. Interestingly, Glashow and Weinberg were the members of the same classes at the Bronx High School, New York City (1950) and Cornell University (1954). Not only classes, they shared the 1979 Nobel Prize in Physics along with Abdus Salam. Weinberg received a graduate Studies degree from Neil's Bohr Institute, Copenhagen. In 1957, Weinberg received his Ph. D. degree from Princeton University under the tutelage of Sam Treiman.

Abdus Salam, on the other hand, was the first Pakistani and first Muslim to achieve a Nobel Prize in Science. Since early age, he established his reputation as a precocious child. At the age of 14, he topped the Punjab University by scoring the highest marks ever recorded. Although Salam was interested in Urdu and English Literature, he was keenly interested in Mathematics. He received his B.A. in Mathematics from the Government College University in 1946. Furthermore, in 1949, he received a BA degree with Double First-Class Honors in Mathematics and Physics from St Jones's College, Cambridge. In addition, Salam received a Ph.D. degree in the Theoretical Physics from the Cavendish Laboratory, Cambridge.

Personal Life

Sheldon Glashow married Joan Shirley Alexander in 1974; they have four children. Glashow was one of the 22 Nobel Laureates to sign the humanist Manifesto III in 2003. On the other hand, Weinberg married Louis Weinberg in 1954 and has one daughter, Elizabeth. Unlike Glashow and Weinberg, Salam married twice and lived a very private and secrete life. He fathered six children. At the age of 70, he passed away from the terminal disease called Progressive Supranuclear Palsy (PSP).

Research and Career:

Glashow examined vector boson in his Ph. D. thesis between 1958 and 1960. In addition, he studied their possible role in the weak interaction during his post-doctoral fellowship in Institute for Theoretical Physics, Copenhagen. He propounded a paper proposing that not two but three vector bosons—positive, negative and neutral—carry the electroweak force. Glashow proposed the existence of fourth variety of quark, charm, in 1964. In 1973, Glashow's electroweak schemes wereconfirmed in short range order. To contribute more in Physics, he posited the existence of charmed particle in 1974. To acquire Nobel Prize in 1979, his preceding exposition an effect known as atomic parity violation (1978) played instrumental role. From his early age, Glashow was disposed towards the domain of Physics that has experimental ramifications and is carrying outdifferent fruitful experiments and research to find out how high-energy processes could be made experimentally observable. Aside from scientific articles, Glashow has written books, popular articles, potpourri of tales and poems and so forth particularly about Physics and Physicist.

When Steven Weinberg was younger he was passionatelyinclined towards Science. His father, Frederick Weinberg, spurred his inclination and motivated him to pursue a domain of Physics. Weinberg performed research in a multitude of topics of Particle Physics—High-energy behavior of quantum field theory, symmetry breaking, pion scattering, quantum gravity and infrared photons. When Weinberg was a visiting professor at MIT, in 1967, he posited his model of unification of electromagnetism and of nuclear weak force. As the result, Weinberg theory contributed the profound basis for the formulation of full standard model. Interesting, in 1973, Weinberg proposed a modification of the standard model, which did not contain fundamental Higgs bosons. Moreover, in 1979, Weinberg pioneered the modern view on the renormalization of quantum field theories as effective theories. His approach, sufficiently, allowed the development of effective theory of quantum gravity, low energy QCD, heavy quark effective field theory and so forth. Besides his scientific research, Weinberg has ben a prominent public spokesman for Science, prolific newspapers article writer. In addition, Weinberg has written several books illustrating profound insight in succinct and lucid approach.

Although Abdus Salam had a profound disposition towards mathematics, he applied for the job for the Indian Railways but his application for the job was turned down. But when he published his doctoral thesis, he was successful in garnering international recognitions colossally. At the age of 33, Salam became one of the youngest persons to be opted for a Fellow of the Royal Society. In 1959, Salam presented his work on neutrinos to Oppenheimer, an American Theoretical Physicist who played crucial role in the development of atomic bomb during World War II. In the subsequent years both worked towards the foundation of electrodynamics. Salam introduced Chiral Symmetry in the theory of neutrino, which facilitated profoundly in the development of the electroweak interactions. In addition, Salam published a paper on the interactions of vectors meson, photon and renormalization of the vector mesons. In 1960, Salam was successful in explicating electromagnetic interactions between magnetic monopoles. Salam and Jogesh Pati were the first to notice quarks and leptons have similar representation content, that is, SU (2) * U (1).

Abdus Salam founded the International Center for Theoretical Physics (ICTP) in Italy. Furthermore, to promote Science in his country, Salam founded International Nathiagali Summer College (INSC) in 1974. Salam was instrumental in the development of space program in Pakistan by establishing Space Science program. In Pakistan he is remembered as the '*Father of Pakistan's School of Theoretical Physics.*'

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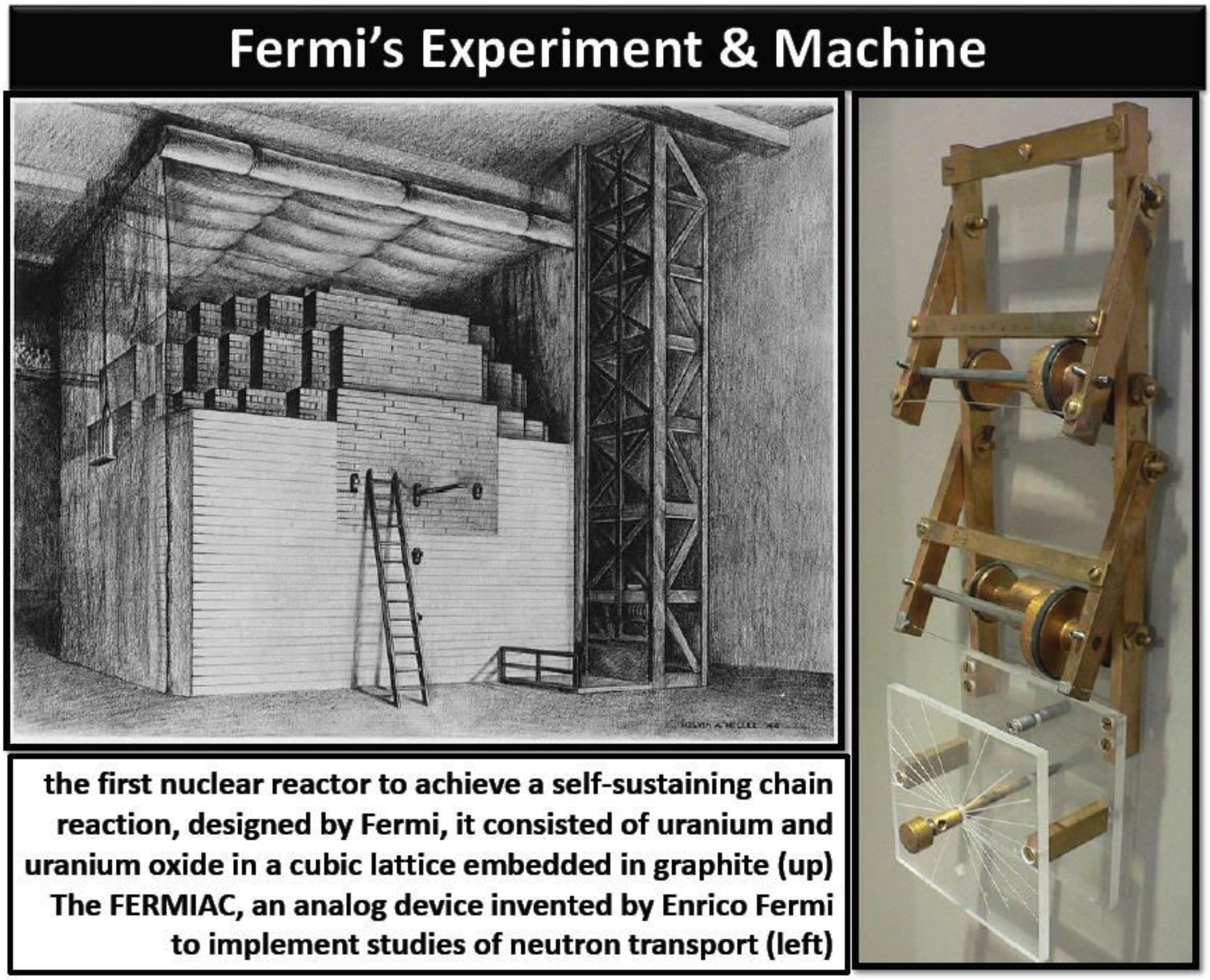

An Encounter with

Dr. Keith Groves

Dr. Patricia H Doherty

Boston College, Boston, USA

1) Could you please say few words on the purpose of your visit to Nepal?

Both: **We are here to participate in the workshop on GNSS(global navigation satellite system) organized by UN. There are 65 participants from 40 different countries. We are also looking forward to exploring the possibility of research collaboration in Nepal.**

2) Would you like to share something about your current research work?

Keith: **I am involved in the study of radio wave propagation and space weather. We are using more and more technologies which are dependent on satellite. Due to this, higher accuracy of device used and change in space weather are very important.**

Patricia: **I am involved with ICTP and am currently studying to the ionosphere under contact to the aviation system. This helps to enhance the operating capabilities of the aviation system.**

3) Countries like Nepal cannot afford to send solar probes or Rockets into space. How can they contribute towards space-science?

Both: **Nepal has a unique environment. Also, GNSS technology is quite affordable. If we could lay out the network of GNSS receivers onto the ground, it can help us to understand anomaly at the low altitude. This is a low-cost opportunity. Satellites are already there, only ground based equipment is required.**

Boston Faculties with editors of symmetry

4) What are your suggestions to the students like us who are pursuing their career in physics?

Both: **The interest in physics among students of the United States and other developed nations is dwindling. It is heartwarming to see so many physics students in Nepal. It is important to have young people with new ideas. Students are advised to get the solid foundation in physics. First, focus on your basics. And apply for the institution which can provide you the best training. For the students going to any field, training is most important.**

Boston College, Boston (USA) is a private institution that was founded in 1863. It has a total undergraduate enrollment of 9,309, its setting is suburban, and the campus size is 338 acres. It utilizes a semester-based academic calendar. Boston College's ranking in the 2018 is 32. BC has nine schools, which include such highly ranked graduate programs as the Lynch School of Education, Boston College Law School and Carroll School of Management.

Dr. Suyog Shrestha

CERN Scientist

(Dr. Shrestha did Ph.D. from USA and now post doctoral physicist on the ATLAS experiments at CERN. He had organized master-class in computational high energy physics at CDP during June 2016 and this year he came here for multiple purposes.

First of all, we would like to know about you and your research work.

My name is Suyog Shrestha. I am originally from Sindhuli. I have attended schools in Sindhuli, Biratnagar, and Kathmandu. After I.Sc., I went to the U.S. from where I finished Bachelor's and PhD. Currently, I am a postdoctoral physicist on the ATLAS experiment at CERN. ATLAS is one of the four major detectors built around the Large Hadron Collider (LHC). The LHC circulates beams of protons (and also heavy ions) near the speed of light in clockwise and anti-clockwise directions in a 27 km tunnel 100m underground. These beams are brought to collision at four points, around which the detectors are built. ATLAS is one of those detectors. It "takes pictures" of proton-proton collisions. Based on these "pictures", which give us information such as momentum and energy, we try to identify the particles created in the collision and to classify the candidate physics event. My primary task is to search for di-Higgs events. That is, to identify events in which two Higgs bosons are produced. We have already found event in which one Higgs boson is produced. That was the discovery of the famous Higgs boson, which led to the physics Nobel prize in 2013. Now we are searching for new particles that may decay to two Higgs bosons. This analysis is also very interesting and important because it will reveal, once we collect enough data, how the Higgs boson interacts with itself. This is a mystery for now, but it won't be for very long. And I am super-excited to be part of what one day will become another historical discovery!

2. Why did you choose to pursue particle physics?

Sometimes I wonder too. But on a more serious note, I went to Iowa State University (for graduate school) to do condensed matter physics (CMP). I had done some research as an undergrad at Grinnell College, and I thought it'd be a smooth transition, not to mention that CMP tends to have more funding in general. However, even after the first semester in grad school, I had not made up my mind. I was questioning myself if I really wanted to do CMP. The first two years you are generally busy with courses and teaching, but you are supposed to pick up someone to start summer research with after your first year. I spoke with several faculty members, tested the labs, but I was not quite satisfied. Something just didn't click.

Fortunately, for people like me the department organized a weekly seminar in which faculty members would come and give a talk about their research. And I was impressed by the talk given Prof. Jim Cochran. He talked about the LHC, the ATLAS experiment, and all the cool things they were expecting to do – Higgs boson, supersymmetry, extra dimension, quantum black holes! I was hooked. This also fit very nicely with my somewhat romantic idea of fundamental physics since high school days of reading Feynman and Hawking. So I signed up to be in his research team for the following summer, enjoyed it a lot, and stayed with them until my PhD was done. Looking back, it was not such a bad decision, you know!

Editors are taking interview with Dr. Shrestha (CDP)

What is the purpose of your visit to Nepal? For how long will you be staying here?

We have come to Nepal for a workshop- the first South Asian High Energy Physics Instrumentation workshop. The workshop was hosted by Kathmandu University and organized by KU in partnership with CERN. The workshop brought together some 70 scientists working in the region to learn about each other's work, to discuss possible collaboration with each other and with CERN. There is no signed agreement that came from the workshop, but we now know a lot more about the regional science, and there is a lot of good will to educate and train young scientists. So, for example, a student from Nepal doesn't necessarily have to go to

CERN to contribute to its experiments, but can do so from India or Pakistan, both of which are associate members of CERN and carry out excellent research activities related to CERN. We also learned that Sri Lanka is very actively moving forward in its high energy research activities and it has a lot of support from its government - to the extent that we had a representative from Sri Lankan Ministry of Science and Technology at the workshop, who significantly contributed to the discussion. We can learn a lot from Sri Lanka. The workshop also showed the level of enthusiasm and talent we have in Nepal – some 40 students and researchers from Nepal were present, including very high level personnel such as the Vice-Chancellor, Registrars (current and former), Deans etc. They were incredibly supportive in making the workshop a great success, and they commit to supporting collaborative activities in the future! This is great news for the future of Nepali science – to be able to work alongside the best in the field from all over the world!

Recently you met with the president of Nepal at CERN. What opinions did you get from the head of the state? What did you suggest for Nepal, particularly for the improvement of Research Field?

Yes, it was an excellent visit in many ways! For the President of Nepal to take time out of her busy schedule and visit CERN shows her interest in science, the country's interest in science. And we scientists need to make sure that we are informing and educating our policy-makers about the work we do, about the importance of it, its impact on society, the benefits that it affords. That should be part of our job. Otherwise, how are they going to support us, make policies? They may not always support us, but if they are not even aware of our work, it is not possible for them to support it. So in this particular sense, it was a fruitful visit. She was highly supportive of the core message of CERN: "Science For Peace". During her visit, she showed much interest in the work we do at CERN and the benefits that society has received over the years. She was particularly interested in the medical applications such as the proton therapy for cancer treatment, which is one of the spin-offs of high energy particle physics. I'd not say that we suggested anything specific for the improvement of research culture in Nepal. The discussion generally focused on research and its benefits. The President, and many policy-makers, are intelligent and they know the importance of investment in science for sustainable development. This is also one of the key messages of UNESCO Science Report 2030. The question is how do we move forward in implementation. This is going to be challenging. But it is not impossible given the talent and enthusiasm present in Nepal. One example of a success story is the small outreach projects we started in 2013 which have now gained some historic significance in the sense that these activities basically seeded the growth of relation between CERN and Nepal. We have received several summer students and high school teachers from Nepal for training. We have produced a Master's thesis. We have been able to work with the government to formalize an agreement with CERN so that more scientists and students get access to the resources at CERN. We have been able to bring together scientists from all over South Asia and pave path for future collaboration within the region. So short-term suggestions and responses are important, but perhaps more important is to continue to do our work.

Editors are with Dr. Shrestha in CDP premises

Recently, particle physics and Quantum Field Theory courses have been added to the curriculum or M. Sc. Physics. Do you see any possibility of help/ encouragement from CERN so that students can learn the techniques of Data Analysis here?

That is excellent news, indeed! And of course, if a student is already familiar with theoretical particle physics, it'll be much easier to work her/him. There are several tutorials online which explain how to use the tools for high energy physics data analysis. This may not be too different from the tools used in astrophysics research carried out here at CDP, so you may have local support. But if there are interested students, standard online tutorials can be followed and perhaps long-distance learning can be set up, so that a student can write a thesis on experimental particle physics.

We have heard that you are supervising a thesis student of this department. How do you feel working with him?

Yes, indeed! Santosh Parajuli is a Master's student at CDP, who had come to CERN in 2015 as a summer student. I worked with him then on the optimization of vector-like quark analysis. He did a fine job in the summer and expressed an interest in continuing his work for his thesis. So we set up a sandwich program for him such that he is a student at TU with support from ICTP. With his ICTP credentials, he could access ATLAS data and do the analysis. I have enjoyed working with Santosh – he is bright, curious, and hard-working. After his summer at CERN, we have been meeting on Skype somewhat regularly. We also communicate a lot in email. Long-distance is not as efficient as in-person meetings, *but if you are determined, you can make it work. And this is a fine example.*

Large Hadron Collider has been sometimes criticized for its inability to produce New Physics apart from the discovery of Higgs Boson. What is your opinion about this?

One thing that may set things in perspective is to understand the difference between new physics and new results. Whether or not there is new physics is beyond the control of the LHC or any scientist. We will just have to wait and see how Nature reveals itself. As for new results, we are constantly publishing them. We make new and more precise measurements of the processes within the Standard Model. We search for new particles and in the absence of discovery, we set upper limits on their production cross-section, or limits on their masses etc. These are completely valid, scientific results, which say, simply speaking, that if this particle does exist, its mass has to be higher than X GeV. This is a good result in the sense that now we can focus our efforts beyond X GeV. In carrying out these measurements and searches, we learn a lot about our detector, our techniques, and we improve them for future data. This all leads to better and improved searches for new physics in the future. The exploration must continue!

What are your suggestions for the young researchers in Nepal who want to pursue their career in particle physics?

There is no particle physics program in Nepal, so a student will have to seek alternatives if she/he wants to pursue a career in particle physics. If going abroad provides you with that opportunity, go ahead. If you'd like to get involved while still here, something like a sandwich program – at the moment suitable for M.Sc. - may be an option. Additionally, there are open data and online tutorials on how you can analyze them, so you can check that out as well. That will give you a flavor of the research work. But to study it seriously, to really get your hands dirty working with the detectors, to devise your own strategy to search for your favorite particle, to really do the full statistical treatment of the data; you will want to do your PhD and at the moment, I see no viable alternative to going abroad. We are discussing a possible sandwich PhD program, but this will take some time to mature. Ask me next year where we stand then!

CERN is a European research organization that operates the largest particle physics laboratory in the world. It is an official United Nations Observer, established in 1954, and has 22 member states. Israel is the only non-European country granted full membership.

CERN is a huge laboratory, which in 2016 had 2,500 scientific, technical, and administrative staffs, and hosted about 12,000 users all around the globe. CERN generated 49 petabytes of data in 2016!

Dr. Michele Trenti

Researcher

(Dr. Trenti is affiliated with University of Melbourne, Australia. He received Kavli Institute Fellowship of University of Cambridge for his excellent research on 'Formatio and evolution of stars in the galaxy'. He had organized 'First Kathmandu Astrophysics School' at CDP, TU, Kirtipur during 24-28 October 2016.)

As a lead organizer, how do you feel being part of Kathmandu Astrophysics School?

I feel I have been very fortunate and privileged for the opportunity to organize the school with an amazing group of lecturers and for the incredible enthusiasm and commitment shown by the students. Mentoring is a fundamental aspect of the professional life of an astrophysicist, and the Kathmandu Astrophysics School has been among my personal highlights. I am definitively looking forward to the opportunity to contribute to future editions of the school.

Nepal is quite behind in research activities particularly in the area related to astrophysics. What was the main goal of this astrophysics school?

Nepal has undoubtedly some challenges regarding the breadth of astrophysics research, but that seems inevitable given the very low number of professional astronomers in the country. So the main goal of the school was to complement traditional curriculum education in Nepal by focusing on offering the students a "hands-on" team-based research experience. In addition, we added a mix of traditional lectures and professional development seminars, such as how to write an effective Curriculum Vitae or cover letter for study or employment applications, with the goal of empowering the attendees to be more successful in their academic and professional careers. Since I understand that a significant fraction of the master students attending the school may work as high-school science teachers at some stages of their careers, we are also hoping to leverage the positive impact of the school to a broader audience by contributing to form better teachers. It is a small contribution, but hopefully it will have a positive impact to grow research activities in Nepal in the long term.

What were the challanges of organizing this school?

Remote organization of events is always challenging, and that was my first time in the role of lead organizer for a school. So I had a double set of challenges to face. Fortunately, we could count on a very strong support by the Central Physics Department at Tribhuvan University, which made logistic arrangements very easy to handle. The curriculum development required a bit of guessing regarding student interests and background preparation. I think all worked out well based on the feedback we received, but we also identified some areas for future improvements.

Why did you choose Nepal for organising this school? Did you enjoy your stay in Nepal?

The idea for KAS16 was born during my first visit to Nepal for a high-energy astrophysics conference in 2013. I was really impressed by how keen the local students were to engage with conference attendees, so I thought that organizing a school would have been an excellent opportunity to complement the international conference.

I really enjoyed my stay in Nepal, both in 2013 and in 2016. I think it is mostly because of the smiles I see around and of the friendliness of the Nepali.

Trenti, delivering hands-on lecture at CDP Seminar Hall

What is your suggestion for the young physics students of Nepal?

Studying physics gives you the opportunity to learn problem solving, and I think this is a skill that is *extremely valuable both in the academia and for employment in the industry. Try to make the most out of it, and always have a critical attitude to learning. Try to understand actively what you study rather than repeating passive knowledge during exams, and do not hesitate to apply the order of magnitude estimates beyond physics to everyday life.*

Discussing with young students

What brought you to science? Why did you choose astrophysics as a field of study? Please share us about your current researches.

When I was a little kid I was pestering my parents by constantly asking "Why?". That curiosity, coupled with the fascination of looking up at the night sky and wondering what is out there, then naturally drove me to astrophysics. At the moment, I am mostly focused on trying to understand how the first generations of stars and galaxies formed in the Universe, and how those early objects contributed defining the properties of stars like our Sun and galaxies like our Milky Way. For this I am using big space telescopes such as Hubble and Spitzer, and very much looking forward to the launch of the James Webb Space Telescope next year. But I have been very impressed by progress in nanosatellite technology, so my latest research interest is also branching out toward exploiting opportunities to design and build a small but powerful space telescope. You can learn more at http://skyhopper.space

Delivering lecture

What are your hobbies and interests outside of work?

I love walking and running on trails, especially when surrounded by majestic mountains, as well as cooking. One of my most memorable moments has been having the opportunity to take a cooking class at a teahouse in the Langtang Himalaya and help cooking Dal Bhat for the guests. A great way to end a day of hiking! Spending time with my wife, friends and family playing strategy board games is also very high on my list of fantastic ways to relax.

Established in 1853, the University of Melbourne is a public-spirited institution that makes distinctive contributions to society in research, learning and teaching and engagement. It's consistently ranked among the leading universities in the world, with international rankings of world universities placing it as number 1 in Australia and number 31 in the world (University Rankings 2017-2018).

Experience

Bibek Tiwari: Entrance Topper 2072

Bibek Tiwari is from Simara, Bara. He is the topper of M. Sc. Physics Entrance examination 2073. He has also topped M. Sc. First semester examination with SGPA 4.00.

1. What inspired you to study physics?

From my childhood, I was fascinated with the beauty of nature which is responsible for my interest in science. To be frank, I was not good at academics at early stages of student life. At first, I was interested in the mathematical studies of algebra and geometry. Then I became fascinated with computer science but gradually I began to realize that physics was the fundamental above all. So I decided to study physics only after the completion of Plus two.

2. Had you ever thought that you could top the entrance examination of M. Sc. at CDP?

No. Since the competition is very tough, we never know who will be top until the result is published. My priority was to get my name among those top 92 students to get enrolled in the CDP. For me, being the topper is not essential; being the part of CDP itself is enough.

3. Can you describe the moment when you were declared as an entrance topper of physics?

As the day for the result approached, since I had done a lot of hard-work for the examination, I started to become anxious about whether it will be paid off or not. After the announcement of the result, my anxiety was at its peak. When I saw my name at the top of the list, I was quite shocked. I rechecked my name and roll number just to make sure that the person at the top of the list was me.I was very happy not only because I became top but also because I would be able to study in the building, onwhose premise I was standing right then. What I was feeling at that moment was a pure joy.

4. What do you think was the key factor behind your spectacular performance?

Of course, hard labor is the key to every success. Moreover, I spent my time understanding the concepts rather than memorizing the formulas. Also, I used to visualize the problem so that it would stick to mind faster.

5. What were your preparation strategy and routine study period for entrance exam of CDP?

I was concerned more with revising the contents studied in the B.Sc. level thoroughly. I tried to understand each derivation and build up the concepts. My aim was to improve my basics. I believe that with good basics, it is easier to tackle unseen questions. I usually don't have any specific study period. I used to set a target to understand certain topics each day and used to go beyond the syllabus so that the minimum base is built up.

6. What are your future plans?

I would like to pursue my higher studies in abroad and would like to use my brainpower in the useful research sector wherever it fits.

7. Give some advice to those students who are preparing for the entrance exam.

I advise them to develop the necessary concepts regarding the contents. Practicing problems directly isn't probably the best idea, I suggest avoiding doing so. To be familiar with the formulae, try manipulating variables involved in the expression concerning the order of the quantities involved.

8. Have you noticed any similarities or differences between the academic exam and the entrance exam?

Yes, the pattern of the questions in the entrance exam focuses on the in-depth concepts and requires skill on solving the related problems within short time limit whereas the academic examination's focus is on the derivation of the necessary physical equations and formulations which are essential in developing and understanding new physics.

9. Say something to motivate those who are having difficulties studying physics?

Physics is a lot more interesting than we could ever imagine. It relies on one's ability to imagine the various natural phenomena in a fundamental way and constructing the problem-specific model. As Feynman once said "Mathematics is the deep way of expressing nature", so understanding physics requires a solid background in mathematics. However, physics is not only math. One should be aware of the philosophy and its interpretation and also be capable of logical reasoning of the machinery and mechanism even in non-abstract languages.

10. Why do you think most of the students of physics go abroad as soon as they complete their M. Sc.?

The government is unable to promote the research activities within Nepal in more efficient way. The laboratories here lack necessary facilities for research activities, which I think is the main cause for the students of physics to go abroad.

11. Finally, how have you thought of contributing to your nation after being graduated from this university?

Frankly speaking, until and unless the sufficient budget is properly allocated for the research projects by government, an individual effort or a private institution cannot do much. Firstly, a proper manpower is needed in order to handle such projects. Unless the government is able to control such brain drain, it is sad to say, we graduate and be competent to apply for the further studies in abroad and motivate other students to do the same, being a teacher, lecturer or professor.

Experience

Amit K Shah: Entrance Topper 2073

My name is Amit Kumar Shah. I am from Morang district which is in the eastern region of Nepal. Currently, I am a first-semester student of CDP.

Please share us, what inspired you to study Physics?

I have always loved science. I am always enthusiastic about the laws of nature since my childhood. When I reached college, there was no doubt in my mind that I would pursue a major in one of the natural sciences. My father's wish too worked somehow. It was really just a motive of which one as I found. However, I finally decided to study Physics because I liked it preeminent of all.I loved learning new techniques and seeing how experiments work. That is the reason why I chose Physics as my favorite.

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

Being a diligent and enthusiastic student, I could have successfully topped the entrance. My honesty in work will make me perform and study with full passion and discipline which eventually paid for.

What do you think was the key factor behind your spectacular success?

That was my personal road of conquering a coveted degree in Physics. But I would modestly not have been able to varnish the journey single-handedly. I want to acknowledge the person that essentially picked me up and put me on the road: my family members, teachers and all of my friends.

What was your preparation strategy and routine during the entrance preparation period?

It takes a lot of hard work to prepare for entrance exams but along with hard working, knowing some tips and tricks is beneficial. I mainly focused on the practical ideas and the visualizations of the problems rather than to just remember the things forcefully.

Can you describe the moment when you were announced as an entrance topper of physics?

I really excited when I heard that I top the entrance examination. The entrance was really competitive more than I thought. So it was really the joyful moment.

How would you like to give some advice to those students who are preparing the entrance exam?

Firstly, I would like to say one should require analyzing the problematic situations. You should study regularly and rationally which will ultimately take you towards the door of success. You should have a practical study plan according to your own strength and weakness. These are the tips for all who are preparing the entrance exam.

Say something to motivate to those who are facing problem while studying physics?

Everyone experiences difficulties while studying physics. To overcome these difficulties is the part of the learning. Proper time and materials management will be the key for study after what you can enjoy physics.

Why do you think most of the students of physics go abroad after they complete their M. Sc.? In your opinion, what should be done to engage them in our country?

I think seeking an opportunity for the human being is obvious. But the lack of proper opportunities in science and technology arena is the main cause of brain drain. However, one should return and contribute to his nation after a certain period when he/she achieve the goal of the abroad study. I think the government should investigate in the research field to engage them in Nepal.

With friends at CDP premises

Finally, what is your plan after graduation?

My greatest ambition is to pursue scientific research at the highest level. I am passionate about promoting scientific activities in Nepal. I always want to develop nation through my experience. I also want to motivate youngsters towards Physics. I am confident this opportunity to study at CDP would help me a lot not only to get pertinent knowledge but also enhance the modern practical ideas, which will eventually help me to do something for the scientific development of my country.

Nobel Lauerate Prof. Dr. Dan Shechtman wrting a message to CDP family.

An Encounter with
Prof. Dr. Shekhar Gurung

Editors (Khagendra Katuwal, Bibash Sapkota, Ramesh Dhakal, Prakash C. Adhikari, Esha Mishra, Prakash Chalise and Sunil Lamichanne) with Prof. Dr. Shekhar Gurung
Location: Prof. Gurung's resident, Baluwatar, Kathmandu
Date:2017/07/16

BRIEF PROFILE

Date of birth:	2010 Jestha 8 B.S.
place of birth:	Sifal
Schooling:	Prabuddha & Ghum School, Darjeeling
I.Sc.:	Censor College, North Bengal
B.Sc.:	St. Joseph College, North Bengal, India
M.Sc.:	CDP, TU, Kirtipur, Nepal
Ph.D.:	Germany
Ph.D. Thesis Title	variation of solar UV radiations at different altitudes in Nepal

1) How was your childhood? Please tell us something about your school life. Could you recall what used to be your aim of life those days? During your childhood, which moment comes to your mind that puts a smile on your face?

I was born in Mabu VDC, Ilam. My early days of the village were quite happier though there were many complications. Among my four brothers and a sister, I was lucky to go to school at that time. My elder (Jetho & Mahilo) brothers got the education only at home. My other brother was able to get the school education too. Later my dad initiated to establish the school in the village for the betterment of child though he himself was uneducated. Our market at that time was Darjeeling rather Ilam. My father invited teachers from Darjeeling.

I completed my primary education from Prabuddha Primary School, Ilam. The school at that time was not well managed. A teacher had to teach from class one to four even in a single classroom. I remember we ourselves made the infrastructure of School. There were no specific textbooks, so we had to depend on books from India. I had to look after livestock. One day I left the livestock in the forest and went to the School but my parents didn't complain me. Probably that event inspired me very much to go school. I completed up-to class six in Prabuddha School and then went Ghum Boys School, Ghum, Darjeeling for further study with my brothers. First time I saw a bus there.

At class seven, I first time knew that there are different teachers for different subjects. At Ghum School, I somehow felt hesitation due to my different background and poor schooling. However, I didn't give up and did well in my study. I remember my brother strongly motivated me at that time. Accordingly, I passed my SLC from Ghum School with the good result of that time.

Actually, I don't remember any such aim of my life at that time. I just concentrated on my study.

2) What is the reason behind choosing physics? What actually influenced you to study physics?

To be frank, there was no such factor that led me to choose physics. But I remember once my teacher (Rai Sir) at PUC said, "*Physics is exact and systematized knowledge about anything*". Probably that quotation influenced me very much.

Taking with Symmetry editors

3) Tell us about your life in university as a student. Where did you complete your B.Sc. and M.Sc.?

I completed my PUC (PCL equivalent, 1-year course) from Censor College as an average student. Then, I went to St. Joseph College, North Bengal for B.Sc. I passed first and second year of my B.Sc. (3 years course) with distinction from which later inspired me to join M.Sc. I came to Kathmandu to join M.Sc. and at first applied in Amrit Science College. Later I met Balaram Joshi Sir (the then HoD of Central Department of Physics (CDP) with recommendation of H. N. Bhattacharya and ultimately joined CDP. I was the regular and

obedient student there. Then I topped Tribhuwan University in the fifth year (M.Sc. 1st year) with first division. In the sixth year, I attained the second position. I stayed in Kanti boys' hostel during my M.Sc.

4) You got a chance to study in Germany. How did you get there? Please, share with us the rare experience you obtained working there. What were your fields of research there?

Yes, I got a chance to study in Germany. Exposure was not easy at those times since there were no Internet facilities. We had to wait for the advertisement to be published in Gorkhaptra. I got there through the same process, the advertisement in the newspaper. I applied and got selected.

5) What was your Ph.D. thesis related to?

My Ph.D. thesis title was related to the variation of solar UV radiations at different altitudes in Nepal.

With spauce at his drawing room

6) You are also linked with literary works, what is the main theme of your writings?

In fact, I have not so much interest in literature but I somehow love reading poems and stories. As far I remember there are no such mentionable writings of mine.

7) What do you think would the world be like in next 50 years? What accomplishments in physics do you expect to be achieved in that period?

I think the time governs everything in the universe. But we have to be optimistic. At least I can hope for the better students, lecturers, and administration in near future. To make the ground for future leadership is important for me.

8) Will you share with us the happiest moment of your life?

You all (*Editorial board*) **are here with me…..** (*a big laugh*)**. I had enjoyed each of my contributions to the university as a lecturer and an administrator. This is some happy moment for me.**

With family

9) As you have a long experience of working as an administrative head (as HoD, as proctor, as principal of University campus), please share your experience.

The political situation at the time of my tenure was very volatile so I faced many difficulties. There was a situation when I was the HoD, Proctor, Principal, Warden of Boy's hostel and Warden of Girl's hostel simultaneously. I would recommend some person for those posts, but other people would not let him/her work. So that I alone had to take responsibility for all those posts.

It was a challenging work and sometimes hectic too. Because of it, I could not give as much time as I wanted towards my academic endeavors. But I am satisfied with what I have contributed to CDP as an administrative head.

10) You have been considered as a very planned and strong administrator on TU. We have heard that because of your continuous effort, TU Hostel was finally organized, the old cafeteria had been re-structured, these new buildings (Higher Education Project) came, and much more. During that time, you may have encountered many hurdles. How did you overcome those?

In the field of administrative work, it is normal to encounter some opponents as you cannot make everyone happy. Also, the political situation at the time of my tenure was very volatile so I faced many difficulties. I had my own way to deal with it.

I remember one incident in which some students had locked my office. To have a proper functionality of the administration, I would require its access. The protestors would remain at the department only during day period, at night, they would return their home. So I went there at night when everyone had left, noted down the model number of the lock they had used. I purchased the

lock of the same model and broke the original one. Then at every night I would bring the necessary documents and would use the new lock. Days passed by, but the work was unaffected. At last students decided to withdraw their protest. But when they tried to open that lock with their keys, it would not open. They did not have the clue that I had swapped the lock.

After receiving Mahendra Bidhya Bhushan at then Royal Palace

Another time, some people had planned to disrupt the examination by capturing the question paper before it was distributed to the students in the examination hall. To prevent this, I hired female examination-guards and placed the question papers in their bag. Nobody would dare to check the bag of female guards.

Organizing the hostel was the most difficult one. I had fractured my foot because of that. Student leaders of different parties had captured hostels. They did not want to vacate the rooms. So I, with my fractured legs, went to the hostel and asked the police officer to remove the flag from the hostel. At first, he hesitated, but upon my firm order, he complied. There were some groups which were dissatisfied with each other. So I went inside, and talked with unsatisfied groups and used them to clear the hostel. Sometimes you have to divide and conquer!!!

One time, some people were rallying against me. They were chanting slogans like, *"Sekhar Gurung, Murdabad !!"*. **So I went to that group and I myself started to chant the slogans with them which were directed against me. The crowd could do nothing, and eventually got dispersed. There are many incidents like these. These are most memorable ones.**

11) Apart from the aforementioned works, what were your contributions as a HoD to CDP?

I brought two computers to the CDP, although they were a second hand (previously used by ICIMOD). And we connected the internet from the account of BCSPIN. Before that, students and faculties used to go abroad for short-term programs only. Introduction of internet enabled them to be familiar with various opportunities available at the international level. After that, people started to visit international institutions for long-term projects also. I think these computers played the crucial role in it.

But only two computers were not enough. So I formed a representative committee of teachers and students. Under the observation of this committee, we bought four more computers by collecting money from students. All the students of the department were dependent on these four computers for their thesis work.

12) You are one of the prominent personalities of Nepal Physical Society. You became president of this society several times and organized all Nepalese physics graduates in and around? Are you satisfied with the activity of Nepal Physical Society? What was your thought about this society in the beginning?

Yes, I became the president of the Nepal Physical Society four times. Since its inception, in order to attain its aims and objectives, this society is organizing seminars, symposiums, and workshops on topics of current interest in Theoretical and Experimental Physics on the regular basis. Since Nepal Physical Society is a reciprocal society of American Physical Society and a member of Association of Asia Pacific Physical Societies (AAPPs), it is carrying out its aims and objectives in an impactful way. Yes, since the beginning, I was and I am positive with the activities of the society but was never complacent.

With German Embassodor and colleague at CDP, TU

13) As a teacher, what sort of students you are attached with the most? Please make a light on the weakness of students these days?

Truly speaking, I was and I am strongly attached to all sorts of students. However, I like those students who constantly work hard and never stop working hard. Moreover, as I always like to see students achieving stupendous achievements, I appreciate those who have endurance and resilience ability during failure. As discipline, resolution, and diligence are a most for a student, student who does not have these attributes sometimes annoys me.

14) You are one of the renowned professors of Nepal, what would you like to suggest for the students who are thinking about their career in physics?

Since Physics deals with profound brain functions, convoluted notions, and complex equations, those who are aspiring to have a career in physics should have an acute and discriminating mind. Otherwise, the career in Physics is likely to be painful. Thus, choose the career in Physics if you have a sharp mind, which can identify, comprehend, and fix the problem.

15) If you were not physicists by profession, then what would you have been?

As many of my friends were recruited in military service, I may have tried to be in the military service. Frankly speaking, I don't know what profession I would have been pursuing now because I did not know what profession I would be choosing in the future when I was a teenager.

With Professors and colleague at Germany

16) We wish to know how you spend your normal day (from morning to night). May we know your further plans after retirement?

Generally, I wake up at 5 o'clock. After a light exercise, I take a snack. Then, I read newspapers, magazines, and physics books. If I have free time, I will help my wife in the kitchen. If I have an appointment, I will work for the appointment; if not then I spend time with my family. Furthermore, I do gardening and watering of flowers of my garden to invigorate myself. I generally go to bed at 9 0'clock.

17) The education system is highly affected by the current political affairs. What is your opinion on the engagement of student on political affairs?

The academic performance and academic capability have no relation with the political dogma or philosophy. It is solely the person's forte. I am very sad that the realm of academia is affected by the political affairs. Politics is important but it has its own place. University is the wrong place to practice politics. For the good of our country and for the betterment of future generation to come, the academic sector should be kept unstained.

It was subtle and was not to such extent in the past years but with time it has gotten worst. But blaming is not an option; we have to do what we can with what we have. The one thing which gives me pleasure is that at least the department of physics is not under the acute shadow of politics.

18) Now we have semester system and a relatively younger team at CDP under the captainship of Binil sir. What is your opinion on this change? Please say something about current semester system at CDP?

It is not necessary that the person should be old to run the administration effectively. The fundamental requirement is that the person should be capable and when I see the dedication of Binil ji, his way of handling administration, I must say it is really appreciable. During my tenure, because of the political disobedience and other various reasons, I was obliged to work more on administrative and managerial aspects than academic one but now the condition is different. In this new circumstance, he is the most appropriate person. Now there is semester system. It demands hard labor; one should be conscientious and old folks like us can't handle it in a proper way. So the young and energetic team is necessary.

With Profs. Devendra Raj Mishra & Uday Raj Khanal

19) Now there are 26 Ph.D. students at CDP, mostly they are regular and peer reviewed publication rate is also better. How do you observe? Is it improving than the older days?

The condition of our time was different. Very few students used to go abroad but now the situation has drastically changed. Now you should be more competitive and smart. The younger generation should be always ahead than the older one.

20) In our department, new generations of faculties are coming up. What sort of message do you wish to convey to them for the improvement of research and education level of the masters' & Ph.D. work in physics?

I just want to say that one should not compromise on quality. All teachers should focus on quality than quantity. It is good that the number of research works is increasing but while doing so one should be careful whether the standard of the work is maintained or not.

21) Finally, a large number of your students want to hear a lifetime guideline from you. What is your message to them?

The main duty of a student is to study well. While studying make sure that you do entertaining and invigorating activities to reinvigorate and motivate your mind. Always remember that only motivated mind can acquire the stupendous feats. Also, while choosing the career, make sure that you will be highly compatible with the prospective job that you are likely to get after the completion of the study. Always be disciplined and never give up. No matter how hard it will be in the initial phase, you can reach your destination if you have determination, discipline, and diligence. Also, don't be dejected during failure, and complacent during success. Always strive for more!!

Questions Asked to Madamme

1) Please tell something about your husband. His good habit, bad habit, humor, interests, weaknesses, etc.

The habit I like the most about him is that he is a very determined person. If he has to get something done, he does it with a lot of determination until it gets completed. He also helps me at home during his free times. His bad habit is that he is quite short tempered. His high blood pressure might be the reason behind it.

2) Since you are the wife of a very renowned Physics professor of Nepal, please tell something about your feeling about physics?

Physics starts with an alphabet 'P', that is all I know about physics. I know it is a difficult subject to learn.

CDP Alumni: First Batch to Seventh Batch (BS 2022-2028)

CDP FIRST BATCH (BS 2022)	
1	Jayshree Malla
2	Bishnu Das Singh Dangol
3	Rabindra Nath Adhikari
4	Ram Prasad Pradhanang
5	Kedar Govinda Amatya
CDP SECOND BATCH (BS 2023)	
1	Hari Prasad Rijal
2	Ram Nihar Singh
3	Bed Kesheb Shrestha
CDP THIRD BATCH (BS 2024)	
1	Mukunda Kaphle
2	Renuka Devi Shrestha
3	Bikram Chhetri
4	Lok Narayan Jha
5	Kedar Nath Baral
6	Surendra Shrestha
7	Ganesh Bd Basnet
8	Sambhu Sudhanshu
CDP FOURTH BATCH (BS 2025)	
1	Chandra S. Bhattarcharya
2	Kesheb Nepali
3	Ashok Ratna Shakya

CDP FIFTH BATCH (BS 2026)	
1	Devi Dutta Paudel
2	Padma Tara Tuladhar
3	Shesh Kanta Aryal
4	Kedar Jung Thapa
4	Surya Pd Upadhaya
6	Narayan Pd Upadhaya
CDP SIXTH BATCH (BS 2027)	
1	Bidur Upadhaya
2	Dhruba Das Mulmi
3	Ramesh Shakya
4	Padam Ratna Shakya
5	Khadga Bd Thapa
6	Shekhar Gurung
7	Lalit Basnet
CDP SEVENTH BATCH (BS 2028)	
1	Kamal Rauniyar
2	Basanta Kumar Gautam
3	Laxmi Pd Gyawali
4	Swatantra Bd Tamrakar
5	Gajendra Bikram Niraula
6	Hari Bd Khatri
7	Toya Nath

These students are admitted at the CDP as per the record.

The Topology of Electron Density and Chemical Bond

Dr. Rajendra Parajuli
Associate Professor, Amrit College, TU

ABSTRACT

With quantum theory, it is possible to explain the theoretical basis of chemistry. The molecular orbital is obtained from approximate wavefunctions and various parameters can be determined with these wavefunctions.Same thing can be obtained from the values of electron densities, with the help of density functional theory. From the topology of electron density, chemical bondings will also be explained.This article intends to present the brief review about topology of electron density and how it helps to explain chemical bonding.

Since the invention of quantum mechanics, the theoretical basis of chemistry is explained by solving the Schrödinger equation:

$$H\Psi = E\Psi$$

The molecular orbital is then obtained from the approximate (except for hydrogen atom) wavefunctions. This process is not only complex and time consuming, but also computationally expensive.

Density functional theory provides the more efficient way to do the same with the help of electron density, ρ(r). Different properties of matter such as energy, electron density, density of states, band-structure, etc., can be calculated with the help of this theory.

The topology of electron density can also explain chemistry. The 2016 Nobel Prize in Physics was awarded to three Physicists: David J. Thouless, F. Duncan M. Haldane, and J. Michael Kosterlitz for theoretical discoveries of *topological phase transitions and topological phases of matter*. Topology is the study of the nature of space. An analysis of the topology of ρ(r) leads directly to the chemical concepts of atoms, molecules, structures of molecules and bonds. For this, we need electron density distribution of a molecule.

Figure 1 shows a representative map of electron density distribution of typical molecule, (Diborane, B2H6). This map tells us that the maxima of ρ(*r*) occurs at the nuclear sites and it decays in a nearly spherical manner away from the nuclei.In these figures one can see the saddle points between the nuclei as well (clearly in Figure 1(a)).

Furthermore, for quantitative topological analysis gradient of electron density ∇ρ is considered. The gradient of electron density vanishes at some particular points. These particular points are called critical points. The characteristics of these points are determined by the Hessian. The Hessian is the (3 x 3) symmetric matrix of partial second derivatives.

$$\nabla\nabla\rho=\begin{bmatrix} \frac{\partial^2\rho}{\partial x^2} & \frac{\partial^2\rho}{\partial x\partial y} & \frac{\partial^2\rho}{\partial x\partial z} \\ \frac{\partial^2\rho}{\partial y\partial x} & \frac{\partial^2\rho}{\partial y^2} & \frac{\partial^2\rho}{\partial y\partial z} \\ \frac{\partial^2\rho}{\partial z\partial x} & \frac{\partial^2\rho}{\partial z\partial y} & \frac{\partial^2\rho}{\partial z^2} \end{bmatrix}$$

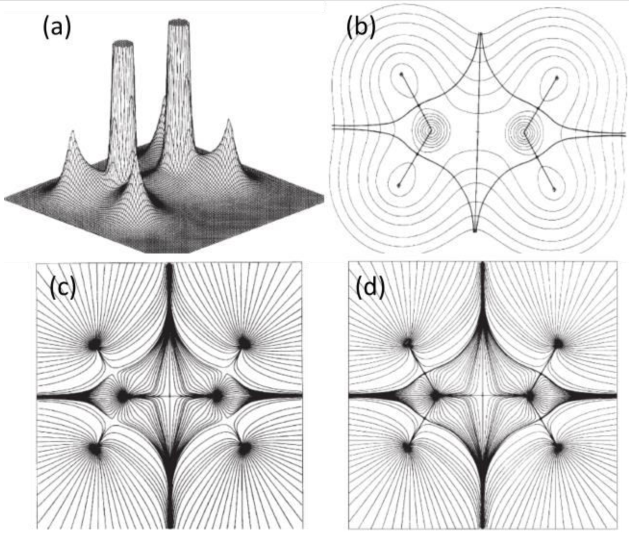

Figure 1: *Relief (a) and contour maps (b, c, d) of the electron density for diborane (B2H6) in the plane of the terminal hydrogen atoms.*

When we diagonalize the above matrix, the off-diagonal terms are zero. Thus, we can obtain the three principle axes of curvature. These principle axes will correspond to symmetry axes, if the critical point lies on a symmetry element. The sum of diagonal terms is now Laplacian of ρ. This, $\nabla^2\rho$, is important parameter.

$$\nabla^2\rho = \frac{\partial^2\rho}{\partial x^2} + \frac{\partial^2\rho}{\partial y^2} + \frac{\partial^2\rho}{\partial z^2}$$

The eigenvalues of the Hessian are real and non-zero at a critical point (CP). ACP is labeled according to the rank and the signature of matrix. The rank is defined as the total number of non-zero eigenvalues and is three for topologically stable critical points. The signature is the algebraic sum of the signs of the curvatures. Each one of the curvatures contributes either +1, if it is a positive curvature, or -1, if it is a negative one.

There are four possibilities:

1) *First Possibility*: All curvatures are negative. In this case signature is -3. The critical points have rank 3 and signature -3. These occur in the nucleus and are called nuclear critical points (*n*). There is a local maximum of electron density in nucleus and the terminus of the ∇ρ trajectories (Fig 1). Nuclear critical points (n) are thus classified as (3,-3) critical points.

2) *Second Possibility*: Two curvatures are negative and one is positive. Electron density (ρ) is a maximum in a plane and minimum perpendicular to this plane. In this case ∇ρ trajectories link the nuclei of the two bonded atoms (Figure 1c). This trajectory is known as a bond path (Figure 1d). The critical points have a rank of 3 and a signature of -1. These critical points are called bond critical point (b) and classified as (3, -1) critical points.

3) *Third Possibility*: Two curvatures are positive and one is negative. P is a minimum in a plane and a maximum perpendicular to this plane. The critical points are characterized by a rank of 3 and a signature of +1. These critical points appear in those systems where the bond paths form a ring. They are located in the interior of the rings, and are called ring critical points (*r*). They are classified as (3, +1) critical points.

4) *Fourth Possibility*: All curvatures are positive. The critical points are characterized by a rank of 3 and a signature of +3 and are located in the interior of a volume enclosed for two or more ring surfaces. These critical points are named as cage critical points (c) and classified as (3,+3) critical point.

The number and type of critical points that can exist in a molecule or crystal follow following relationship: $n - b + r - c = 1$. This rule is called *Poincare-Hopf rule*. One can categorize the type of bonds from the values of electron density and Laplacian of electron density. This methodology is called atoms in molecules (AIM) or Quantum theory of atoms in molecules (QTAIM). If the charge density at a bond critical point (BCP) is larger than 0.1 a.u., the bond is covalent. For weak interactions including ionic bonding, this valueat BCP is about 0.01 a.u. or less, and is about 0.001 a.u. for van der Waals complexes [3,4]. For hydrogen bonding interaction Koch and Popelier gave the range of ρ and $\nabla^2\rho$. These are 0.002-0.034 au for ρ and 0.024 to 0.139 au for $\nabla^2\rho$ [5].

To find the value of electron density at critical points of molecules, molecular complexes we need wave functions and for this, we have to apply quantum mechanical method. Once the wavefunctions are known then we have to use AIM theory for finding the values of electron densities and Laplacian of electron densities and molecular graph. The diagram of molecule including critical points is called molecular graph. For this article, GAUSSIAN 03[6] software was used for Gaussian wavefunctions and AIM2000 package [7] was used to find ρ, $\nabla^2\rho$ at CP and molecular graph (Figure 2-6).

Figures 2-5 are representative molecular graphs of various types of bondings. Figure 2 is for covalent bond, Figure 3 is for ionic bond, Figure 4 is for van der Waal's bond and Figure 5 is for hydrogen bond. The nature of bonding can be categorized if the values of electron densities at CP are known. The values of electron densities are according to the values depending upon the types of interactions. They are given in the sides of the figures.

Figure 2: *Molecular graph of H_2 showing BCP at bond path. The values of electron density and Lapacian of electron density are also given in the sides.*

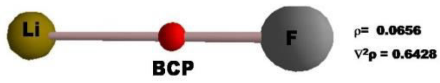

Figure 3: *Molecular graph of LiF showing BCP at bond path. The values of electron density and Lapacian of electron density are given in the sides.*

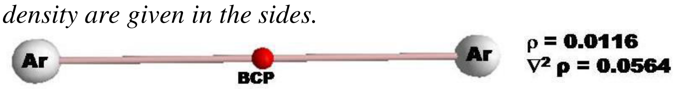

Figure 4: *Molecular graph of $(Ar)_2$dimer showing BCP at bond path. The values of electron density and Lapacian of electron density are given in the sides.*

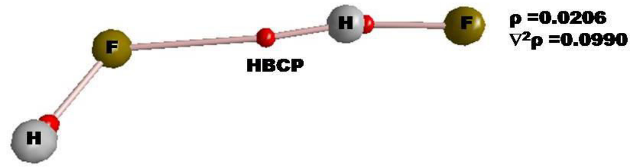

Figure 5: *Molecular graph of $(HF)_2$ dimer showing BCP and hydrogen bond critical point (HBCP) at bond path. The values of electron density and Lapacian of electron density at HBCP are given in the sides and they are within range given by Koch and Popelier*

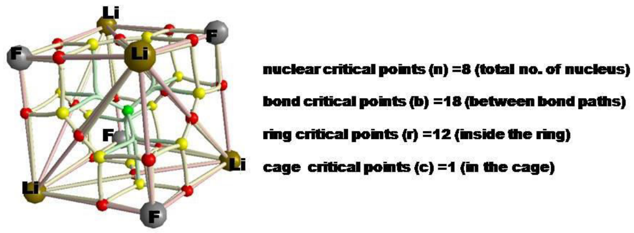

Figure 6: *Molecular graph of $(LiF)_4$ tetramer showing all types of critical points. This is an example of Poincare-Hopf rule i.e. $n - b + r - c = 1$.*

Figure 6 shows the molecular graph of $(LiF)_4$ Clusters. We can see all types of critical points in this system. Here nuclear critical (3, -3) points (*n*) are 8, bond critical (3, -1) points (b) are 18, ring critical (3, +1) points (r) are 12 and cage critical point (3, +3) is 1. Hence it follows Poincare-Hopf rule i.e., $n\text{-}b\text{+}r\text{-}c\text{=}1$.

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A Simple Technique for the Construction of Constant Amplitude and Variable Frequency Sawtooth Generator

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ABSTRACT

A 555 timer IC can be used to construct a fixed amplitude and variable time period ramp signal generator. The charging and discharging time can be externally controlled as per requirement. The amplitude of the sawtooth wave is fixed by the biasing voltage (V_{CC}) of the timer. The linearity of the ramp voltage can be improved by using separate power supply (VT). The larger the ratio of VT to VCC, the more will be the linearity of the ramp signal. By only changing the value of one resistor, the time period of the ramp signal can be changed without changing its amplitude.

Introduction: The 555 IC

Internal electronic structure of 555 timer integrated circuit (IC) is shown in Figure 1. The 555 timer IC has 8 pins, two comparators, one R-S flop-flop, a potential divider circuit and a discharge transistor. A positive bias voltage (V_{CC}) is provided through terminal 8 and the terminal 1 is grounded for proper operation of the 555 timer IC. Generally, a positive 5 Volts supply is used for V_{CC} though it can be 4.5 to 15 Volts. The 555 timer IC has two inputs: Threshold (pin 6) and Trigger (pin 2).The threshold is connected to the positive input of one comparator and the trigger is connected to the negative input of the other comparator. The potential divider circuit provides $2V_{CC}/3$ to the negative input of the first comparator and $V_{CC}/3$ to the positive input of the other comparator. Output of the first comparator drives S and output of the second comparator drives R of the R-S flip-flop. The output of the 555 timer is taken from the terminal 3, which is directly connected to complementary output ($\bar{Q}$) of R-S flip-flop. Thus, output of the timer circuit will be switched to high when S = 0 and R = 1 and low when S = 1 and R = 0. The outputs of the R-S flip-flop remain constants when both S and R equal to zero. When the output of R-S flip-flop is high, the terminal 7 of the timer is connected to the ground via saturated transistor. On the other hand, the transistor as well as the terminal 7 of the timer cuts off from the ground when the output (Q) of the R-S flip-flop goes to low. Terminal 4 of the timer is directly connected to the reset terminal of the R-S flip-flop. Hence, for normal operation of the timer the terminal 4 should be high. The control terminal (pin 5) is seldom used. [1,2]

As the 555 timer IC has comparators, flip-flop and discharging transistor, this IC can be used for a wide variety of applications. By externally connecting resistors and capacitors the 555 timer IC can be converted into multivibrators and sawtooth wave generator.

The Sawtooth Wave

Sawtooth wave is a special type of triangular wave. A triangular wave which has very short discharging time and very long charging time is called a sawtooth wave (see Figure 2). One of the most useful applications of the sawtooth wave is the sweep signal of the oscilloscope. This type of voltage signal is internally applied to the horizontal axis of the oscilloscope. Due to this sawtooth voltage the cathode ray beam of the oscilloscope gradually moves to right and the electron beam quickly comes back to the leftmost position immediately after it reaches to the rightmost position. A periodic voltage signal (external input signal) to be analyzed is connected to the vertical axis of the oscilloscope.

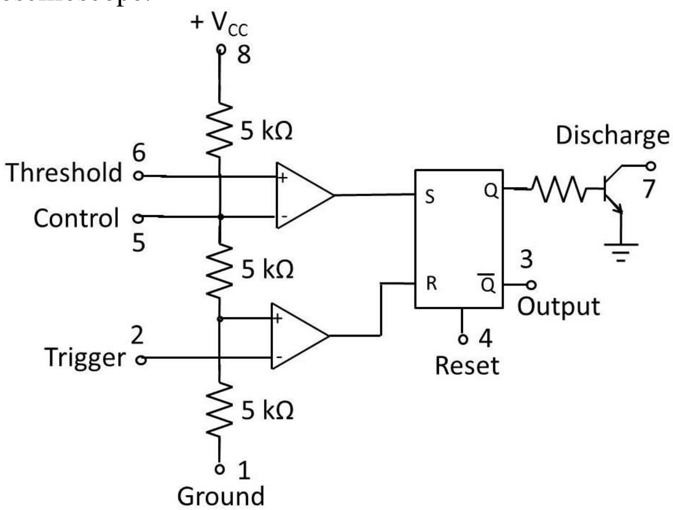

Figure 1: *Internal Electronic Circuit of 555 Timer IC. [1,2]*

When the frequency of the applied signal is an integer multiple of the frequency of the sweep signal (sawtooth wave), a stationary pattern of the externally applied input signal will be seen in the screen. The amplitude of the sweep voltage is adjusted in such a way that the electron beam should cover whole range of horizontal axis of the oscilloscope. Since the dimension of the oscilloscope screen is fixed, the amplitude of the sweep voltage should also be equal to some pre-assigned value. The frequency of the sweep signal should be adjusted according to the frequency of the applied signal.

Sawtooth wave can be generated using a circuit shown in Figure 3. This circuit is working on the basis of charging and discharging of a capacitor through a resistor. The positive supply (V_T) charges the capacitor C through resistors R_A and R_B provided the transistor internally connected to pin 7 be at cut-off mode. On the other hand, the capacitor C discharges through resistor R_B whenever the transistor connected to pin 7 is at saturation mode.

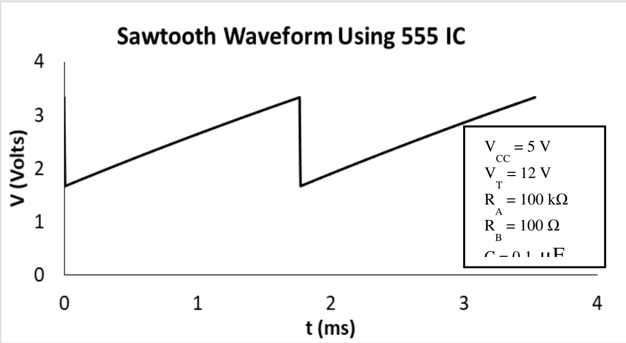

Figure 2: *Sawtooth waveform produced by the circuit shown in Figure 3. Component values are given in the box.*

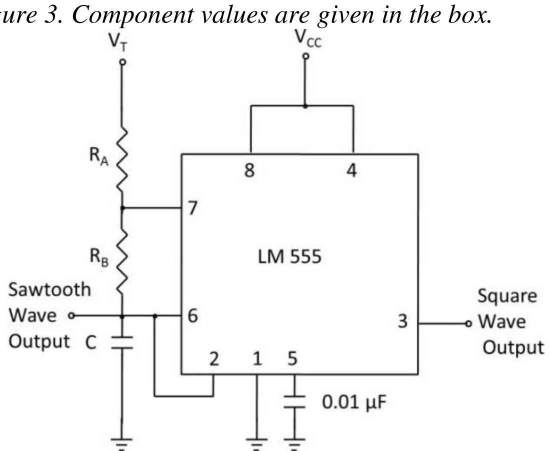

Figure 3: *Circuit Diagram of Sawtooth Generator.*

The sawtooth output voltage is taken from the capacitor C. The capacitor's voltages during charging and discharging are calculated using equation 1 and 2 respectively.

$$V = V_1 + (V_T - V_1)\left(1 - e^{\frac{-t}{R_1 C}}\right) \qquad (1)$$

$$V = V_2 e^{\frac{-t}{R_2 C}} \qquad (2)$$

For the circuit shown in Figure 3, the values of V_1, V_2, R_1 and R_2 are $V_{CC}/3$, $2V_{CC}/3$, (R_A+R_B) and R_B respectively. As the capacitor is connected to pins 2 and 6 of 555 timer IC, the capacitor's maximum and minimum voltages are decided by the 555 timer IC. Both R and S inputs of the R-S flip-flop remains low when the capacitor voltage lies between $V_{CC}/3$ and $2V_{CC}/3$. The outputs of flip-flop remain unchanged as long as both R and S inputs remains low. When the capacitor voltage goes just below $V_{CC}/3$ during discharging of the capacitor, R becomes high and S still remains low. As a result output Q resets and the pin 7 disconnects from the ground and the capacitor starts charging by the target voltage V_T. The capacitor continues charging until its voltage becomes just greater than $2V_{CC}/3$. As soon as the capacitor voltage exceeds $2V_{CC}/3$, the input S becomes high and the input R still remains low and the output Q of R-S flip-flop becomes high. The high Q saturates the transistor and the pin 7 connects to the ground through the saturated transistor. When the pin 7 connects to the ground, the capacitor discharges through the resistor R_B. The capacitor discharges until its voltage goes just below $V_{CC}/3$ and the process retraces its operation.

Since the capacitor voltage, V increases from V_1 ($=V_{CC}/3$) to V_2 ($=2V_{CC}/3$), the charging time, T_1 can be calculated as

$$T_1 = (R_A + R_B)C\log_e\left(\frac{V_T - \frac{V_{CC}}{3}}{V_T - \frac{2V_{CC}}{3}}\right) \qquad (3).$$

During discharging process the capacitor discharges from $2V_{CC}/3$ to $V_{CC}/3$. Therefore, the discharging time, T_2 will be equal to $0.693R_BC$. The discharging time can significantly be made small by using very small R_B for given value of C. The time length of the sawtooth voltage can be adjusted by adjusting value of the resistor R_A. When $V_T = 12$ V and $V_{CC} = 5$ V, the charging time, T_1 will be equal to $0.18(R_A + R_B)C$. The linearity of the ramp voltage can be improved by increasing V_T/V_{CC} ratio.

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Wife is dying - "Tell her to wait a moment till I'm done."

Gauss was an ardent perfectionist and a hard worker. According to Isaac Asimov, Gauss was once interrupted in the middle of a problem and told that his wife was dying. He is purported to have said, "***Tell her to wait a moment till I'm done.***" This anecdote is briefly discussed in Waldo Dunnington's Gauss, Titan of Science where it is suggested that it is an *apocryphal story*.

The Wonder World of Dwarf Galaxies

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ABSTRACT

We know, almost every scientist agrees, that our universe was started from the Big bang. But that is not the full story, astronomy is a study of history of the Universe and we actually do not know how it evolved after the Big-Bang with certainty..

Introduction

We know, almost every scientist agrees, that our universe was started from the Big bang. But that is not the full story, astronomy is a study of history of the Universe and we actually do not know how it evolved after the Big-Bang with certainty. There are some information about the Universe, such as total energy and matter, expansion rate which we are measuring ever precisely with advancement of technology and methodology. Energy budget of our universe is dominated by dark-energy and dark-matter where only 4.6\% of the mass-energy density is observable [1]. Dark matter is supposed to made of non-baryonic particles and It plays an important role in galaxy formation. Galaxies are collection of stars, gas and dark-matter particles and they are the building blocks of observable universe. They are also a major source of information to study the evolution of Universe from the Big-Bang to present. In fact, almost all properties of our universe are actually derived from observing the galaxies of various distances. Therefore, our understanding of formation and evolution of galaxies is crucial to make accurate theory about the evolution of our Universe from the Big-Bang.

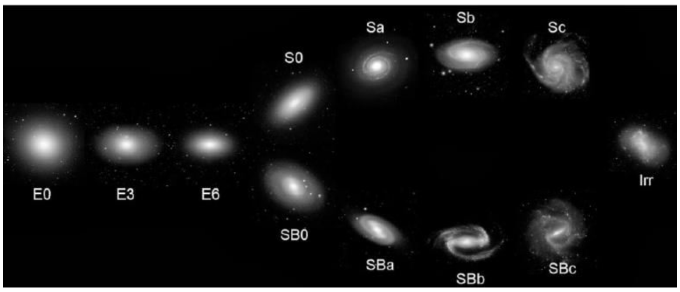

Figure 1: *Hubble tuning fork classification of galaxies. It starts from Elliptical galaxies in the left and branches into two types of spiral galaxies (barred and non-barred) in the right.*

According to numerical cosmological simulations, our Universe is dominated by cold dark matter particles, and they seem to cluster hierarchically in ever increasing number counts for smaller and smaller sized halos [2]. Galaxies are formed within these dark matter halos. In this formalism, low mass galaxies are the first to form and they merge together to form high mass galaxies, later. There are enough number of normal-galaxies (like Milky-Way mass) are observed as predicted from numerical cosmological simulation, but the low-mass galaxies (of mass less than 100 times of MW) seems to be an order of magnitude lower than expected from the simulation [3]. Prediction of numerical cosmological simulation of our Universe with cold-dark matter and hierarchical clustering does not match with observation of dwarf galaxies. Therefore, study of dwarf galaxies provides a crucial test on the dark-matter dominated, hierarchical clustering model of the Universe and they represent some of the biggest mysteries about our Universe.

Dwarf galaxies are not only small galaxies, they are also faint object in the sky. Some of them are 1000 times fainter than darkest sky night observed from the surface of earth, which also poses another challenge to observe these mysterious objects, and only the telescope with large mirror are able to detect them. In addition to this, dwarf galaxies do not follow the standard Hubble classification of galaxies as in the case of massive galaxies and they generally have random morphology. This makes morphological classification is not as simple as Hubble did it for massive galaxies nearly 100 years ago. However, astronomers have grouped dwarf galaxies according to their optical properties, such as star-forming and non-star-forming (also called early-type) dwarf galaxies, ultra-faint dwarf galaxies, blue-compact dwarf galaxies etc. Blue compact dwarf galaxies are star-forming dwarf galaxies with high star-formation rate. The ultra-faint dwarf galaxies are recently discovered types which are also non-star-forming galaxies. There is also non-star-forming compact dwarf galaxies called ultra-compact dwarf galaxies [4,5]

Figure 2: *Two examples of dwarf galaxies. Left, a irregular and patchy appearance is of a star-forming dwarf galaxy. In right, smooth appearance galaxy is a non-star-forming galaxy.*

Star-forming galaxies are rich in neutral hydrogen. The neutral hydrogen is a main source of star-formation in galaxy. On contrary, non-star-forming galaxies are free of neutral hydrogen. Another main difference between star-forming and non-star-forming dwarf galaxies is the former are mainly found in isolated environment and the later are mainly satellites of massive galaxies or found in the centre of galaxy group and cluster. For example, almost all dwarf satellites of our own Milky-Way galaxies are non-star-forming dwarf galaxies, except Magellanic clouds. This environmental dependence of galaxy morphology is called morphology-density relation [6]. In other word, in low density environments, such as fields or isolations where very few neighbor galaxies are present, the galaxies are likely to be star-forming and in high dense environments, such as in group or cluster, galaxies are likely to be non-star-forming. Therefore, study dwarf galaxies is also related to the study of effect of environment on the galaxy evolution.

One of the important question in understanding of formation and evolution of dwarf galaxies is how these various morphology dwarf galaxies come to exist and are they transformed from each other during the course of evolution. Dwarf galaxies are low mass object and therefore the capacity of gravitationally bound their content is low compare to their massive counterparts. Because of this dwarf galaxies are quite vulnerable to the environmental effects.

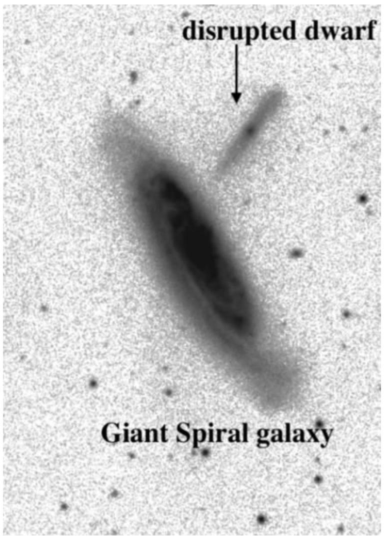

Figure 3: *Disruption of a dwarf galaxy by the tidal force from Milky-Way mass massive galaxy UGC 3412. We can see that body of the dwarf galaxy is stretched.*

Dwarf galaxies are easily disrupted by the tidal force of their nearby companions. Tidal force can be very lethal to these low mass systems, in some cases it can easily destroy entire galaxies to individual stars floating in intergalactic space. As the dwarf galaxies orbit around their nearby massive companion, the tidal force gradually stretches their body forming stream of star and gas along the orbit. A classic example is disruption of Sagittarius dwarf galaxy by the Milky-Way where the Sagittarius dwarf galaxy is nearly 1000 times smaller than the Milky-Way galaxy [7]. Astronomers are curious about survival of Sagittarius dwarf whether it becomes a small compact dwarf galaxy or it may be completely destroyed. Recently, Paudel et al. discovered several examples of dwarf galaxies with stellar stream around them as a sign of ongoing disruption by the tidal force of nearby companion and they notice that some these disrupted dwarf galaxies are actually being transformed from star-forming to non-star-forming dwarf galaxies [8.9]. Other are becoming ultra-compact dwarf galaxies after losing their outer part.

In case of giant galaxies, non-star-forming galaxies (also called elliptical galaxies) are formed after merging of star-forming giant disk galaxies. On contrary, astronomers are not actually sure about what kind of galaxies formed after merging of dwarf galaxies. Star-forming dwarf galaxies are extremely rich in neutral hydrogen gas and there is not conclusive theory about how gas rich dwarf galaxies become gas poor and non-star-forming. Instead, it is believed that surrounding environment plays a key role to remove the star-forming gas from these low mass galaxies and transmutes their morphology from star-forming class to non-star-forming class. Current research on dwarf galaxies is focused on two fundamental questions, i.e. how many dwarf galaxies are located in different environments and how much surrounding environment affects the formation and evolution of different morphological classes of dwarf galaxies. The former question is directly related to answer whether our idea of cold dark-matter dominated universe is true and the second allow us to explore of physical process that are involved in formation and evolution of galaxies.

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Development of Theory of Atomic Collision

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ABSTRACT

Scattering problem is one of the oldest problems in atomic physics. With the advance of the experimental setup and observed experimental data, serious shortcoming in previously accepted theoretical methods has been observed. In order to fulfill the void between data required and data available, a large number of attempts are being made to extend correct quantitative knowledge with the aid of quantal, semi-empirical and semi-classical prescriptions. A brief introduction to the development of the theory of atomic collision will be discussed.

Introduction

Atomic collision involves the collision between an elementary particle and an atomic system. The collision of charged particle with a gas atom may result in a number of effects. Scattering techniques represent one of the most powerful and direct ways to obtain information on the microscopic structure of the quantum system. Electron-atom collisions that ionize the target provide a very interesting diversity of phenomena. The discovery of X-ray by Rontgen in 1895 marked the beginning of quantitative studies of ionized gases and experimentally done by Franck and Hertz in 1911. Around 1935, the growth of scattering process was suddenly retarded by the fast rising interest for Nuclear Physics. In 1952, a book by Mossey and Bulthop [1] appeared on electronic and ionic impact phenomenon. This provided the basis on which the young generation could start using the technical tricks and developed nuclear collision atomic physics.

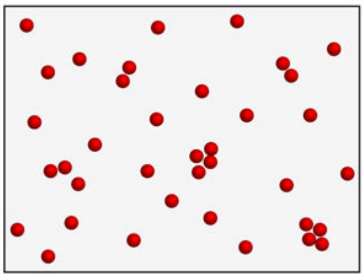

Figure 1 : *Atomic movement and collision*

In the early days of 1960, experiments were designed to measure total cross sections and experimental data of electron scattering were reported. These differential cross section measurements paved a major challenge for theorists since the more detailed information could not be explained using the standard elementary theories of that time. The ultimate goal of any theoretical scattering calculation is to produce accurate scattering amplitudes which could then be implemented to predict physical observables for the system. As the structural complexity of colliding systems increases, the difficulty in obtaining good wave functions also increases. A brief introduction to the development of the theory of atomic collision is presented here.

General Theoretical Approach

After the discovery of atomic model by Rutherford in 1911 the classical methods were used to describe collision processes. With the advent of quantum mechanics, classical methods are rarely considered in atomic physics. In certain cases, the classical approach provides the same results as the semi-classical and pure quantum mechanical. In general, the exact solution of the problems of atomic collision processes has not been possible. Various theoretical approaches for calculating collision cross section can be broadly classified into the following three categories: (1) Pure classical and Binary encounter approximation, (2) Semi classical and semi-empirical method, (3) Quantal method.

Several quantal approximations have been proposed for the atomic collision process in different energy regions. In the low energy region, quantum mechanical methods have been used for investigation of collision process whereas, in high energy region, it failed to give useful differential cross section. Different exit channels in collisions like excitation, ionization, electron capture and charge transfer have different theoretical boundary conditions. So a single theoretical formalism in the framework of quantum mechanics is unable to produce cross sections for different channels in collision problems. Hence, due to the complexity of a full quantum mechanical treatment, a large number of semi-empirical and semi-classical formulas have been developed. The basic assumptions applied in the derivation of collision/ionization cross section limit their range of validity. Quantum mechanical methods are frequently used for investigation of collision processes in the low energy region. At sufficiently high energies, the first Born approximation is found to give accurate results. For the intermediate region, the high energy method can`t be used without some modification.

Semi-empirical and semi-classical treatments of the electron impact process attempt to formulate simple equations containing parameters determined experimentally in order to reproduce the measured cross section and possibly determine cross sections for systems which have not been studied experimentally [2]. The semi-classical treatments make classical approximations to the full quantum mechanical scattering problem, providing a large degree of simplification of the problem in the process. In some cases of semi-classical methods, an attempt is made to improve their accuracy by the use of adjustable parameters determined by comparison of the basic theory to known ionization cross section data. According to Rudge(1968), three basic approximations must be used in treating electron

impact ionization by classical methods. They are listed below:
a. A classical description must be found for the initial state of the bound electron. Several descriptions have been used assuming the electron to be at rest, to have a fixed velocity or to have some prescribed velocity distribution.
b. The collision has to be described in the frame of classical laws of motion.
c. In most treatments, the collision process has been described as though it were a two body one like Binary Encounter Approximation (BEA)[3].
The binary encounter model is based on the following two assumptions:
1. Electrons of the target atom are regarded as completely independent of each other and they do not interact with each other in course of collision. The atomic electron and the nucleus are assumed to be independent scattering center. Under this condition the momentum transferred by the incident particle to one of the target electrons would be larger than the momentum associated with the atomic electrons and energy transferred would be much larger than the binding energy of the bound electron.
2. Prior to the collision, target electrons are regarded as free particles having a velocity distribution which is characteristic of the target binding force. Mutual interaction between the atomic electrons and nucleus is disregarded during a collision. The validity of this assumption is that the time of interaction between the incident particle and target electron should be small compared to the orbital period of the target electrons.

Importance of the Study

Studies of scattering theory and theory of ionization are used in different fields of science like astronomy, nuclear physics, particle physics, general research in physics and chemistry, plasma physics and in fields of medical science, ion beam technology for example thin film manufacturing etc.

Rutherford's discovery of the nucleus, collisions between atoms and alpha particles, has provided a means of determining atomic structure and the force of interaction. Scattering of different elementary particles and photons having different energies with target atoms give the origin of a number of particles and birth of particle physics. Therefore, knowledge of scattering theory plays important role in high energy physics.

Studies of atmospheric and astrophysical phenomena have revealed that ionized gas play an important role in nature and present knowledge is insufficient to explain many of the observations. Analysis of atomic lines from the ionized gas associated with quasars provides information about the nature of these striking astronomical objects including indirect information about their energy source. The study of ionized gas in our own and other galaxies provides information, for example, about the variation of the abundances of the chemical elements and hence about nucleosynthesis, star formation etc.

It may be pointed out that the world's conventional energy resources, including fissionable materials, are expected to be largely exhausted within a few centuries. The development of the technique for the controlled fusion of light nuclei in thermonuclear plasma appears to offer the greatest hope for the long range solution to our fuel problem. Electron-impact ionization cross sections are widely used in a modeling of fusion plasmas in tokamaks. Low energy scattering plays an important role in a number of critical applications. In magnetically confined fusion machine, low-temperature plasma occurs near the wall of the device. It is essential to understand how wall materials erode and how the resulting impurities are transported to the central plasma region [10].

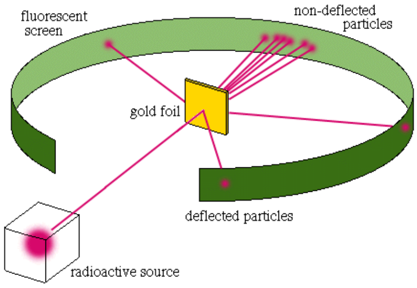

Figure 2: *Rutherford's Scattering*

These considerations explain the continuing and growing interest in ionized gases and the fact that the research efforts in this area are as vigorous and extensive as that in any other field of physics today.

Conclusion:

The discovery of X-ray made important contributions to the growth of physics, both in the development of experimental techniques and in the formulation of modern theory. Very significant progress has been made in developing the understanding during the past three decades both experimentally and theoretically. However, much remains yet to be done and understand. In order to fulfill the void between data required and data available, a large number of attempts have been made to extend our correct quantitative knowledge of the electron impact ionization.

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Fascinating Association Between Pulsar and Far Infrared Cavity: Whats' the Reason?

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ABSTRACT

We present a study of positional correlation between the pulsars and far infrared loops of the Milky Way. Pulsar is a very dense and compact system of neutrons supported by its degenerate pressure. It is a rapidly rotating star that has a very strong magnetic system. There are more than 2000 such objects in the Milky Way, immersed in a very dilute medium containg far infrared loops. We noticed a very good correlation between these loops and the pulsar, particularly at the Galactic plane. This will be presented and discussed in this article.

Introduction

The medium between the stars is not empty. It constitutes a variety of shells, cavities, filaments, arcs and loops containing interstellar gas and dust. These structures and their energetic are organized and ruled by the bubbles and super bubbles produced by supernova explosions and the violent stellar wind emitted from stellar associations (Weinberger & Armsdorfer 2004). Kiss et al. (2004) and Koenyves et al. (2007) identified 462 far-infrared loops in our Milky Way. They used 100 and 60 μm IRAS maps and studied their size luminosity distributions and concluded that these structures are formed and governed by supernovae and stellar winds at the low Galactic latitude. Interestingly, in the low Galactic latitude, there are large numbers of pulsars in our Milky Way. We are interested to study a correlation between these 462 far infrared loops KK-loops hereafter) and 2067 pulsars discovered by Taylor et al. (1993) and Manchester et al. (2005).

Far Infrared loops

Kiss et al. (2004) and Koenyves et al. (2007) reported 462 far infrared loop-like structures (KK-loops) in 100 and 60 μm IRAS maps. All sky distribution of these loops can be seen in Fig. 1.

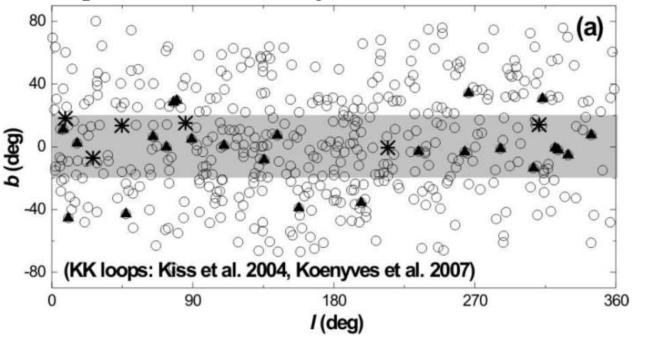

Figure 1: All sky distribution of far infrared loops (Kiss et al. 2004, Koenyves et al. 2007; KK-loops hereafter). The solid circle and `star' represent the loops under study.

A large number of loops are aggregated close to the galactic plane (grey-shaded region). At the high galactic latitude, the number density of the loops is found to be decreased. Therefore the effect of supersonic wind and radiation field in these loops cannot be ruled out (Aryal *et al.* 2010). The position angle and axial ratio (minor to major diameter: (b/a) distribution of KK-loops are shown (Fig. 2a,b).

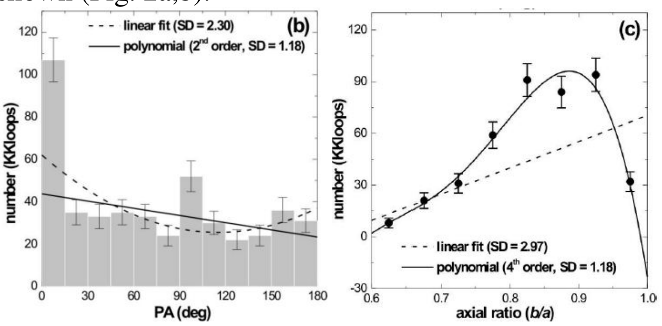

Figure 2: *Position angle (PA) and axial ratio distribution of KK-loops. The solid and dashed curves represent linear, polynomial fits. The statistical ±1σ error bars are shown. The standard deviation (SD) is given.*

The database are taken from GIRL (Galactic Infrared Loop) catalog available at http://kisag.konkoly.hu/CFIRLG/. The major diameters of a large number of projected loops (106) are found to align along northern direction (PA = 0°). Most of the loops are found to be face on ($a = b$). In addition, number of loops is found to decrease with the increase of PA. No loops are seen that have $b/a < 0.50$ in the database (Fig. 2b). The number of loops is found to increase with the increase of axial ratio. The straight line does not fit the axial ratio distribution. The best fitted curve is the fourth order polynomial. The lack of face-on loops can be seen in the histogram (Fig. 2c). This suggests that the search of far infrared loops is not complete.

ATNF pulsars

Taylor et al (1993) and Manchester et al. (2005) (hereafter ATNF pulsars) compiled a database of 558 radio pulsars and 1509 spin-powered pulsars. We studied the number distribution of these pulsars within 1° x 1° radius around 462 far infrared KK-loops. Only 37 ATNF pulsars are found to be located around 1° of 30 KK-loops (solid up-triangle in Fig. 1).

Within 3° radius around KK-loops, 399 ATNF pulsars are found. The number of pulsars is found to increase to 1714 around 6° radius of KK-loops. Fig. 2a-c shows number distribution of pulsars within 3°, 6° and 9° radius around far infrared KK-loops. We have tried to observe the correlation between the numbers of nearby pulsar with the distance from the KK-loop centre.

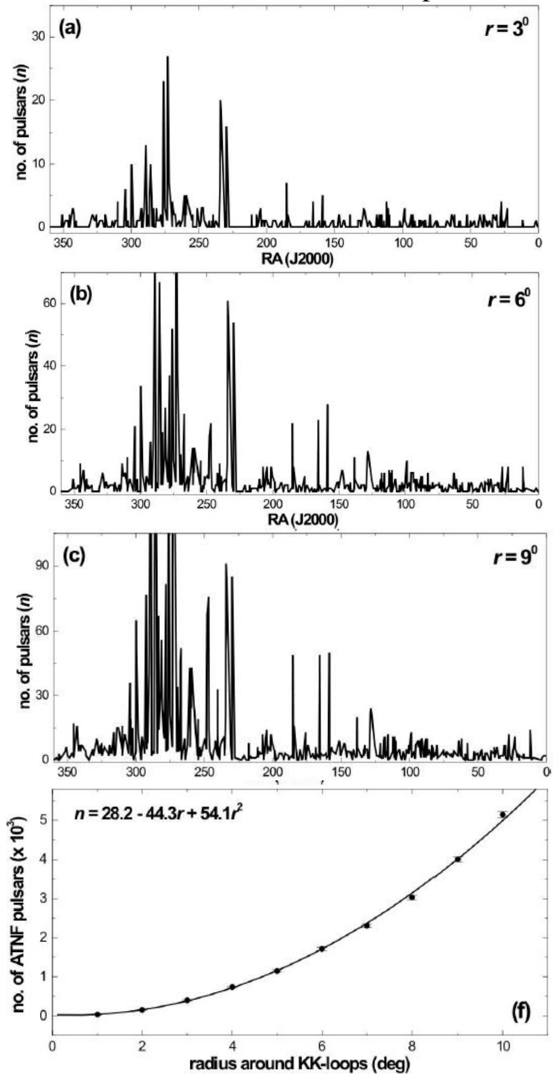

Figure 3: *Number distribution of ATNF pulsars (Taylor et al. 1993, Manchester et al. 2005) within 3° (a), 6° (b), 9° (c) around KK-loops (Kiss et al. 2004, Koenyves et al. 2007). (d) The number distribution of ATNF pulsars with radius of KK-loop. The statistical ±1σ error bars are shown.*

A good correlation between KK-loops and the ATNF pulsars is noticed. The number distribution is found to be related with radius according as this relation (Fig. 2d):

$$n_p = 28.2 - 44.3r + 54.1r^2$$

This is a second order polynomial equation with a positive very large changing slope. The database of 30 KK-loops around ATNF pulsars which are found to be located within 1° radius is listed in Table 1. The data listed in the first six columns of the table are taken from GIRL catalog. The last five columns list the data calculated by the author. These values strongly suggest a possible fascinating relation between the interactions of point source with various dusty substructures in the interstellar medium. We are interested to select a few loops located nearby pulsar for the further study. A knowledge of dust color temperature, their mass, density and inclination angle will provide a very good information regarding the interaction between the pulsar wind and the ambient interstellar medium (Jha *et al.*, 2017).

Table 1: The database of 30 far infrared loops (KK-loops). All sky distribution of these loops is seen in Fig. 1 (symbol solid up-triangle) First column is the KK-loop identifier. The second and third columns give positions. The next three columns list major and minor diameters (a and b) and position angle (PA). The seventh and eighth columns show the average dust color temperature (T_d) and inclination angle (i) of KK-loops. The last three columns list the number of ATNF pulsars (n_p) within 3°, 6° and 9° of KK-loops. The first six columns are taken from GIRL catalog.

GIRL	α(J2000) (deg)	δ(J2000) (deg)	a (deg)	b (deg)	PA (deg)	T_d (K)	i (deg)	n_p 3°	n_p 6°	n_p 9°
G007+10	260.53	-16.91	1.3	1.1	85	40.0	45	5	14	43
G007+18	254.43	-12.96	2.2	2.1	0	33.0	25	2	10	19
G010-45	321.23	-34.21	1.0	1.0	0	31.2	0	1	2	4
G016+02	273.06	-13.80	1.7	1.7	0	128.5	0	27	106	202
G026-06	285.58	-8.13	2.1	2.0	92	38.9	25	10	67	183
G044+14	275.13	16.64	1.6	1.2	82	36.4	57	3	10	21
G047-42	326.95	-8.43	7.3	6.3	108	29.8	43	1	1	3
G064+06	292.12	31.14	1.6	1.6	0	41.9	0	2	6	34
G073-00	304.28	34.95	1.9	1.7	17	41.7	38	6	21	36
G077+28	270.13	50.11	1.1	1.0	142	37.7	35	2	2	4
G079+29	268.67	52.18	1.6	1.3	-42	47.3	50	2	2	4
G085+15	293.61	53.19	1.4	1.1	54	34.2	53	1	2	3
G089+04	311.57	51.01	1.0	0.9	0	38.1	37	1	6	11
G110+00	345.47	60.89	2.2	1.5	62	67.2	64	2	9	17
G135-08	33.59	52.54	4.8	3.3	-61	36.2	63	2	2	2
G143+07	61.94	61.99	4.5	3.0	16	36.2	65	2	4	10
G157-39	40.36	16.33	6.1	4.8	84	39.4	53	2	3	4
G197-35	64.58	-4.23	3.2	2.9	63	36.6	36	1	1	2
G214-01	102.51	-2.17	2.1	2.0	90	46.7	25	1	3	5
G234-02	110.12	-20.26	2.2	2.0	59	38.1	35	2	7	9
G263-03	128.21	-45.44	0.8	0.7	112	38.4	41	3	13	24
G266+34	161.07	-19.40	4.9	4.6	-14	38.0	29	1	1	3
G286-01	158.65	-59.61	1.7	1.6	0	57.3	28	5	28	50
G307-13	211.01	-75.94	0.9	0.8	-17	66.9	39	2	2	6
G310+14	204.46	-48.05	1.3	1.0	37	36.6	55	3	8	14
G313+30	203.20	-31.35	1.6	1.5	-28	34.2	29	1	3	6
G321-00	229.72	-58.31	2.1	1.9	90	43.5	36	16	54	85
G323-02	233.99	-58.24	0.8	0.6	119	32.1	57	20	61	91
G329-05	246.83	-56.59	1.4	1.4	90	36.7	0	3	22	76
G344+07	247.96	-36.99	2.0	1.6	37	41.9	51	3	18	68

Conclusion

The axial ratio distribution of KK-loops shows a significant lack of face-on loops and suggests that the search of loop is probably incomplete. Interestingly the number of KK-loops falls exponentially with the projected area of the loops. In addition, we summarize our results as follows:

1. A very good correlation is noticed between the KK-loops and ATNF pulsars. Their distribution is found to be related through second order polynomial.
2. Thirty KK-loops are found to be located within 1° radius of ATNF pulsars.

The superposition and possible interaction of these loops with the pulsars (or other sources?) will be studied in the future.

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Asymptotic Giant Branch Star and its Evolution

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ABSTRACT

Asymptotic giant branch stars are low and intermediate mass stars driven by nuclear burning which happens when the star leaves the main sequence through red giant and passed the horizontal branch. It is the final nuclear burning stage. AGB stars are the main source of dust in the interstellar medium. They have different stages of stellar evolution after leaving the main sequence so in this article basically AGB star and its different stages are tried to explain. Another important task of this article is to describe thermally pulsating phase which in responsible for the production of shock wave.

Introduction

When a star exhausts the supply of hydrogen by nuclear fusion processes in its core, the core contracts and its temperature increases, causing the outer layers of the star to expand and cool. The star's luminosity increases greatly, and it becomes a red giant, following a track leading into the upper-right hand corner of the HR diagram.

Eventually, once the temperature in the core has reached approximately 3×10^8 K, helium burning (fusion of helium nuclei) begins [1]. The onset of helium burning in the core halts the star's cooling and increase in luminosity, and the star instead moves down and leftwards in the HR diagram. This is the horizontal branch (for population II stars) or red clump (for population I stars). After the completion of helium burning in the core, the star again moves to the right and upwards on the diagram. Its path is almost aligned with its previous red-giant track, hence the name asymptotic giant branch. Stars at this stage of stellar evolution are known as AGB stars which is shown in Hertzsprung-Russell diagram.

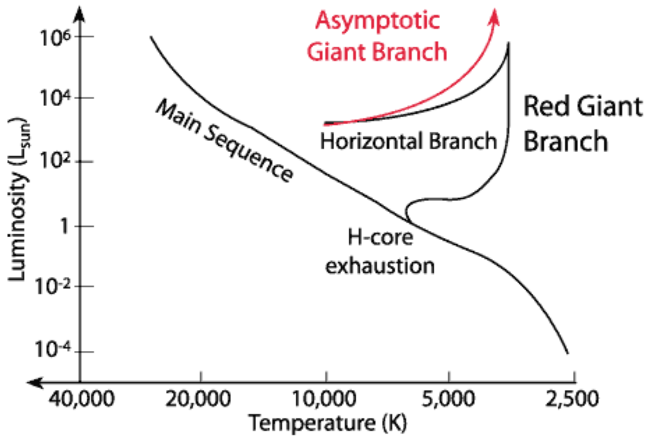

Figure 1: *HR-duagram showing post main sequence stellar evolution of less massive (<$8M_{sun}$) star. The Asymptotic giant branch can be seen [3].*

Observationally, an asymptotic-giant-branch (AGB) star will appear as a bright red giant with luminosity thousands of times the Sun. Its interior structure is characterized by a central and inert core of carbon and oxygen, a shell where helium is undergoing fusion to form carbon (known as helium burning), another shell where hydrogen is undergoing fusion forming helium (known as hydrogen burning) and a very large envelope of material of composition similar to main-sequence stars.

Dust color temperature estimation

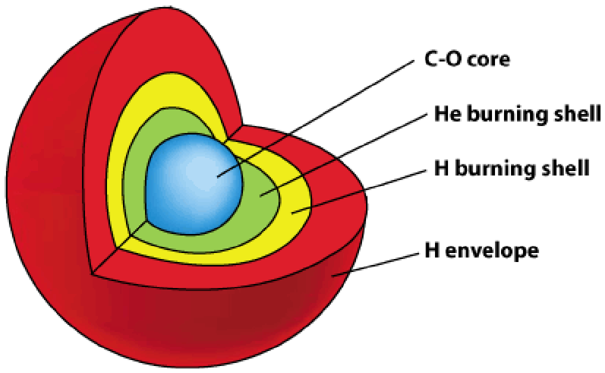

Figure 2: *Internal structure of AGB star. Two burning shells (Hydrogen and Helium) can be seen.The core is non-fusing and non-generate [3].*

AGB stages

AGB phase is particularly important to understand the origin of various elements heavier than H and He, and how they influence the chemical evolution of their hosting system. This phase is characterized by a strong mass loss period that only stops when the outer envelope is completely lost. The AGB phase is divided into two parts, the early AGB (E-AGB) and the thermally pulsing AGB (TP-AGB). During the E-AGB phase, the main source of energy is helium fusion in a shell around a core consisting mostly of carbon and oxygen. During this phase, the star swells up to giant proportions to become a red giant again. The star's radius may become as large as one astronomical unit (~215 $R_\odot$)[2].

After the helium shell runs out of fuel, the TP-AGB starts. Now the star derives its energy from fusion of hydrogen in a thin shell, which restricts the inner helium shell to a very thin layer and prevents it fusing stably. However, over periods of 10,000 to 100,000 years, helium from the hydrogen shell burning builds up and eventually the helium shell ignites explosively, a process known as a helium shell flash. The luminosity of the shell flash peaks at thousands of times the total luminosity of the star, but decreases exponentially over just a few years. The shell flash causes the star to expand

and cool which shuts off the hydrogen shell burning and causes strong convection in the zone between the two shells.[3] When the helium shell burning nears the base of the hydrogen shell, the increased temperature reignites hydrogen fusion and the cycle begins again. The large but brief increase in luminosity from the helium shell flash produces an increase in the visible brightness of the star of a few tenths of a magnitude for several hundred years, a change unrelated to the brightness variations on periods of tens to hundreds of days that are common in this type of star.

During the thermal pulses, which last only a few hundred years, material from the core region may be mixed into the outer layers, changing the surface composition, a process referred to as *dredge-up*. Because of this dredge-up, AGB stars may show S-process elements in their spectra and strong dredge-ups can lead to the formation of carbon stars. All dredge-ups following thermal pulses are referred to as third dredge-ups, after the first dredge-up, which occurs on the red-giant branch, and the second dredge up, which occurs during the E-AGB. In some cases there may not be a second dredge-up but dredge-ups following thermal pulses will still be called a third dredge-up. Thermal pulses increase rapidly in strength after the first few, so third dredge-ups are generally the deepest and most likely to circulate core material to the surface.

Late Thermal Pulse

As many as a quarter of all post-AGB stars undergo what is dubbed a *born-again* episode. The carbon–oxygen core is now surrounded by helium with an outer shell of hydrogen. If the helium is re-ignited a thermal pulse occurs and the star quickly returns to the AGB, becoming a helium-burning, hydrogen-deficient stellar object. If the star still has a hydrogen-burning shell when this thermal pulse occurs, it is termed a *late thermal pulse*. Otherwise it is called a *very late thermal pulse*.

The outer atmosphere of the born-again star develops a stellar wind and the star once more follows an evolutionary track across the Hertzsprung–Russell diagram. However, this phase is very brief, lasting only about 200 years before the star again heads toward the white dwarf stage. Observationally, this late thermal pulse phase appears almost identical to a Wolf–Rayet star in the midst of its own planetary nebula.

Super-AGB stars

Stars close to the upper mass limit to still qualify as AGB stars show some interesting properties and have been dubbed super-AGB stars. They have masses above 7 $M_\odot$ and up to 9 or 10 $M_\odot$ (or more). They represent a transition to the more massive supergiant stars that undergo full fusion of elements heavier than helium. During the triple-alpha process, some elements heavier than carbon are also produced: mostly oxygen, but also some magnesium, neon, and even heavier elements. Super-AGB stars develop partially degenerate carbon–oxygen cores that are large enough to ignite carbon in a flash analogous to the earlier helium flash. The second dredge-up is very strong in this mass range and that keeps the core size below the level required for burning of neon as occurs in higher-mass supergiants. The size of the thermal pulses and third dredge-ups are reduced compared to lower-mass stars, while the frequency of the thermal pulses increases dramatically. Some super-AGB stars may explode as an electron capture supernova, but most will end as an oxygen–neon white dwarf. Since these stars are much more common than higher-mass supergiants, they could form a high proportion of observed supernovae. Detecting examples of these supernovae would provide valuable confirmation of models that are highly dependent on assumptions.

Conclusion

We draw following conclusion:

- AGB-Stars are the final evolution stage of low- and intermediate-mass stars driven by nuclear burning.
- This phase of evolution is characterized by nuclear burning of hydrogen and helium in thin shells on top of the electron-degenerate core of carbon and oxygen or for the most massive super-AGB stars a core of oxygen, neon and magnesium.
- On the top of the C-O core a layer of hydrogen exhausted helium-rich material is located and above this, lies an extended hydrogen rich envelope which contains most of the mass of the star.
- The main source of luminosity in TP-AGB stars is hydrogen shell burning whose ashes become part of the inter shell. The inter shell hence grows in mass and its temperature rises steadily, until it is hot enough to ignite helium at its base, producing a thermally unstable runway of energy called thermal pulse (TP).
- During the TP AGB phase, He-burning shell is very thin compared to its radius so it becomes thermally unstable. After a few hundred years material from the core region may be mixed into the outer layers changing the surface composition, a process referred to as dredge-up which is the mechanism for producing carbon stars.

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Progress in Tokamak Fusion Research

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ABSTRACT

In nuclear fusion two light nuclei are fused together to create a larger nucleus plus a large amount of energy. For fusion to take place very high temperatures are required such that two positively charged nuclei come together overcoming the repulsive force. The temperature is so high that the fusion fuel is in the plasma state and its confinement is not an easy task. Two principal mechanisms for confining the fusion fuelare Magnetic Confinement Fusion (MCF) and Inertial Confinement Fusion (ICF). In MCF, plasma is confined using sophisticated magnetic field whereas in ICF high energy lasers are used to compress small pellets of plasma fuel to very high densities within their inertial position. A Tokamak is a device using magnetic field to confine plasma and has made significant progresses towards realizing fusion energy on earth. The progresses made in Tokamak fusion research and its progress is presented.

Introduction

Nuclear fusion is a process by which two light nuclei fuse together to form a heavier nucleus, and in doing so release considerable energy. In order to overcome the repulsive force that exists between the positive nuclei the fuels must be heated to very high temperatures before the fusion can start. In order to create fusion on earth the most convenientfusion reaction is that between deuterium (D) and tritium (T) as shown schematically in Figure 1.The D-T fusion is most conveniently achievable because the collision cross-section of the D-T fusion reactions is the highest and occurs at relatively lower temperature [1]. The temperature required is of the order of 10^8 K, which is even more than the temperature at the core of the sun.

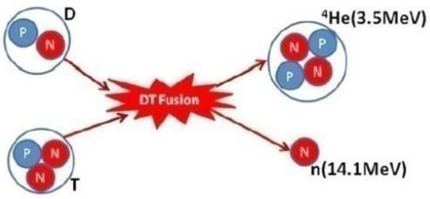

Figure 1: *Schematic of a D-T fusion reaction [1]*

As the temperature of any solid material is raised, its state changes from solid to liquid and then to gas. If we increase the temperature of a gas beyond a certain limit, it enters a regime where the thermal energy of its constituent particle is so great that the electrostatic forces which ordinarily bind electrons to atomic nuclei are overcome. Instead of hot gas composed of electrically neutral atoms, we then have a mixed population of charged and neutral particles. With increasing temperature the number of ionized particles increases and the ionized gas starts behaving differently. After the fraction of ionized particles is sufficiently high the ionized gas starts exhibiting collective behavior and the state of matter is plasma, and it is neither solid nor liquid nor gas. Plasma is thus defined as a quasineutral gas of charge and neutral particles which exhibits collective behavior [2]. Quasi-neutrality of plasma implies that the electron density and ion density are nearly equal and the collective behavior means that the motion of species depend not only on the local conditions but also on the state of the plasma far away from the point of interest.It is interesting to note that plasma can exist in diverse ranges of temperature and density ranges much lower as well as much higher than that of solid, liquid, and gas (as illustrated in Figure 2).

Nuclear fusion as the source of energy of the Sun and the stars was suggested many years ago [3] [4]. Since then, fusion energy is considered as one of the best potential sources of virtually unlimited energy for mankind [5]. Various methods for the realization of fusion energy were proposed and the most studied are Magnetic Confinement Fusion (MCF) and Inertial Confinement Fusion (ICF) [6] [7]. In MCF, the plasma is confined using a sophisticated magnetic field at very high temperatures, whereas in ICF high power lasers are used to compress small pellets of plasma fuel to very high densities within their inertial position. In both schemes it is desired to achieve the Lawson Criterion [5], which implies that more energy is produced through fusion reactions than the amount used up to start and maintain it [8]. In MCF, low density plasma is confined for longer period of time (few seconds to minutes), whereas in ICF high-density plasma is confined for few nanoseconds. Since nuclear fusion can potentially provide and almost unlimited source of energy, it is one of the most important scientific challenges man faces today [9].

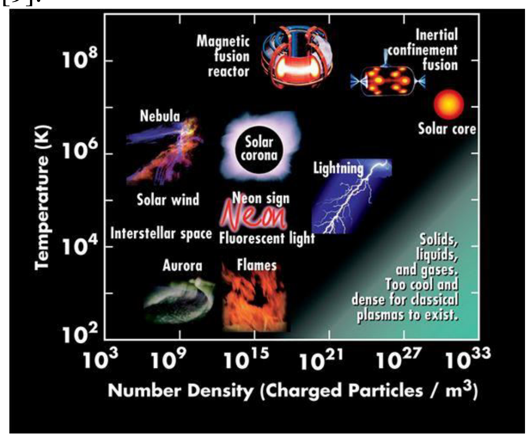

Figure 2: *Existence of plasma in diverse ranges of temperature and density [10]*

Tokamak and ITER

The most successful magnetic device, so far, for confining fusion plasma was invented in the late 1950s and is called 'Tokamak'[11]. The original idea of

Tokamak was given by Oleg Lavrentiev and invented in the 1950s by Nobel Laureates Igor Tamm and Andrei Sakharov. As obvious from its name a Tokamak uses powerful magnetic field configured in a sophisticated manner to confine thermonuclear plasma in the shape (Figure 3). Tokamaks have demonstrated better progresses as a fusion reactor especially in transport properties, operating density and stability of the fusion plasma which makes it the most promising approach for future commercial fusion reactors.

The Joint European Torus (JET), the world's largest Tokamak is also the most successful so far and serves as the milestone for the suitability of the Tokamak for future power production. In 1990s JET demonstrated controlled release of deuterium-tritium fusion power delivering 16 MW of fusion power using 10 MW as the input power [12]. It is worth considering the progress of magnetic confinement fusion research in terms of the fusion triple product achieved in various Tokamak devices (Figure 4). Since the start of Tokamak experiments in the 1960s, this product has increased by more than three orders of magnitude. Encouraged by the results fusion scientists from all over the world have come together in the construction of ITER (International Thermonuclear Experimental Reactor), which also means "the way" in Latin and hence the machine is expected to demonstrate the way forward for the construction and operation of future fusion power plants (Figure 5). ITER is an ambitious project whose initial concept was started in 19 November 1985 during Geneva Summit between the then US President Ronald Reagan and Soviet General Secretary Mikhail Gorbachov. As of now, the machine is designed to produce approximately 500 MW of fusion power sustained for more than 15 minutes by the fusion of about 0.5 g of deuterium - tritium mixture which corresponds to a gain of 10 with respect to the input power [13]. Construction of the facility began in 2007 in Cadarache of France, and the first plasma is expected to be produced in 2025.

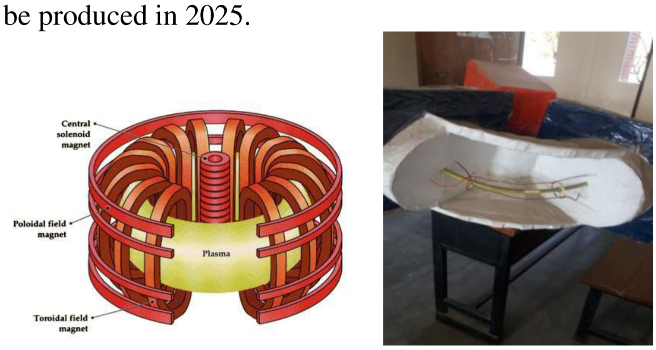

Figure 3: *Schematic of a Tokamak and a prototype at Central Department of Physics, Kirtipur*

Sun and stars are producing fusion energy for billions of years and nuclear fusion has already been tested as a nuclear weapon (so called hydrogen bomb) but unfortunately it is taking longer than expected for its realization of harnessing as an energy source. As fusion is clean, safeand virtually inexhaustible it is still a challenge for scientists and will be worth spending time and money for its research.

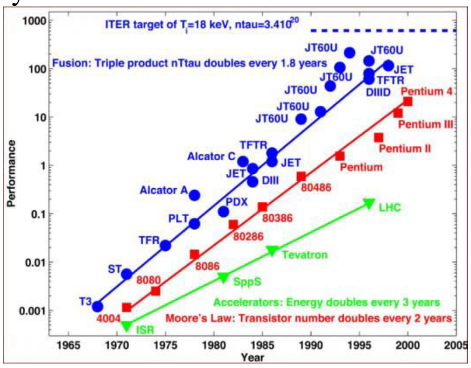

Figure 4: *Progress in plasma confinement performance* [13]

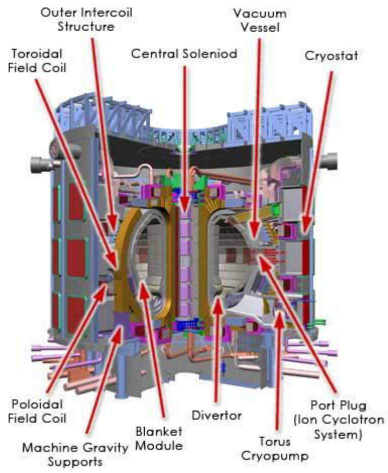

Figure 5: *Schematic diagram of ITER showing important components [13]*

Sometimes people argue that "*fusion is impossible*" but it has already been demonstrated in JET and many other devices across the globe and the progresses being made in construction of ITER is encouraging. The success of ITER will not only pave way for future fusion power plants but also demonstrates how science can bring people together to work for the betterment of mankind. As of now we can only hope that everything goes well as planned and fusion energy becomes available and for that we just need to push that date forward as quickly as possible.

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Magnificant Astrophysical Plasma: Planetary Nebula

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ABSTRACT

A glowing cloud of gas and plasma formed by certain types of stars at the end of their lives, called planetary nebula. About 30-50% volume of planetary nebula is covered by astrophysical plasma. A planetary nebula is formed when a red giant star approaches the end of its life span and begins to lose mass very quickly. In this article, I will explain the properties of this naturally formed astrophysical plasma, that untimately triggers star formation in the interstellar medium.

Introduction

Most of the (visible) universe is in form of plasma: plasmas form wherever temperatures are high enough, or radiation is strong enough, to ionize atoms. An astrophysical plasma is a highly ionized gas whose physical properties are studied as part of astrophysics. Much of the baryonic matter of the universe is thought to consist of plasma, a state of matter in which atoms and molecules are so hot, that they have ionized by breaking up into their constituent parts, negatively charged electrons and positively charged ions. Because the particles are charged, they are strongly influenced by electromagnetic forces, that is, by magnetic and electric fields. All astrophysical plasmas are likely influenced by magnetic fields [1].

Figure 1: *Lagoon Nebula. This Nebula is a large, low-density cloud of partially ionized gas. It is found that about 40% volume ($13pc^2$) is covered by astrophysical plasma [4].*

In this article, a very beautiful astrophysical creature called planetary nebula will be described in the sense of astrophysical plasma.

Planetary Nebula

A planetary nebula is an astronomical object consisting of a glowing shell of gas and plasma formed by particular types of stars at the end of their lives. They are in fact unrelated to planets; the name originates from a supposed similarity in appearance to giant planets. They are a short-lived phenomenon, lasting a few tens of thousands of years, compared to a typical stellar lifetime of several billion years [2].

A planetary nebula is created when a star blows off its outer layers after it has run out of fuel to burn. These outer layers of gas expand into space, forming a nebula which is often the shape of a ring or bubble. About 200 years ago, William Herschel called these spherical clouds planetary nebulae because they were round like the planets. At the center of a planetary nebula, the glowing, left-over central part of the star from which it came can usually still be seen.

Planetary nebulae are important objects in astronomy because they play a crucial role in the chemical evolution of the galaxy, returning material to the interstellar medium which has been enriched in heavy elements and other products of nucleosynthesis (such as carbon, nitrogen, oxygen and calcium) [2].

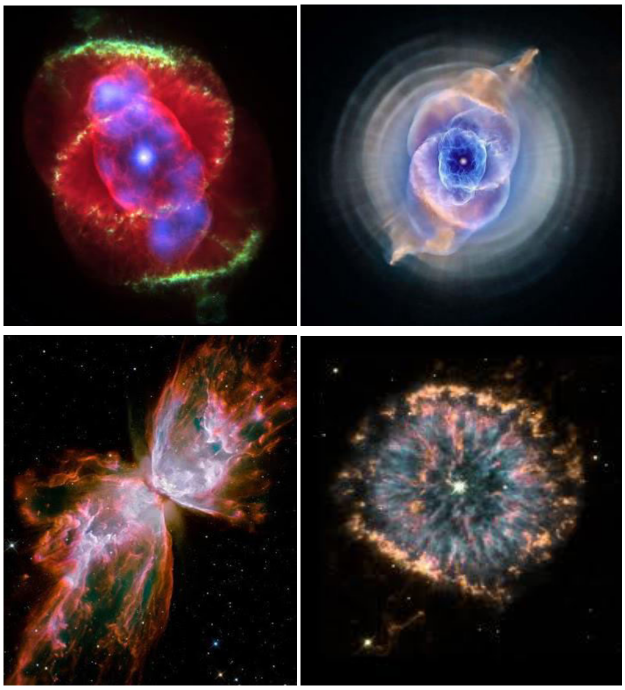

Figure 2: *A few planetary nebula of our Milky Way Galaxy. They can have different morphology during evolutionary stages, but exhibit identical characters, close to the plasma state [4].*

In the above figure, four planetary nebula of our Milky Way are shown. All these structures are somehow different, and contain a central star, which is supported by electron degeneracy pressure.

Planetary nebulae are typically about 1 light-year in diameter. There is, however, quite a range of sizes due mainly to the fact that these objects expand with age. For example, NGC 3918 in Centaurus, which may be only 3,000 years old, measures only 0.3 light-year across whereas the famous Helix Nebula in

Aquarius, which is believed to be at least 10,000 years old, spans roughly 2.5 light-years [3].

Although the density of ionized gas in a planetary nebula is higher than that of the surrounding interstellar medium, it is still extremely low by everyday standards. Densities range from about 10^3 particles/cm^3 to as much as 10^6 particles/cm^3 in the clumpier parts of young nebulae. The temperature of the nebular gas averages about 10,000 K, with a range of 8,000 K to 23,000 K, depending on the individual nebula, the location within the nebula, and the method used to derived the temperature (for example, observations of He I recombination lines tend to give lower temperatures than those derived from H I recombination lines).

With a typical expansion speed of 20-30 km/s, the material in a planetary nebula becomes too spread out to be visible after 10,000-50,000 years [2].

The most widely used scheme to classify planetary nebulae by their appearance has been the Vorontsov-Velyaminov scheme. However, in recent years, the use of more powerful instruments, such as the Hubble Space Telescope, and electronic detection methods have revealed a much greater diversity in the morphology of planetary nebulae than was previously realized. To the list of known objects conforming to the classical ring and disk shapes have been added other, often young planetary nebulae, with more complex shapes [3]. Roughly one-tenth of planetary nebulae have a prominent bipolar structure. A few are significantly asymmetric.

Various ideas have been put forward to account for the broad range of morphologies observed. These include interactions of the nebular gas with magnetic fields from the central stars, interactions between material moving away from the star at different speeds, multiple ejection events, and, in the case of strongly bipolar nebulae, gravitational interactions with companion stars if the central stars are members of binary systems.

Spectral Information

Hubble Space Telescope obtained spectra of large number of nearby planetary nebula. In the spectra, a very strong ionized dxygen lines and large number of metallic lines are found. The characteristic temperatures of these lines are found to lie in the range of 10,000 K to 13,500 K [3]. When calculating intensity, scientists found that Oxygen ions and ionized Hydrogen are in the plasma state. These ions show collective behavior as described by the plasma criteria.

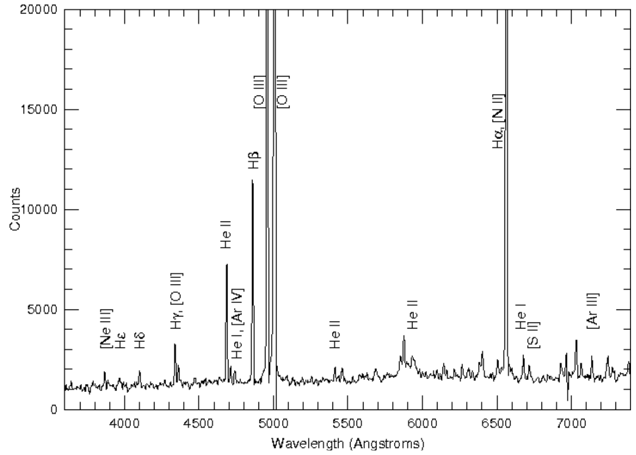

Figure 3: *A typical spectra of planetary nebula[3].*

The majority of planetary nebulae occur near the plane of the Milky Way, with the greatest concentration near the galactic center, indicating that they are primarily disk objects. However, a few been found in globular clusters and elsewhere in the galactic halo [3].

Some planetary nebulae have also been identified beyond the Milky Way, in other galaxies of the Local Group, including the Magellanic Clouds and the Andromeda Galaxy.

Conclusion:

A very widely dispersed region of planetary nebula contains ionized gases and metals which are in the plasma state. A large number of photometric and spectroscopic surveys have been carried out in the last 10 years.

To sum up – plasmas of planetary nebulae return to the interstellar medium by ejecting matter. The physical process of this return is still unknown. This ejected matter, enriched in elements such as carbon, nitrogen and oxygen, is the stuff from which a new generation of stars will eventually form. Therefore, it is essential to understand the transition process of astrophysical plasma to the orginary matter.

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An international team of researchers from Innsbruck, Harvard, Copenhagen and Waterloo put forward a new method to protect quantum information stored in trapped ions. In their new proposal, the authors use dissipation (i.e. the interaction of a quantum system with its environment) to correct quantum states. Quantum devices allow us to accomplish computing and sensing tasks that go beyond the capabilities of their classical counterparts. However, protecting quantum information from being corrupted by errors is difficult.

Ultrasonography as a Technique of Medical Imaging

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ABSTRACT

Ultrasonography being the very safe way of depicting two and three dimensional images of stationary as well as moving internal body parts, it is frequently used to diagnose the health related disorders. Ultrasound machine has its section called transducer which converts electrical signal to high frequency sound wave or ultrasound and such wave is sent into body tissues. The transducer also receives the echo from the tissue interfaces and nature, i.e. intensity or amplitude and time of such echo is recorded to depict the images on a screen. The interfaces of varying density have different acoustic impedances so that the sound wave is reflected back. Doppler shift is used to obtain the color Doppler images of vascularity. The gray-scale two dimensional imaging also provides the information for the diagnosis of concerned diseases and abnormalities in the internal parts of the body. Echocardiographic tracing visualize the heart dimensions and related activities by the moving mode scanning technique of ultrasongraphy.

Theory of Ultrasonography

The ultrasonography (USG) is a very useful tool in the evaluation and management of disorders found in the body parts by means of imaging procedures. USG is non-invasive, widely available, less expensive and does not use any ionizing radiation. USG helps to guide diagnostic and therapeutic interventional procedures in cases of different diseases though it cannot determine the functions of the body organs. Color as well as power Doppler ultrasounds are useful to evaluate vascularity of the glands, organs and focal masses. The vascular structure supplied by arteries and veins can be visualized on color Doppler examination where as the flow parameters from these vessels can only be analyzed by spectral Doppler examination. [1]

For example, a patient is examined in supine position with hyper-extended neck, using a high frequency linear-array transducer (7-15 MHz) that provides adequate penetration and high resolution image. Scanning is done in transverse as well as longitudinal planes. Real time USG of thyroid lesions is performed using both gray-scale and color Doppler techniques. Such imaging characterizes location, size, shape, margins, echogenicity, contents and vascular pattern of the gland mass [1].

Figure 1: *A transducer probe generating ultrasound and receiving the echoes from the tissue interfaces (adapted from ultrasound technicalcenter.org, 2012).*

The ultrasound is produced by the transducer probe by piezoelectric method and the probe also records the pulse of echo coming back from the tissue interface. The sound is reflected from the tissue boundary due to the acoustic impedance which is defined by

$$Z = \frac{\Delta P}{u} = v\rho$$

where ΔP is the excess pressure, u is particle velocity, v is wave velocity and r is the density of the tissue medium through which sound wave travels [2].

If Z_1 and Z_2 are the acoustic impedances in both sides of the interface, the reflection and transmission coefficients of the ultrasound wave are given by

$$R = \left(\frac{Z_2 - Z_1}{Z_2 + Z_1}\right)^2 \text{ and } T = \frac{4Z_1Z_2}{(Z_1 + Z_2)^2}$$

The Doppler ultrasound depends on the Doppler shift defined by

$$\Delta f = \frac{2fv'\cos\theta}{v}$$

Where f is frequency of sound used, v' is the source or blood flow speed, θ is angle of incidence and v is the sound speed [2].

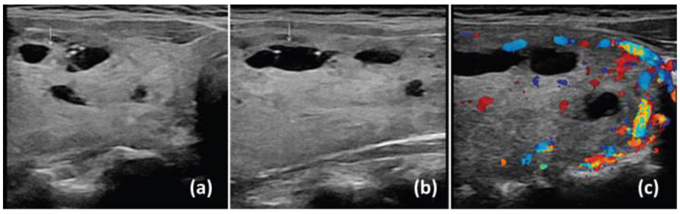

Figure 2: *Thyroid USG diagnosing colloid multinodular goitre in a 50-year old-Indian female: (a) transverse and (b) longitudinal gray-scale images showing enlarged thyroid gland with multiple hyper-echoic colloid nodules and internal cystic areas indicated by arrows with ring down sign, (c) color Doppler image with increased peripheral vascularity and some intra goitrous vascularity[1].*

Imaging Technique

While taking ultrasound imaging, the transducer probe is placed on the skin or inside the body opening. The sound produced is focused by placing a lens or making arc shaped face of the transducer. To provide the easy path to the ultrasound wave, a thin layer of gel is put on the skin of the body part. The wave signal is focused into the required depth and it is partially reflected from the tissue interface. Even the small change in acoustic impedance from the cells and organelles can make the sound signal reflect back to the transducer probe. The returned sound waves vibrate the transducer, turn into electrical pulses and travel to the ultrasonic scanner where they are processed and transformed into a digital image. The image pixel depends on the return time as well as amplitude of echo. The strong echo gives the white and the weak one gives the black pattern of the gray-scale image. As given in the reflection coefficient (R), the greater the change in acoustic impedances, the stronger the echo is.

A two dimensional (2D) image of the body slice is obtained by sweeping the transducer and hence the ultrasonic beam. A series of the adjacent 2D images is used to generate a 3D image such as live 3D image of beating heart. Doppler USG is used to study the blood flow and muscle motion. For the ease of interpretation, alternate colors are represented for the amplitudes of the received echoes.

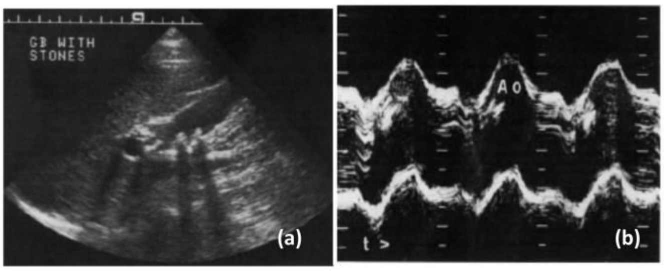

Figure 3: *Images obtained by USG modes: (a) B-mode image of gall bladder in which the stones restrict the transmission of sound wave so that the low intensity echo is recorded behind the stones and (b) M-mode echocardiographic tracing [2].*

USG Modes of Imaging

There are three different modes of ultrasound imaging: A-mode, B-mode and M-mode display. In the amplitude or A-mode imaging, the echoes returning from the tissue interface (such as study of midline structures in brain by echoencephalography) are recorded as signals on a cathode ray tube (CRT).

In the brightness or B-mode pulse echo imaging, the location of echo producing interfaces is displayed as 2D image on the video screen (Figure-3a). The amplitude of each echo is represented by the degree of brightness at the x-y location. On a gray scale imaging, bone has high reflectivity which is depicted as white, muscle has low reflectivity which is depicted as gray and water has almost no reflectivity which is black. The deeper body part structures are displayed on the lower side of the screen and superficial structures on the upper side.

In the moving or M-mode ultrasound imaging, the position of each echo-producing interface is presented as a function of time to depict the moving structures. The frequently used M-mode scanning is echocardiography (Figure 3b), where the motion of various interfaces in the heart is depicted graphically on the CRT display or chart recording [2]. The M-mode is commonly used for measuring chamber dimensions of the heart as well as for finding the fractional shortening and ejection fraction [3].

Conclusion

Out of many medical imaging techniques, ultrasonography is very effective and safe tool for imaging the internal body parts. It does not use any ionizing radiations which are harmful to the living cells. This technique renders the live images where the operator can rapidly diagnose the changing patterns and also allow for the ultrasound guided biopsies or injections. Thus a high level of skill and experience is needed to acquire the good quality image and to make accurate diagnosis.

Acknowledgement

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Researchers look to the fruit fly to understand the human brain

The human nervous system is like a complex circuit board. When wires cross or circuits malfunction, conditions such as schizophrenia or bipolar disorder can arise. For a long time, scientists have been working to zoom in and identify how brain circuits form so they can learn to rewire troublemaking neurons. Now, researchers at Stanford led by professor of biology Liqun Luo and professor of bioengineering and of applied physics Stephen Quake have taken a significant step forward in that direction by making a detailed cell-by-cell gene blueprint of the fruit fly's olfactory neurons. Their work has been published in Cell. The basic idea behind the research is to understand the neuronal cell types of the relatively simple fly brain, and to identify the molecules that direct the precise wiring of different types of neurons in the fly brain. Over time, researchers want to use a similar approach to study the far more complex cellular makeup of the human brain, and maybe one day even repair the miswiring in brain

Force Field Analysis in a Biomolecule

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ABSTRACT

Biomolecules are those molecules which involve in the maintenance and metabolic processes in living organisms. After the advancement of high-performance computing technology, physical science has developed the modeling for the simulation of different activities of biomolecules so that the theoretical study of the biological system has been possible. The simulation basically depends on the interaction among the atom-atom, atom-molecule and molecule-molecule. They can be generated computationally by designing the force fields. Some fundamental characteristics of force fields are explained in this article.

Introduction

Force fields are the energy functions or interatomic potentials in which the combination of mathematical equations and associated parameters are designed to reproduce molecular geometry and properties of specific molecular structures. Force field designing is very important to estimate the correct result in the theoretical study of biomolecules, particularly in protein folding, membrane formation, transportation properties, molecular diffusion, and interaction between the molecules. Classical force fields are applied in molecular dynamics. Although quantum mechanics can describe the physical and chemical properties of the molecular system in detail, it needs high computational performance, prohibitively expensive in many situations. Therefore, in such molecular systems, Hamiltonian can be derived in terms of classical mechanics force fields, which can accurately provide the matching result with the experiment.

There have been many types of force fields to solve the problems associated with molecular dynamics simulation. Some important force fields which are applicable in biomolecular systems are CHARMM, AMBER, GROMOS, OPLS, MARTINI, etc. In general, first four force fields are compatible with the all-atom model (all the atoms in a system are treated as separate and complete units) simulation and the last one (i.e. MARTINI) is useful in coarse-grained (the group of atoms are treated as a single unit) simulation.

Nowadays, molecular dynamics simulation is popular in many branches of science like Physics, Biology, Biotechnology, Chemistry, and bio-engineering. Physicists basically concentrate on geometric, energetic, dynamical and dielectric properties of the molecules. The atoms in a molecule are bounded by chemical bonds and electronic interactions. The detailed study of the molecule is possible only when we consider all possible interactions involving the interaction.

The potential energy functions are primarily described in terms of bonded and non-bonded interactions. The bonded interactions are strong interaction between the atoms in the intramolecular and the intermolecular system, whereas non-bonded interactions are weak interactions between the atoms and molecules. Bonded interactions are the consequences of bond stretching (2-body interaction), harmonic angle (3-body interaction), and proper and improper dihedral angles (4-body interaction).

The potential energy functions for the bonded interaction are:

$$U_{\text{bonded}}=\sum_{bonds}\frac{k_i}{2}\,(r_i - r_o)^2 + \sum_{angles}\frac{k_i}{2}\,(\theta_i - \theta_o)^2 + \sum_{dihed}\frac{V_n}{2}\,(1+\cos(n\omega-\delta)) \qquad (1)$$

In equation (1), the first term in right-hand side represents the potential energy due to bond stretching, the second term represents the potential energy due to harmonic angle variation, and the third term represents the potential energy due to dihedral angle (i.e. torsion angle) with usual symbols in Physics.

The Potential energy functions due to electrostatic (Coulomb) interaction and Van der Waal interaction contribute to the non-bonded interaction between the atoms and molecules. So, the potential energy functions for the non-bonded interactions are:

$$U_{\text{non-bonded}} = \sum_{i=1}^{N}\sum_{j=i+1}^{N}\frac{\sigma_i\sigma_j}{4\pi\epsilon_0 r_{ij}} + \sum_{i=1}^{N}\sum_{j=i+1}^{N} 4\,\epsilon_{ij}\,\left[\left(\frac{\sigma_{ij}}{r_{ij}}\right)^{12} - \left(\frac{\sigma_{ij}}{r_{ij}}\right)^{6}\right] \qquad (2)$$

In equation (2), the first term in right-hand side represents the potential energy due to Coulomb potential and the second term represents the potential energy due to Lenard John potential.

Theoretical Analysis of Force field in Alanine Molecule

An amino acid is an organic compound which consists of an amine group (NH_2), a carboxyl group (COOH) containing a functional group R, bonding with the bare carbon and a hydrogen atom in it. In Alanine, the functional group R is a methyl compound (CH_3). The visual molecular dynamics design of Alanine is shown in fig (1).

In this analysis, Alanine, an amino acid, is taken as the reference molecule and GROMOS force field is taken to find the potential energy curves. In the X-axis the separation between the atoms are taken in nanometer (nm) and Potential energy is taken in kilojoule per mole (kJ/mol) in the Y-axis. The nature of curves for each of above described five energy functions are studied theoretically. A sketching software, xmgrace, is used to sketch each graph.

The force field modeling of alanine molecule involves following considerations:

(i) Bond Stretching: The covalent bonding of two atoms in a molecule is characterized by the bond stretching behavior. It is modeled with quadratic energy function. At equilibrium separation ($r_i = r_o$), the potential energy is minimum, which is the most stable state of two atoms in the molecules. With the variation of temperature and pressure, the separation between the atoms varies with certain distance and the molecule oscillates as a spring. The Potential energy curve versus bond length is shown in fig. 2.

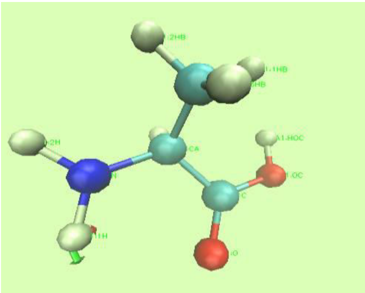

Figure 1: *Molecular dynamics design of Alanine.*

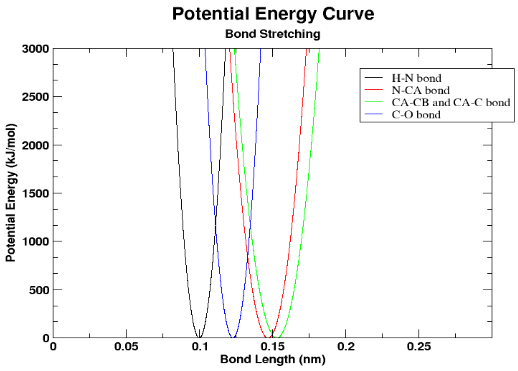

Figure 2: *Potential energy curve for bond stretching.*

(ii) Harmonic Angle: The harmonic angle is characterized by three atoms making some angle at the central atom. It is also modeled with quadratic energy function. At equilibrium separation ($\theta_i = \theta_o$), the potential energy is minimum, which is the most stable state of two atoms in a molecule.

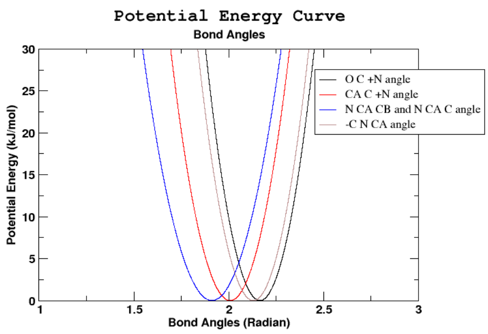

Figure 3: *Potential energy curve for harmonic angle*

The variation of energy in angle variation is similar to the bond stretching. The Potential energy curve versus bond angles is shown in fig. (3). The carbon atom of preceding atom and nitrogen atom of succeeding atom in peptide bond is also considered to sketch the graph.

(iii) Dihedral Angle: It is characterized by the torsion character of four atoms of a molecule as these atoms form the planar angle in between two middle atoms. It defines the geometric relation of two parts of a molecule connected by a chemical bond. The characteristic of potential energy versus dihedral angle in an amino acid molecule is shown in fig. (4).

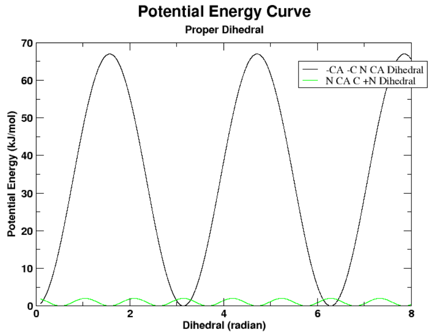

Figure 4: *Potential energy curve for dihedral angle.*

(iv) Coulomb Interaction: Coulomb interaction occurs due to the unequal distribution of charges in the molecules. It is long range force. In molecular dynamics simulation, the distance of charges is chosen for the significant value of interaction, a very long distance is cut off. The characteristics curve for potential energy versus atom separation for attraction and repulsion of charges is shown in fig. (5).

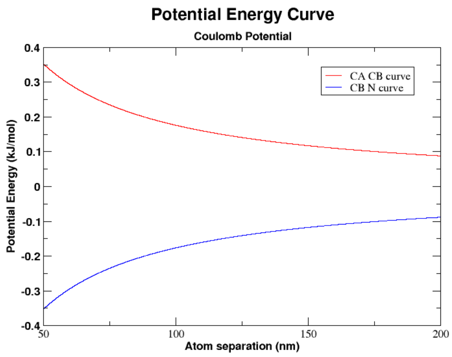

Figure 5: *Potential energy curve for Coulomb interaction*

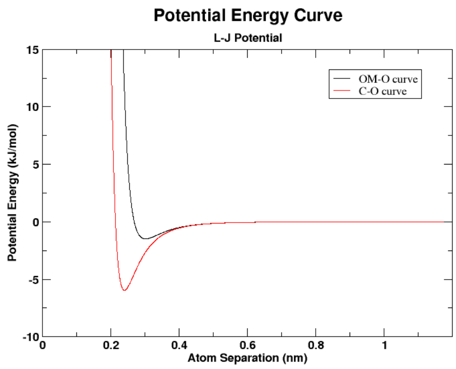

Figure 6: *Potential energy curve for Van der Waal interaction.*

(v) Van der Waal interaction: This interaction is generally taken into consideration which cannot be incorporated by the Coulomb interaction. It has also specific cut-off distance. The characteristics curve of potential energy versus atom separation in Van der Waal interaction is shown in fig. (6).The sixth power term represents the attractive behavior and twelfth power term represents the repulsive behavior of the molecules.

Conclusions

Every year, many new macromolecules are being discovered in the bio-research lab. The experimental exploration of functions of each newly discovered molecule is almost impossible in the laboratory: it is rather time-consuming and highly expensive. So, the theoretical study, computational designing of such molecules and study of their biological characteristics, is very important in the present research. The research trend all over the world has been motivated by computational simulation aside of wet lab experiment. The matching of theoretical and experimental works provides the reliable and most acceptable result. The force field designing for biomolecules is a very important and difficult task in the theoretical study of biomolecules. Basically, the bonded and non-bonded interactions are considered to solve the problems associated with the bimolecular interaction.

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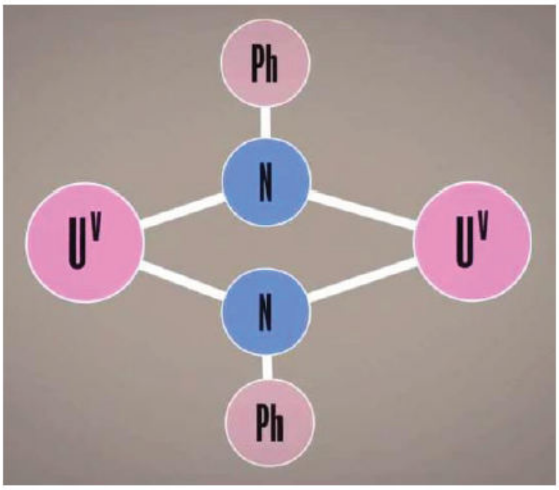
Uranium to replace plastic?

Chemistry breakthrough could pave the way for new materials

Uranium can perform reactions that previously no one thought possible, which could transform the way industry makes bulk chemicals, polymers, and the precursors to new drugs and plastics, according to new findings from The University of Manchester.

Writing in the Journal Nature Communications, the chemists have discovered that uranium can perform reactions that used to be the preserve of transition metals such as rhodium and palladium. And because uranium sits between different types of reactivity of lanthanides and transition metals it might be able to combine the best of both to give new ways of producing materials and chemicals. This discovery is also profiled in a new which is part of a series produced by the School of Chemistry.



Chemists at Manchester have developed the world's smallest fuel powered motor and identified that Parkinson's sufferers can have a unique smell identifying the disease - before any medical professional can see symptoms. The YouTube series attempts to put world class scientific papers into words that anyone can understand. The latest discovery means that industry might now be in a position to develop new compounds that can't be made in any other way.

Read more at: https://phys.org/news/2017-12-uranium-plastic-chemistry-breakthrough-pave.html#jCp

Introduction to Microprocessor 8085

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ABSTRACT

Before microprocessor, computers were very large, very expensive and almost none were owned by individuals. Due to the introduction of microprocessor which revolutionized the computer field and we have personal computers. Not only this, today, microprocessor-based computers have become heart for research, business as well as individuals. Nowadays, microprocessors are being used in controlling various parameters like speed, pressure, temperature etc.also it is used for data acquisition systems, multi user-multi function systems, communication systems and many more. It is, therefore, essential for every physicist, to know at least little bit about microprocessors.Apart from history of microprocessor, this article is based on 8085 microprocessor for helping beginners to understand the basic concepts related to any microprocessors.

Introduction

The 8085A (commonly known as the 8085) microprocessor is one of the widely used microprocessor in college laboratories because of its simple architecture and instructions set. It was introduced by Intel in the year 1976. This microprocessor, is an update of 8080 microprocessor, works on +5V power supply and 3 MHz clock frequency. It has 8 bit bidirectional Data Bus and 16 bit unidirectional Address Bus and also it has Control Bus. It has 40 pins dual in line in its chip. In this processor lower order address bus is multiplexed with data bus to minimize the chip size.

This 8085 microprocessor is an 8-bit microprocessor capable of addressing 64 KB of memory. It has six general-purpose 8-bit registers to store 8-bit data; these are identified as B, C, D, E, H and L. They can be combined as register pairs – BC, DE and HL to perform some 16-bit operations. Also it has an 8-bit special-purpose register called an Accumulator to perform arithmetic and logical operations. The result of an operation is stored in the Accumulator. The data conditions, after an arithmetic or logical operation, are indicated by setting or resetting the flip-flops called Flags. The 8085 includes five Flags: Sign, Zero, Auxiliary Carry, Parity and Carry. Also it has two 16-bit special-purpose registers: the Program Counter (PC) and the Stack Pointer (SP). The PC is used to sequence the execution of a program, and the SP is used as a memory pointer for the stack memory.

Microprocessor System

The *microprocessor* is a clock-driven, register based, programmable digital electronic device that reads binary instructions from memory, accepts data from input devices (or reads stored data from memory), processes the data according to the instructions, and displays the results at output devices or stores them in memory.

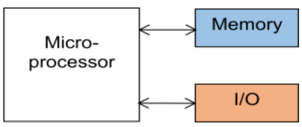


Figure 1: *Microprocessor System*

The microprocessor alone does not serve any useful purpose unless it is supported by memory and input/output (I/O) ports. The three together make up what is known as a *microprocessor system* which is shown in Figure 1.

Internal Architecture of 8085 Microprocessor

The architecture of 8085 consists of main sections: ALU (Arithmetic and Logical Unit), Timing and Control Unit, Registers Array, Instruction Register and Decoder, Interrupt Control and Serial I/O Control.

ALU: The ALU performs arithmetic and logical operations. It includes the Accumulator, the Temporary Register, the Arithmetic and Logic Circuits and Flags. It always stores result of operations in Accumulator.

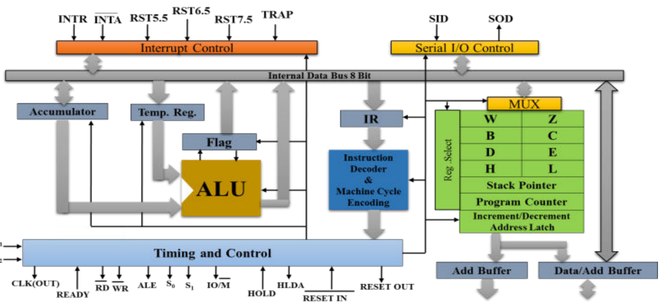


Figure 2: *The 8085A Microprocessor Functional Block Diagram*

Timing & Control Unit: This unit synchronizes all the microprocessor operations with the clock and it generates timing and control signals, which are necessary for communication between the microprocessor and peripherals to the execution of instructions.

Registers Array: The programmable registers were discussed above in the introduction unit. Except that two additional registers W and Z are included in the Register Array which are not available to the programmer. These registers are used to hold 8-bit data during the execution of some instructions.

Instruction Register (IR) and Decoder: The IR is not accessible to the programmer but this is a temporary storage for the current instruction of a program. After fetching an instruction from memory, the processor loads it in the IR. This instruction is decoded by the decoder and the processor then executes the instruction.

Interrupt Control:Interrupts are the signals generated by external devices to request the microprocessor to perform a task. There are 5 interrupt signals, i.e. INTR, RST 5.5, RST 6.5, RST 7.5, and TRAP. The microprocessor temporarily stops the execution of main program whenever the interrupt signal is enabled and the microprocessor shifts the control from main program to process the incoming request and after the completion of request, the control goes back to the main program.

Serial I/O Control: There are 2 serial I/O signals, i.e. SID (Serial input data) and SOD (Serial output data). These signals are used for serial communication.

SID: the data on this line is loaded into accumulator whenever a RIM (Read Interrupt Mask) instruction is executed.SOD: This pin provides serial output data. Data on this line is loaded into accumulator whenever a SIM (Set Interrupt Mask) instruction is executed.

The 8085 Bus Structure

Microprocessor communicates with memory and peripherals using three buses: Address Bus, Data Bus and Control Bus, commonly these buses are called system bus.

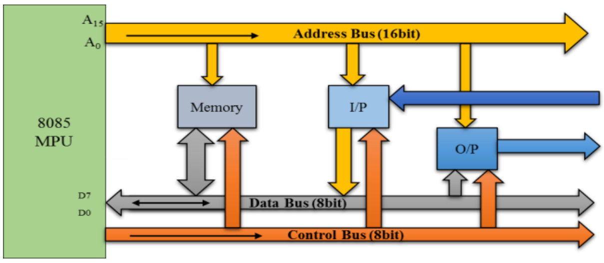


Figure 3: *8085 Bus Structure*

Address Bus: The Address Bus is unidirectional and it consists of 16 wires in this microprocessor. The size of the address bus determines the numbers of address line (2^{16}= 56,536) which can be used. To communicate with memory the microprocessor sends an address on the address bus to the memory.

Data Bus: The Data Bus is bidirectional. The size of the Data Bus in this microprocessor is 8 bit so memory size is $2^{16}\times 8$= 64 KB. The Data Bus carries instructions from memory to the microprocessor and vice-versa.

Control Bus: The Control Bus is used for sending (unidirectional) control signals to the memory and I/O devices by microprocessor for proper operations.

Pin diagram of 8085 with name of corresponding pins is shown in Figure 4. The complete pin description is not included in this introductory article.

Operation of Microprocessor: (summary)

The microprocessor follows a sequence called: i) Fetch, ii) Decode and iii) Execute. Initially, the instructions are stored sequentiallyin the memory. The microprocessor fetches those instructions from the memory, then decodes it and executes those instructions till STOP instruction is reached. Between these processes, the register stores the temporarily data and ALU performs the computing functions under the supervision of control signals.

Program Example:

For illustration a very simple program is discussed here i.e. Addition of two 8-bit Hex numbers.

For this program one should follow the following steps:

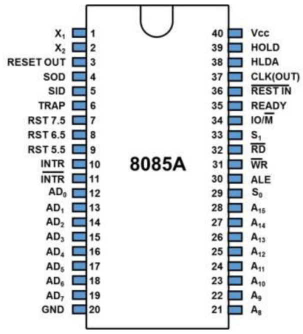


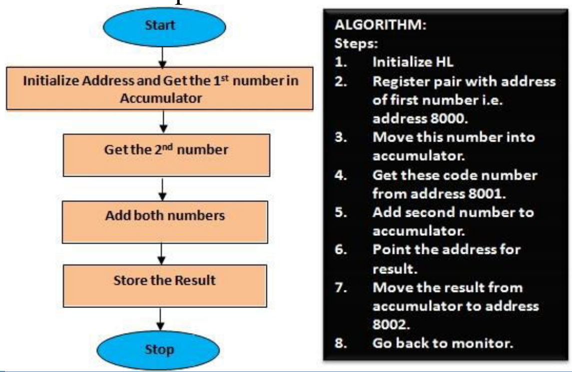
Figure 4: *Pin Diagram of 8085*

1) PLAN:

This program will add two 8-bit hexnumber sat address 8000 and 8001.The result is stored at address 8002. Data field: 8000 – 8002; Program field: 8003 – 800B.

2) Program Flowchart OR Algorithm:

One may use only one technique either Flowchart OR Algorithm of the program. But here both techniques are presented for example.



program field						
	Address	Code	Label	Mnemonic	Operand	Comments
	8000		Data			Firstnumbertobeadded
	8001		Data			Secondnumbertobeadded
	8002		Data			Result
Step1	8003	21	Start	LXI	H ,8000	Pointtofirstnumber
	8004	00				
	8005	80				
Step2	8006	7E		MOV	A , M	Movetoaccumulator
Step3	8007	23		INX	H	Pointtosecondnumber
Step4	8008	86		ADD	M	Addsecondnumbertoaccumulator
Step5	8009	23		INX	H	Pointtheaddressforresult
Step6	800A	77		MOV	M , A	Storetheresult
Step7	800B	EF		RST	5	Gobacktomonitor

(a) Address	Data		(b)	Data
8000	15		8000	AB
8001	16		8001	11
8002	2B (Result)		8002	BC(Result)

3) Program:

The above program is just an example. Although this article could not cover all aspects of 8085 microprocessor but surly will grow an interest in the field of microprocessor.

Acknowledgement:

I would like to express my special thanks of gratitude to my teacher Associate Prof. Dr. Hari Prasad Lamichhane for his encouragement and continuous support.

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Dispersion Relation for Magnan in Ferromagnet & Antiferromagnet

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ABSTRACT

Elementary excitations of a spin system have a quantized wavelike form that represents magnons. They are quasiparticles having fixed energy and lattice momentum, also obey bosonic behavior. In case of ferromagnet, the magnon energy varies with square of wave vector while in antiferromagnet it varies linearly with wave vector for long wavelength limit or low frequency range.

Introduction

A magnon is a quasiparticle, a collective excitation of the electrons spin structure in a crystal lattice. Magnons carry a fixed amount of energy and lattice momentum, and are spin -1, indicating they obey boson behaviour. A magnon is a quantized spin wave. The elementary excitations of a spin system have a wavelike form and are called magnons. Spin waves are oscillations in the relative orientations of spins on a lattice; lattice vibrations are oscillations in the relative positions of atoms on a lattice. The quantization of spin waves proceeds as for photons and phonons. The energy of a mode of frequency ω_k with n_k magnons is given by

$$E_K = (n_k + 1/2)\hbar$$

The excitation of a magnon corresponds to the reversal of one spin ½. The total number of magnons excited at a temperature T is

$$\sum_k n_k = \int_0^\infty D(\omega) < n(\omega) > d\omega$$

In thermal equilibrium the average value of the number of magnons excited in the mode k is give by the planck distribution i.e.

$$< n(\omega) >= \frac{1}{e^{(\hbar\omega_k)/K_B T} - 1}$$

Where $D(\omega)$ be the number of magnon modes per unit frequency range.

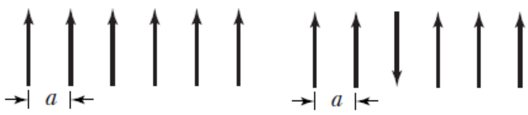

Figure 1: *(a) Ground state of simple ferromagnet in which all spins are parallel. (b) One spin is reversed in a possible excitation[1].*

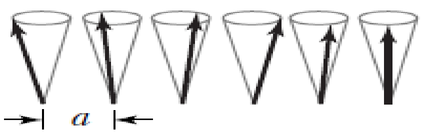

Figure 2: *Elemantary excitations are spin waves in which spin vectors precess at the surface of cones with a constant angle[1].*

Fig (1) represents ground state of simple ferromagnet in which all spins are parallel but fig. (2) represents for possible excitation in which one spin is reversed while fig (3a) elementary excitations of spin waves with a constant angle.

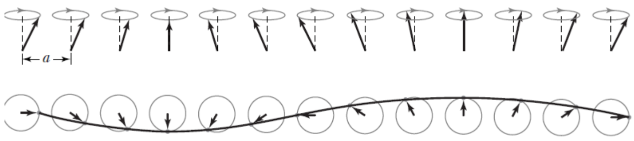

Figure 3: *(a) A spin wave on a line of spins which viewed in perspective ways. (b) A spin wave on a line of spin which viewed by showing one wavelength.*

Fig (3b) represents a spin wave on a line of spins in which spins viewed in perspective way with respect to above, showing one wavelength in which wave is drawn through the ends of the spin vectors so that magnons can be imagined as one complete precession distributed over a chain of spins.

Theory

Let us consider *N* spins each of magnitude *S* on a line or a ring with nearest- neighbor spins coupled by the Heisenberg interaction;

$$U = -2J \sum_{p=1}^{N} \vec{s}_p \,.\, \vec{s}_{p+1}$$

Where, J = exchange integral and $\hbar S_P$ = the angular momentum of the spin at site P in a system

If $\vec{s}_p$ be the classical vectors then in the ground state $\vec{s}_p . \vec{s}_{p+1} = s^2$ and the exchange energy of the system when all spins are parallel or at the ground is

$$U_0 = -2NJs^2$$

If we consider an excited state with one particular spin reversed as shown in fig (2) then the exchange energy becomes

$$U_1 = U_0 + 8Js^2$$

Now, for the magnon dispersion relation in the position of pth spin

$$(\vec{M}_D) = -2J\vec{s}_p . (\vec{s}_{p-1} + \vec{S}_{p+1})$$

Also, magnetic moment at site p as

$$\vec{\mu}_p = -g\mu_B \vec{s}_p$$

From above equation, we get

$$(\vec{\boldsymbol{M}}_D) = -2J\vec{\boldsymbol{s}}_p . (\vec{\boldsymbol{s}}_{p-1} + \vec{\boldsymbol{S}}_{p+1})$$
$$= \vec{\boldsymbol{\mu}}_p . [\left({-2J}/{g\mu_B}\right)(\vec{\boldsymbol{s}}_{p-1} + \vec{\boldsymbol{S}}_{p+1}) = \vec{\boldsymbol{\mu}}_p . \vec{\boldsymbol{B}}_p$$

Where $\vec{B}_p$ be the effective magnetic field or exchange field that acts on the pth spin is

$$\vec{B}_p = \left({}^{-2J}/_{g\mu_B}\right)\left(\vec{s}_{p-1} + \vec{s}_{p+1}\right)$$

Magnon in Ferromagnet

The rate of change of the angular momentum $\hbar\vec{s}_p$ is equal to the torque $(\vec{\mu}_p \times \vec{B}_p)$.

i. e.

$$\hbar\frac{d\vec{s}_p}{dt} = \vec{\mu}_p \times \vec{B}_p \quad \frac{d\vec{s}_p}{dt} = \left(-\frac{g\mu_B}{\hbar}\right)\vec{s}_p \times \vec{B}_p$$
$$= \left(\frac{2J}{\hbar}\right)\left(\vec{s}_p \times \vec{s}_{p-1} + \vec{s}_p \times \vec{s}_{p+1}\right)$$

Components:

$$\frac{d\vec{s}_p^{\,x}}{dt} = = \left(\frac{2J}{\hbar}\right)\left[\vec{s}_p^{\,y}\left(\vec{s}_{p-1}^{\,z} + \vec{s}_{p+1}^{\,z}\right) - \vec{s}_p^{\,z}\left(\vec{s}_{p-1}^{\,y} + \vec{s}_{p+1}^{\,y}\right)\right]$$

Similarly,

$$\frac{d\vec{s}_p^{\,y}}{dt} = = \left(\frac{2J}{\hbar}\right)\left[\vec{s}_p^{\,z}\left(\vec{s}_{p-1}^{\,x} + \vec{s}_{p+1}^{\,x}\right) - \vec{s}_p^{\,x}\left(\vec{s}_{p-1}^{\,z} + \vec{s}_{p+1}^{\,z}\right)\right]$$
$$\frac{d\vec{s}_p^{\,z}}{dt} = = \left(\frac{2J}{\hbar}\right)\left[\vec{s}_p^{\,x}\left(\vec{s}_{p-1}^{\,y} + \vec{s}_{p+1}^{\,y}\right) - \vec{s}_p^{\,y}\left(\vec{s}_{p-1}^{\,x} + \vec{s}_{p+1}^{\,x}\right)\right]$$

The amplitude of the excitation is small (i.e. if $\vec{s}_p^{\,x}, \vec{s}_p^{\,y} \ll \vec{s}$). For approximation of linear equation by taking all $\vec{s}_p^{\,z} = \vec{s}$. Also neglecting product of $\vec{s}_p^{\,x}$ and $\vec{s}_p^{\,y}$. Then, from above equations

$$\frac{d\vec{s}_p^{\,x}}{dt} = (2J\vec{s}/\hbar)\left[2\vec{s}_p^{\,y} - \vec{s}_{p-1}^{\,y} - \vec{s}_{p+1}^{\,y}\right]$$
$$\frac{d\vec{s}_p^{\,y}}{dt} = -(2J\vec{s}/\hbar)\left[2\vec{s}_p^{\,x} - \vec{s}_{p-1}^{\,x} - \vec{s}_{p+1}^{\,x}\right]$$
$$\frac{d\vec{s}_p^{\,z}}{dt} = 0$$

Solutions of the equations are

$$\vec{s}_p^{\,x} = u\exp[i(pka - \omega t)]$$
$$\vec{s}_p^{\,y} = v\exp[i(pka - \omega t)]$$

where u, v are constants, p is an integer & a is a lattice constants. From above equations, we get

$$-i\omega u = (2Js/\hbar)\left(2 - e^{-ika} - e^{ika}\right)v$$
$$= (4Js/\hbar)(1 - \cos ka)v$$
$$-i\omega v = -(2Js/\hbar)\left(2 - e^{-ika} - e^{ika}\right)u$$
$$= -(4Js/\hbar)(1 - \cos ka)u$$

For non-trivial solution, the coefficients of u & v of determinant is equal to zero.

$$\begin{vmatrix} i\omega & (4Js/\hbar)(1 - \cos ka) \\ -(4Js/\hbar)(1 - \cos ka) & i\omega \end{vmatrix} = 0$$

Or,

$$\omega^2 + (4Js/\hbar)^2(1 - \cos ka)^2 = 0$$

Or,

$$\omega^2 = (4Js/\hbar)^2(1 - \cos ka)^2$$

Or,

$$\hbar\omega = 4Js(1 - \cos ka) \qquad (1)$$

This equation represents the dispersion relation for spin waves in one dimension with nearest- neighbor interactions for ferromagnet. For long wave length limit $ka \ll 1$, so that $(1 - \cos ka) \cong {}^1/_2\,(ka)^2$. Then from equation (1), we get

$$\hbar\omega \cong (2Jsa^2)k^2 \qquad (2)$$

The coefficient of k^2often may be determined accurately by neutron scattering or by spin wave resonance in thin films. For the dispersion relation of magnon in case of ferromagnet can be obtained by ploting graph between ${}^{\hbar\omega}/_{4sJ}$ versus k as shown in figure (5) below.

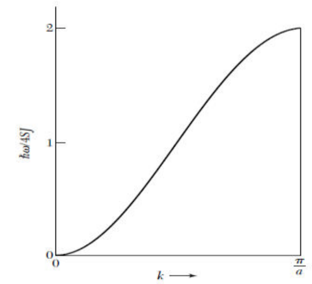

Figure 4: *Dispersion relation for magnons in a ferromagnet in one dimension with nearest neighbor interactions[6].*

Magnon in Antiferromagnet

For the antiferromagnetic magnons, let spins with even indices 2p compose sublattice A , that with spins up $(S^Z = S)$, and let spins with odd indices 2p+1 compose sublattice B , that with spins down $(S^Z = -S)$ as shown in figure below.

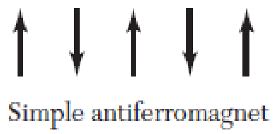

Figure 5: *Spin ordering in antiferromagnets with exchange integral[1].*

We consider only nearest – neighbor interactions, with J negative. Then from above condition,

$$\hbar\frac{d\vec{s}_p}{dt} = \vec{\mu}_p \times \vec{B}_p$$

For sublattice A,

$$\frac{d\vec{s}_{2p}^{\,x}}{dt} = (2J\vec{s}/\hbar)\left[-2\vec{s}_{2p}^{\,y} - \vec{s}_{2p-1}^{\,y} - \vec{s}_{2p+1}^{\,y}\right]$$
$$\frac{d\vec{s}_{2p}^{\,y}}{dt} = -(2J\vec{s}/\hbar)\left[-2\vec{s}_{2p}^{\,x} - \vec{s}_{2p-1}^{\,x} - \vec{s}_{2p+1}^{\,x}\right]$$

For the sublattice B,

$$\frac{d\vec{s}_{2p+1}^{\,x}}{dt} = (2J\vec{s}/\hbar)\left[2\vec{s}_{2p+1}^{\,y} + \vec{s}_{2p}^{\,y} + \vec{s}_{2p+2}^{\,y}\right]$$
$$\frac{d\vec{s}_{2p+1}^{\,y}}{dt} = -(2J\vec{s}/\hbar)\left[2\vec{s}_{2p+1}^{\,x} + \vec{s}_{2p}^{\,x} + \vec{s}_{2p+2}^{\,x}\right]$$

Let us consider,

$$\vec{s}^{\,+} = \vec{s}^{\,x} + i\vec{s}^{\,y}$$
$$\vec{s}_{2p}^{\,+} = \vec{s}_{2p}^{\,x} + i\vec{s}_{2p}^{\,y}$$
$$\vec{s}_{2p-1}^{\,+} = \vec{s}_{2p-1}^{\,x} + i\vec{s}_{2p-1}^{\,y}$$
$$\vec{s}_{2p+1}^{\,+} = \vec{s}_{2p+1}^{\,x} + i\vec{s}_{2p+1}^{\,y}$$
$$\vec{s}_{2p+2}^{\,+} = \vec{s}_{2p+2}^{\,x} + i\vec{s}_{2p+2}^{\,y}$$

From above equations, we get

$$\frac{d\vec{s}_{2p}^{\,+}}{dt} = \frac{d\vec{s}_{2p}^{\,x}}{dt} + i\frac{d\vec{s}_{2p}^{\,y}}{dt} \qquad (3)$$

Substituting the values from above equations in equation (3), then we get condition for sublattice A

$$\frac{d\vec{s}_{2p}^{\,+}}{dt} = (2iJ\vec{s}/\hbar)\left[2\vec{s}_{2p}^{\,+} + \vec{s}_{2p-1}^{\,+} + \vec{s}_{2p+1}^{\,+}\right] \qquad (4)$$

Similarly, for sublattice

$$\frac{d\vec{s}_{2p+1}^{\,+}}{dt} = -(2iJ\vec{s}/\hbar)\left[2\vec{s}_{2p+1}^{\,+} + \vec{s}_{2p}^{\,+} + \vec{s}_{2p+2}^{\,+}\right] \qquad (5)$$

The solution of equations (4) & (5) are

$$\vec{s}_{2p}^{\,+} = u\exp[i(2pka - \omega t)]$$

$$\vec{s}^{\,+}_{2p+1} = v \exp\left[i(2p+1)ka - i\omega t\right]$$

Substituting these values in equations (4) & (5), then we get

$$\omega u = (\omega_{ex}/2)\left(2u + ve^{-ika} + ve^{ika}\right)$$

$$-\omega v = (\omega_{ex}/2)\left(2v + ue^{-ika} + ue^{ika}\right)$$

Where $\omega_{ex} = -\frac{4J\vec{s}}{\hbar} = (4|J|\vec{s})/\hbar$

For non-trivial solution, the determinant of coefficient of u & v becomes zero.

$$\begin{vmatrix} \omega_{ex} - \omega & \omega_{ex}\cos ka \\ \omega_{ex}\cos ka & \omega_{ex} + \omega \end{vmatrix} = 0$$

Or, $\omega^2 = \omega_{ex}^2(1 - \cos^2 ka)$

Or, $\omega = \omega_{ex}|\sin ka|$ (6)

For $ka \ll 1$, i.e. long wavelength limit,

From equation (6), we get

$$\omega^2 \cong \omega_{ex}^2|ka|^2$$

$$\omega \cong \omega_{ex}|ka| \quad (7)$$

Equations (6) & (7) represent magnon dispersion relation for antiferromagnet.

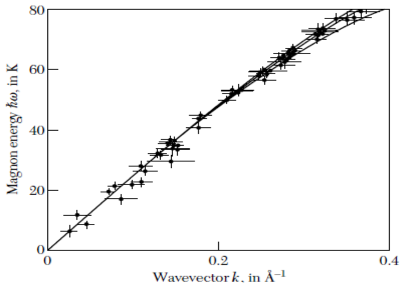

Figure 6: *Magnon dispersion relation in the antiferromagnet RbMnF3 as determined at 4.2 K by inelastic neutron scattering experiment [7].*

The dispersion relation for antiferromagnet can be obtained by ploting a graph between magnon energy with wave vector is as shown in fig (6).

CONCLUSION:

The dispersion relation for magnon in a ferromagnet is different from that of antiferromagnet. The dispersion relation in the case of ferromagnet magnon energy varies with square of wave vector while in the case of antiferromagnet magnon energy varies with linear of wave vector.Magnon behavior can be studied with a variety of scattering techniques such as inelastic neutron scattering, inelastic light scattering,inelastic electron scattering and spin – wave resonance. Magnons behave as a bose gas with no chemical potential.Microwave pumping can be used to excite spin waves and create additional non-equilibrium magnons which thermalize into phonons. Among these scatterings, inelastic neutron scattering measurements can determine the dispersion curve for magnons just as they can for phonons. Magnons are stiffer than that of phonons so we need more energetic neutrons to excite magnons.

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Researchers achieve significant breakthrough in topological insulator-based devices for modern spintronic applications

Realisation of room temperature spin-orbit torque-driven magnetisation switching in topological insulator-ferromagnet heterostructures has promising applications in low power consumption and high integration density memories and logic devices. The current induced magnetisation switching by spin-orbit torque (SOT) is an important ingredient for modern non-volatile magnetic devices such as magnetic random access memories and logic devices that are required for high performance data storage and computing. As such, researchers around the world are actively searching for novel ways to reduce the present high switching current density in order to achieve highly efficient SOT driven magnetisation switching. Researchers from the National University of Singapore (NUS) have recently made a significant breakthrough in this field of research. Led by Associate Professor Yang Hyunsoo from the Department of Electrical and Computer Engineering, the NUS research team has, for the first time, successfully demonstrated room temperature magnetisation switching driven by giant SOTs in topological insulator/conventional ferromagnet (Bi2Se3/NiFe) heterostructures with an extremely low current density, that can address the issue of scalability and high power consumption needed in modern spintronic devices.

Outflowing Winds from the Vicinity of the Supermassive Black Hole in the AGN

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ABSTRACT
This article presents a basic review of winds outflowing from the vicinity of the central supermassive black hole of an active galactic nuclei (AGN). The first section explains why astrophysicists are interested to study the outflow and present the key scientific questions that should be answered to understand the co-evolution of host galaxy and the supermassive black hole of the AGN. The next sections highlight the current understanding and the limitations of the AGN feedback research, and discuss the possible solutions that can be achieved by utilising the unprecendented future X-ray instruments as well as the state-of-the-art computational facilities.

Motivation: why do we care about AGN outflow?

There are many interesting and exotic objects in our fascinating universe. Over the past centuries, many new discoveries have been made unlocking the several mysteries of the Universe. Among these discoveries, the black holes are the least known objects since they do not emit any detectable radiation by themselves. This is because of the fact that the matter density and gravity is infinitely large, not allowing even the light to escape. Until now, astrophysicists agree with the existence of two classes of black holes depending on their mass. Black holes that are few to tens of massive than the Sun are called stellar mass black holes which are believed to be born when an extremely massive stars at their late stage of evolution, explode as a supernova. On the other hand, there exists a supermassive black hole (SMBH) at the centre of galaxies, and has mass millions to billions times the Sun. This system is called active galactic nucleus (AGN), when powered by the accrection of the material onto the SMBH (Lynden & Bell 1969) and manifests itself as the most luminous and persistent source of electromagnetic radiation in the universe. Very recently, there has been ongoing hot debate among the astronomers about the existence of intermediate mass black hole (IMBH) of few thousands of the solar masses at the center of newly discovered exotic ultraluminous X-ray sources (Colbert 2006). The recent detections of the gravitational waves from the collision of the stellar mass black holes also lead to the possible existence of IMBH albeit not yet established. Nevertheless, in this article, I will restrict myself to explain the important feature of the AGN system; the hot and ionised material escaping from the close vicinity of the supermassive black hole against its tremendous gravitational force.

It is well established fact that the AGN are powered by the accretion of surrounding mass onto the SMBH at the center. In the process of accretion, the amount of energy released per second is very high i.e., several billions times the energy released by the Sun. While most of the materials is accreted onto the SMBH via accretion disk, significant portion of it flows away from the nucleus in the form of outflows and jets. The emitted radiation, before reaching to the observer, interacts with the material present in the line of sight. Since the matter is subjected to the intense radiation emitted from the central source of the AGN, almost all the elements present are partially or completely ionised. The radiation matter interaction causes the transition of electrons between various energy levels of the atoms and produces numerous absorption lines with energies corresponding to the energy of excited ions. Since the material is hot, the energy centroid of the absorption lines corresponds to extreme UV and mostly soft X-rays. The absorbing material is called the warm absorber (WA).

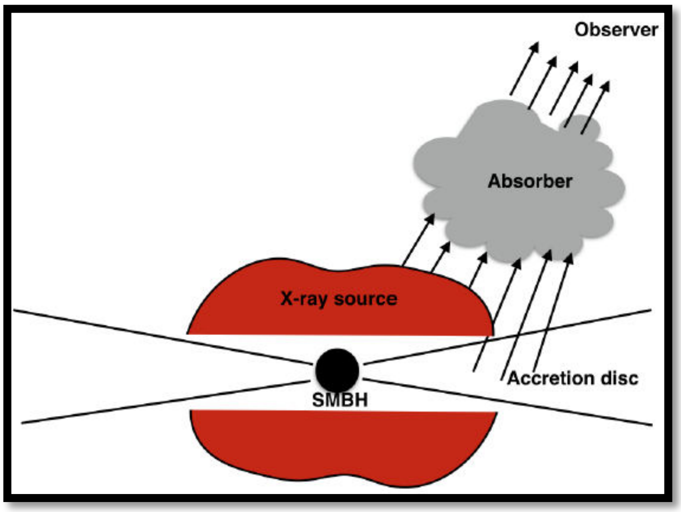

Figure 1: *A Schematic diagram taken from (Adhikari2016a) showing the outflowing wind from the vicinity of the supermassive black hole in AGN. An observer sees absorption lines in the radiation transmitted through the ionised plasma in the wind. The black circle at the center is the representation of the supermassive black hole while the portion with red color is the hot corona from where the primary soft X-rays are produced. The figure is not to scale and very simplified representation of the AGN wind system.*

These lines are detected to be blue shifted in the spectra obtained by the spectrometers installed in the modern X-ray satellites: *Xmm-Newton, Chandra* and *Suzaku* on board in space. Many narrow absorption lines from highly ionised elements are detected in several X-ray observations of the spectra of AGN (Collinge 2001, Laha 2014). The blue shifts for the absorption lines confirm that the material is movingtowards the observer.

For the detection of X-ray lines, space satellites are required since the Earth's atmosphere absorbs and scatters the X-rays coming from the distant sources, and therefore cannot be detected with the ground based instruments.

Despite the significant researches done in the past decades, there exist several unanswered questions regarding this system. What causes the material to flow away from the vicinity of SMBH despite its tremendous force of gravitational attraction? Where does the outflow originate and how it is connected with the process of accretion? How does the outflow affect the various components of the host galaxy? What are the physical conditions of the material present in the ouflow and what is its chemical composition? How does the chemical composition in the outflow correlate with heavy element abundance in the universe? Is there any difference between the outflows close to the SMBH and further away? Some of these questions, if not all, can be addressed by utilizing the existing high resolution X-ray data obtained from the space observatories such as *Xmm-Newton* and *Chandra* X-ray missions as well as performing high precision computer simulations of the AGN outflow. I will present our current understanding of the winds from the AGN and its effect on the host galaxy. I will also briefly mention how the outflow from AGN affects the material that is being constantly fed to the SMBH.

Current understanding of the AGN outflow: where do we stand?

The curiosity of X-ray absorption was started with the work of Halpern (1984), where the existence of absorption edges in the spectra of Quasi stellar object MR 2251-178 was shown. The advent of technology over time has increased the resolution of the spectrometers enabling the detection of the absorption lines and their centroid energy shifts in the AGN spectra. Since then, there have been a lot new exciting discoveries made in the studies of outflow from the AGN (Kaastra2002, Tombesi 2013). From the energy shift of line centroids, it was found that the absorbing matter is systematically outflowing with velocities ranging from 10^2-10^3 km/s (Kaastra 2002). From the study of the absorption spectra from observations, one of the most intriguing finding about the absorber is their broad ionisation distribution (spanning upto 5 orders of magnitude in ionisation degree) including neutral to fully ionised ions (Holczer 2007). In the recent studies of the X-ray outflows in the several AGN, the blue shifted lines corresponding to the Fe K absorption around 7-10 keV moving with the mild relativistic velocities (upto 0.2 - 0.4c, c being the velocity of light) have been detected (Tombesi 2010). These highly energetic outflows are called ultra-fast outflows (UFOs) and expected to be launched much closer to the SMBH than the WA.

One of the the fundamental questions regarding the absorbing gas in the AGN outflow is, whether these clouds exist in pressure equilibrium or the density across the depth of the cloud is constant? Recent photoionisation models suggest that the WA are radiation pressure confined leading to the constancy of total pressure (radiation + gas) (Rozanska 2006, Stern 2014, Adhikari 2015). Adhikari (2015) performed photoionisation simulations of the WA in Seyfert 1 galaxy Mrk 509 and showed that a constant pressure assumption of the WA successfully reproduces the observed ionisation properties of the outflow in AGN. From those simulations, the authors have correctly reproduced the observed broad distribution of ionisation states in Mrk 509. The photoionisation simulations have also been shown to be useful method to constrain the physical properties, in particular the gas density of the ionised emission regions in AGN (Adhikari 2016).

Understanding the effect of wind from the AGN central engine to its surrounding medium, and the co-evolution of the host galaxy and SMBH requires the knowledge of the mass outflow rate and its kinetic luminosity that reaches to the interstellar medium. Since the estimation of the mass outflow rate depends on the geometrical properties of the outflow: covering fraction, volume filling factor and the density profile which is still largely unknown, the derived properties of the outflow are not very accurate. As the outflow kinetic energy directly depends on the mass outflow rate, its very difficult to predict how the outflow affects the interstellar medium of the host galaxy. However, there have been some estimation of these quantities assuming the biconical geometry of the flow (Tombesi 2013, Laha2016). The authors have claimed that the WA have the kinetic energy < 0.5 percent of the AGN bolometric luminosity whereas the UFOs have the values as high as 5 percent of the bolometric luminosity. From the hydrodynamical simulations of the outflow, (DiMatteo 2005) have demonstrated that the outflow with the kinetic energy as low as 0.5 percent of the AGN luminosity can give sufficient feedback to the host galaxy. This clearly shows that UFOs are capable of sweeping away the material and hence lowering the accretion activity of the SMBH. Additionally, the material swept continuously heats up the interstellar medium and thereby quenching the star formation rate. This demonstrates how important is AGN outflow in the co-evolution of the host galaxy and the SMBH.

Future prospects: what next?

The discovery of outflows in the AGN has opened a new way of looking into the extreme environments of super massive black hole (SMBH). Previous sections describe the motivation behind the AGN outflow research and its importance in exploring the co-evolution of the host galaxy and the SMBH. As I already mentioned, due to the advancement in observational techniques as well as the increased numerical simulation capabilities, the AGN research has reached to an exciting level. However, this is only the tip of the iceberg in the understanding of how the AGN feedback works. The astronomers do not know yet, how to quantify the outflowing material with high accuracy and estimate its impact on the chemical enrichment of the interstellar medium. Nevertheless, the future of AGN outflow research is very promising as the high resolution observational data from the recently launched Indian satellite ASTROSAT (Rao 2016) and European future X-ray mission ATHENA (XBarcons 2015) will be available in coming years. In particular ATHENA will have a very high precision detector X-IFU with 10 times better spectral resolution than any other currently working X-ray satellites, and is capable of detecting all lines due to highly ionised species of heavy elements with unprecedented accuracy.

Due to the updates in the atomic databases and advancement in the computer simulation techniques of plasma ionised by the source of radiation, the future of theoretical studies of the AGN outflow looks very bright. The consistent comparison of the results obtained with the unprecedented capabilities of the X-ray space observetories to that resulting from the state-of-the-art computer simulations will surely answer many questions regarding the physical properties of the outfow. Specifically, the understanding of complex geometry of the outflow will provide the accurate estimation of the mass outflow rate and the kinetic energy which will enable us to probe the AGN feedback processes: the accretion of the material into the monster black hole and the effect on the star formation in the host galaxy. Moreover, the new results will potentially provide important insights into the distribution of the matter at different distances from the central SMBH in the AGN which will be a boon for the estimation of heavy element's distribution in the Universe.

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Introduction to High Performance Computing

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ABSTRACT
This article presents a informative review of high performance computing system, its development and future prospectus in the field of research in science and technology. In addition, a brief overview on parallel programming scheme is described.

Introduction

Computers are powerful in solving complex mathematical problems, dealing data intensive problems and simulating experiments. Scientists and engineers are relying heavily on computers to understand real world physical phenomena, to make scientific predictions or for the design, analysis and testing through mathematical modeling. While dealing with scientific computation, it is always an issue how fast the computing task can be accomplished. The efficiency depends on algorithm of programming model and speed of memory access by processor. As the manufacturing speed of single silicon processor is limited to 3 GHz because of heat dissipation that makes the processor unreliable, higher performance can be achieved only with the use of additional processors. High performance computing (HPC) is the method of achieving fast computation by parallelizing the programming model to run on multiple processors than running on single processor. It is also defined as supercomputing or parallel computing.

HPC is essential to the researchers of all disciplines when required to solve large computational problems that cannot be run on a single computer or to accomplish their science goals within certain time limit. Researchers can modify or gain confidence on their models without waiting for longer time through the increase speed of parallel computing. For the experiments that don't provide enough details, problems can be analyzed by generating huge amounts of data running numerous jobs at the same time on multiple processors. Knowledge of HPC is also important to use hardwares much more efficiently than they are designed to work. According to XSEDE portal, HPC is used in all areas of research. Figure 1 shows that biophysics lies ahead in consuming most XSEDE's HPC resources in 2016.

Multiple processors may exist in a single integrated circuit connected with a specialized interconnecting network, different stand alone machines locally connected with high speed ethernet as clusters or distributed at different locations connected via the internet as grid. A core is an individual processor and an object of network in cluster is a node. Supercomputer is a cluster lying at the frontline of current processing capability in terms of memory and speed. Sunway TaihuLight is the world's fastest supercomputer having 10,649,600 processors. It's speed is 93 $\times 10^{15}$ FLOPS while the speed of personal computer (PC) having intel i7 Core is in the order of 10^8 FLOPS where FLOPS (Floating Point Operations per Second) is the unit used in measuring the speed of computer. A newer concept in HPC is the use of GPUs (Graphics Processing Units) which are hardware devices having multiple processors optimized for computer graphics.

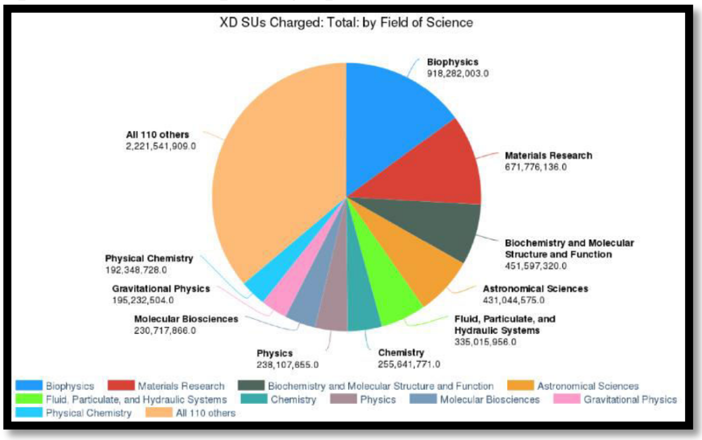

Figure 1: *Research disciplines in HPC according to XSEDE service units (XD SUs) charged in 2016. Source: XSEDE portal.*

Underlying Technologies

Depending on computer architecture, multiple processors may share a single memory space, may have their own locally distributed memory space or both. Different parallel programming paradigms are used for shared and distributed memory system. In the shared memory system, the underlying technology is threads whereas in the distributed memory system, it is based on processes and network communications. Thread is a method of splitting single task into multiple threads or semi-independent parallel tasks sharing same memory, resources, data and program states. Threads communicate by reading/writing variables in the same memory space. In contrast, processes are independent tasks that are executed simultaneously. They don't share states, resources or global memory with other processes. Each process possesses their own memory space and requires network communications to exchange information and data. The fundamental difference between threads and processes is in how resources within a program are used and therefore, how parallel tasks communicate or exchange information. GPUs are heterogeneous system where parts of the code are run on the processors and other parts on the processors of GPUs.

Both threads and processes are the concepts for control flow during program execution and should be incorporated while writing the program in parallel mode.

The primary written languages for HPC code are C, C++ and Fortran. Generally, these languages are designed to keep only one processor busy defined to be serial or sequential programming. For parallel programming, multiple processors are linked by including libraries that communicates between processors. Libraries for communications are typically OpenMP (Open Multi Processing) for shared memory system and message passing interface (MPI) or parallel virtual machine (PVM) for distributed memory system. Programming languages like CUDA (Computer Unified Device Architecture) and OpenCL (Open Computing Language) which are extension of C, C++ and Fortran are used for parallel programming in GPUs.

Parallel Programming

Whether it is serial or parallel programming, program written in any languages at first requires selection of right algorithms and proper implementation of those algorithms. An efficient algorithm is more important than a faster computer. Efficient algorithm improves speed by reducing the number of operations count and cost of memory usage in program execution. In the thread based model or OpenMP, parallelization is done at the position of programming loop so that different portions of the loop are executed in different threads. Speedup is achieved by executing the threads across multiple processors. Thread managements are done by using environment variables and function calls within the code. Threads do not copy program for execution but only duplicate what is needed to allow independent execution. In the distributed or MPI model, parallelization is performed by executing different task on each processors through partitioning of problem data and distribution across different processors. Each processor executes operations on a subset of the problem data by making an independent copy, and it exchanges information and data with other processors working on different subsets. Parallel algorithms should always run faster when more threads or processes are used. It needs to be remembered that program written with the threads or shared memory model cannot be used to distribute tasks across networked processors. However, program written with the distributed memory model works on the shared memory systems.

The most important task in HPC is to insure the validity of data written by multiple threads or processes. Parallel algorithm should always code data integrity, exchanges and synchronizations between the threads or the processes running explicitly. Synchronization of the parallel tasks reduces possible data corruption, avoids race condition and deadlock in communications. Threads are synchronized through mutexes, conditionals, semaphores and barriers while processes are synchronized through communication signals such as send, receive, wait, barrier, etc. MPI model also needs to achieve load balancing by partitioning equal amount of work or data to all the processes. If this condition is not satisfied, some processors will become idle while others are performing computations. Domain decomposition method helps in the equal partition of the data. A critical constituent of HPC is also the selection of suitable compilers. Compiler translates algorithm of the program into machine readable code through code optimization.

Future of HPC

HPC gains importance in all areas of scientific research. It's role is increasing more in the field of physics to simulate experiments that are either experimentally impossible or too expensive besides understanding and solving complex problems. Computers are being available in the market with more and more processor. In future, HPC resources will be more accessible and the scope of computation will be parallel computing. Modern world has already been digitized and big data are being generated in all sectors. Requirements of HPC will enter commercial, business and industrial sectors apart from research field.

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George Mason University **(Mason) is the largest public research university in the U.S. state of Virginia. The Science and Technology campus opened in 1997 as the Prince William campus in Manassas, Virginia. More than 4,000 students are enrolled in classes in bioinformatics, biotechnology, information technology, and forensic biosciences educational and research programs.**

Earthquake Prediction

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ABSTRACT

The main aim of this article is to provide brief information about earthquake prediction, past experiments and theory behind the experiments and their failure. It also includes the brief theory behind earthquake occurrence and some earthquake precursors.

Introduction

Earthquake prediction refers to the specification of the expected magnitude, geographic location and time of occurrence of a future earthquake with sufficient precision. Normally prediction is of three types viz. long, medium and short range prediction. While long range prediction is concerned with forecasting the occurrence of an earthquake a number of years in advance, medium term prediction is to be done a few months to a year or so and the short term prediction implies forecast ranging from a few hours to some days in advance.

Since, earthquake prediction can greatly reduce the loss of lives and property it is therefore an important aspect of seismology. But false alarms and failure in prediction will result in reduction of effectiveness and credibility of the science behind the prediction.

Theory of Occurrence of Earthquake

The earth surface is composed of twelve large semi-rigid tectonic plates amongst which seven major plates covers about 94% of the surface area of earth. The movement of tectonic plate is due to convection current of magma inside the mantle. Three types of motion of tectonic plates results in three kinds of tectonic plate boundaries viz. divergent, convergent and transform plate boundaries. At divergent plate boundaries two plates move away from each other while at convergent plate boundaries two plates move towards each other in which one is subducted beneath the other. Similarly at transform plate boundaries two plates move parallel to each other.

Due to relative movement of tectonic plates, stress is gradually developed and when stress reaches the maximum value (breaking stress) the plate ruptures and the earthquake occurs releasing tremendous amount of energy in short interval of time.

Theory of prediction of earthquake

The prediction of earthquake is largely based on precursory deformation of earth crust. If we are able to measure stress developed due to tectonic movement along the fault line and also the breaking stress of rocks, then we will be able to predict the earthquake within significant time and space window.

Earthquake clustering with power-law temporal decay (Omori's law) can be used to estimate the rate of future earthquake occurrence.

$$R(t) = k/((t+c)^P)$$

Where, $R(t)$ is the rate of occurrence of aftershocks, and k, c, and pare constants

Predictions are significant if they can be shown to be successful beyond random chance. Therefore methods of statistical hypothesis testing are used to determine the probability that an earthquake would happen anyway.

The uncertainty in prediction parameter makes it imperative to formulate forecast in terms of probability. Earthquake prediction is largely a statistical problem, failure to appreciate this is at the root of many difficulties in prediction and analysis. Predicting the earthquake is similar to throwing a dice, one can statistically predict how often it is likely to come but it is difficult to know exactly when it will come. Furthermore all earthquake forecasts (whether deterministic or statistical) need to be evaluated statistically to see if their success could be due to chance.

Gutenberg-Richter (G-R) relation gives the statistical basis to calculate the magnitude of future earthquake using the formula,

$$\mathrm{Log}_{10} N(m) = a - bm$$

Where, $N(m)$ is the number of earthquakes with magnitude greater or equal to m, 'a' is the seismic productivity constant and $b = 1$

Difficulties encountered

- The movement of tectonic plate is not uniform throughout its dimension which leads to development of different level of stress along tectonic plate.
- The composition of tectonic plate is not uniform so that the breaking stress of tectonic rocks at different places is not same.
- Remote sensing technique is used to gather several data about the geology beneath the earth surface whose results are not so accurate.
- Also the breaking stress of tectonics depends upon the natural structure on the surface of earth and also is affected slightly by artificial structure and human activities.
- Most earthquake forecast attempts are not rigorously testable due to an insufficient number of predicted events or prediction ambiguities or a prediction time window too large for the testing to be feasible.

Some earthquake precursors

Animal behavior

The unusual behavior of animals prior to earthquakes received wide publicity after the Haichang earthquake in Liaoning province of China, in February 4, 1975 was successfully predicted.
i) Most animals show increased restlessness before an earthquake.

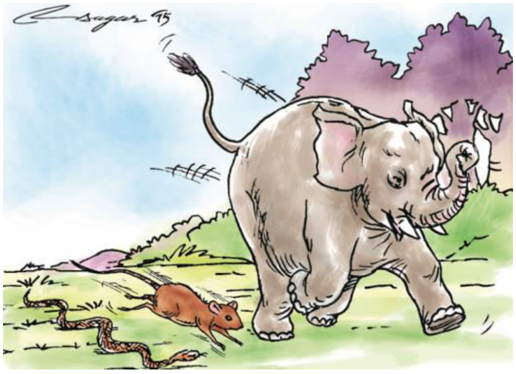

Figure 1: *Animal behavior is supposed to be changed.*

ii) The precursor time varies from a few minutes to several days.
iii) These observations have been noticed predominantly in high intensity or epicentral region close to active faults.
iv) Abnormalbehavior of the animals is observed during earthquakes of magnitude 5 or more.

Hydrochemical Precursors:

Chemical composition of underground water was observed on a regular basis in seismically active regions of Tadzhik and Uzbekistan. These observations yielded following results.
(i) Concentration levels of dissolved minerals and gaseous components remained almost constant during seismically inactive period.
(ii) An appreciable increase in concentration of dissolved minerals was noticed 2 to 8 days before an earthquake.
(iii) After the earthquake, anomalies in concentrations of the gaseous and mineral components disappear.

Temperature Change:

There seems to be some relation between temperature and earthquakes. A considerable rise of temperature by 10°C and 15°C was reported before earthquakes in Lunglin in China (1976) and Przhevalsk in Russia (1970).

Water Level:

There are drastic changes in water level in several wells just before a major earthquake. There was a fall in water level a few days before the Nankai earthquake in Japan (1946). Rise of water level by 3 and 15 cm was reported before Lunglin (China) and Przhevalsk (Russia) earthquake.

Radon Gas:

Radon is a radioactive gas which is discharged from rock masses prior to earthquake. It is dissolved in the well water and its concentration in the water increases. Such an increase was reported in Tashkent in 1972 where increase in concentration varying from 15 to 200 per cent was noticed about 3 to 13 days prior to an earthquake.

Oil Wells:

Large scale fluctuations of oil flow from oil wells prior to earthquakes were reported in Israel, northern Caucasus (Europe) and China. These earthquakes which occurred in 1969, 1971 and 1972 gave rise to increased flow of oil before their occurrence. It has been suggested that when the tectonic stress accumulates to a certain level, the pore pressure within a deep oil bearing strata reach its breaking strength causing oil to sprout along the oil wells.

Past efforts on earthquake prediction

a) In 1965 an Ad hoc committee in USA proposal a large scale empirical search for precursors. It is assumed that some degree of earthquake forecasting can be achieved by understanding the physical phenomenon. Steps to measure absolute stress would be determined and regional and local strains tilts, micro-seismicity and gravitational and magnetic fields would be monitored continuously at many locations in the seismic belt. Coherence between variations in those processes would be examined together with possible correlations with the occurrence of larger earthquakes.

b) *Parkfield and Tokai experiments*
In 1970's scientists were optimistic about earthquake prediction but continued failure of many experiments such as Parkfield experiment and Tokai experiment makes scientists to realize it was not so easy. These experiments were conducted to understand the physics of earthquakes-what actually happens on the fault and in the surrounding region and to forecast an isolated individual earthquake. The main reason for the failure of those experiments was non-linear, scale invariant features of earthquake occurrence. Similarly the general deficiency of the models and techniques proposed to forecast earthquakes was another factor for failure of experiment. Also, the models haven't been falsifiable and efforts to validate and test these prediction algorithms rigorously haven't been encouraged. Studied have been carried out as qualitative verbal, descriptive, storytelling exercise rather than quantitatively predictive science, subject to precise.

c) P. Varotsos and co-workers (VAN group) claim to be able to predict earthquakes in Greece using geo-electrical observations. However, it was pointed out that VAN's work appears unsound from the point of view of tectonophysics. Also it was concluded later that sources were near observatory rather than epicenters which were at distances of over 100 km. There appears to be no convincing evidence that any of the electrical signals observed by VAN are earthquake precursors. Further, VAN's predictions are vague and ambiguous and are not statistically significant.

d) It had been proposed that phase anomalies in the propagation of VLF radio signals broadcast by US Omega system can be used to predict earthquakes.

They claimed that more than 250 variations have been observed before earthquake as small as magnitude 4 at distances of as much as several hundred kilometers from the great circle path between transmitter and receiver. A greater co-relation between earthquake occurrence and the amplitude and phase variations is obtained than for random poissonian earthquake occurrence.

e) The ratio of pressure wave to shear wave changes slightly when the rock is near the point of fracturing. It was observed by Russian seismologists at 1970's. This effect as well as other possible precursor has been attributed to dilatancy where rock stressed to near its breaking point expands slightly.

The velocity of pressure wave (v_p) and shear wave (v_s) is given by Adams and Williamson equation as;

$$vp = \sqrt{((K + \left(\frac{4}{3}\right)\mu)/\rho)}$$

$$\text{vs} = \sqrt{(\frac{\mu}{\rho})}$$

where; K = bulk's modulus
μ= shear modulus
ρ= density

There was successful prediction of earthquake near Blue Mountain Lake in New York State but it turns out to be fluke because the prediction of 5.5 to 6.5 M earthquake near Los Angeles in 1976 failed to occur. And similarly other earthquake prediction based on this theory has also failed.

Current Status

We have new system for highly sensitive magnetic and radon monitoring of the active fault line. Also we have ultrasensitive magnetic gradiometer for long term monitoring, isolation and identification of different phenomena in the geomagnetic field. We have shake-alert alarms, laser monitoring system.

Future hope

In future we expect development of warning system which will include the installation of larger numbers of seismic stations and upgrading station telecommunications. As earthquake is multidimensional and complex phenomena, we should be able to develop proper theory and modeling of earthquake which should be able to point out the exact relation between various factors causing earthquake. The relation between seismology, rock mechanism and geology is key factor to understand the occurrence of earthquake.

Conclusion

During the research of more than 120 years the success in prediction of earthquake is not satisfactory. Many people showed pessimism towards prediction of earthquakes, they suggested that earthquake prediction is nearly impossible. The failure of many experiments also added fuel in it.

Figure 2: *Why we could not predit earth quake?*

But some people showed optimism inspite the several failures in prediction of earthquake. Several theories are devised but none of them are effective. One of the reasons behind the failure is inadequate funding. The cost for earthquake prediction and evacuation of people is higher and is unlikely to be successfully accomplished. Also panic and other undesirable side effects can also be anticipated. It is better to spend to make building and other physical infrastructure safe. So except to those economically powerful nations, most of nation is not spending much for the research based for earthquake prediction.

If proper funding is made and adequate research is done then we could one day be able to design theory that will predict the earthquake which would be great success for mankind and great boon for society and human civilization.

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Physicists have experimentally demonstrated quantum entanglement with 10 qubits on a superconducting circuit, surpassing the previous record of nine entangled superconducting qubits. The 10-qubit state is the largest multiqubit entangled state created in any solid-state system and represents a step toward realizing large-scale quantum computing.

Science Behind the Earthquake

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ABSTRACT
The scientific study of earthquake is called the seismology and the general study of overall earthquake belongs to the geology. Overall Physics behind the earthquake and its way of measurement will be presented. Prediction and forecast of the earthquake will be described in brief.

Introduction

Earthquake is the phenomenon of shaking of the surface of the earth due to the shocks waves generated by the sudden movement of the earth crust. The sudden movement of the earth crust is due to the passage of seismic waves that are emanating from a point in the earth's interier. The earthquake, in general, can range from a faint tremor to a wild motion capable of shaking buildings apart and causing fissures to open up in the ground.

Existing Theories

There are various reasons for the earthquake. Tectonic activity and volcanic activity are the two major natural causes of earthquake while disposing of waste into deep wells, loading of earth crust, setting of underground nuclear explosions etc. can be accounted for the artificial causes of the earthquake. Earthquake is produced by sudden movement along faults, and is of tectonic origin. The concept behind the origin of tectonic earthquake is given by **Elastic-rebound theory**. Such earthquake generally results from sudden release of huge strain produced on the rocks by accumulating stresses. Inside the earth the rocks are continuously acted upon by the forces that tend to bend, twist or fracture them. When rocks bend, twist or fracture they are said to be deformed, which leads to change in strain and the force that causes deformation is stored in the form of energy (stress). The relative displacement of plates cause shaking because displacement of rocks can only be possible by overcoming frictional resistance against the walls of the fault-plane. According to Elastic-rebound theory, materials of the earth, being elastic, can withstand a certain amount of stress without deforming permanently, but if the stress is continued for a long period of time, or if it somehow increased in magnitude, the rocks will first take a permanent deformation or strain and finally rupture. When the rupture occurs, rocks on either side of the fault tend to return to their original shape because of their elasticity and an elastic rebound occurs. It is this rebound that gives the wave as in reaction, which are seismic waves. Thus, the energy stored in the system over a long period, is released instantaneously causing underground dislocations of rocks and setting up vibrations which are feeble. Although volcano itself is caused due to the tectonic activities; this may further causes the earth to shake because of the sudden breakthrough of magma from deep inside the surface which is only possible with the huge release from the weak spot on the earth's crust.

Earthquakes are the result of movement of the plates. There are many hypothetical theories on plate’s movement. However **plate tectonics theory** is considered as most well accepted concept on plates movements. According to the theory, there are three types of plate boundaries; Convergent plate boundary, Divergent plate boundary and Transform plate boundary. The movement of the plates towards each other is called convergent plate boundary. This boundary specially creates the subduction zone and due to the continuous subducts or drives, one beneath the other, the plate which is lighter uplift while the denser plate subducted inside. During such type of collision, if both of the plates are continental, large mountain ranges like himalyas are formed. For example, about fifty thousands years ago, Indianplate separated from Madagaskar and started the motion towards the north. The motion of Indian plate was about twenty nine feets per century which was quite faster in comparision to the others.

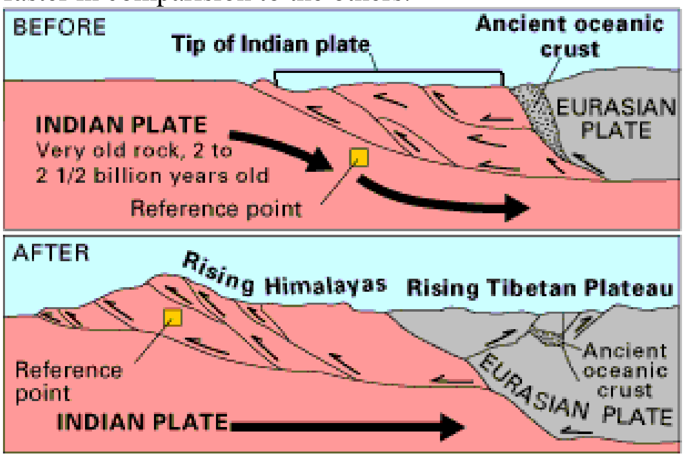

Figure 1: *Convergent plate boundary between Indian and Eurasian plates.*

The Eurasian plate at North was quite denser and almost stable which lead to the massive collision of Indian and Eurassian, forming Jacket-Himalaya Mountain. The Himalayan arc extends over twenty four hundreds kilometer from Nanga Parbat (8,138 m) in the west to Namche Barwa (7,756 m) in the east. This region includes Nepal, Bhutan and as well as part of Pakistan, India, and China. The Benioff zone; the proper zone of earthquake that is produced by the downgoing oceanic crust to the continental crust, makes an angle of forty to sixty degree with the horizontal and since the distance from the subduction point to the margin of that zone is around seven hundreds kilometers, where the packets of magma are formed. So from the basic trigonometry one can predict that the volcanic magma eruption due to subduction geology is around three hundred fitfty kilometer (if the angle is sixty degree) from the subducted zone. Also Nepal lies far from the subduction zone and from the calculation further three hundred fifty kilometers indicate the zero probability of volcanism in Nepal. Due to the continuous subduction, the various active faults areactive due to which there is continuous storage of elastic energy. Thus, the Himalayan zone isalways on the high risk of earthquake.

If the two plates are moving away from each other widening the space creating the sea-floor spacing, it is called the divergent plate boundary.Most of these boundaries occur between oceanic plates and exists as mid oceanic ridges. Great- Rift valley of east Africa is the best example of Divergent plate-boundary.

If the plates are slide to each other the plate boundary is termed as Transform boundary. Crustal plates donot only slides smoothly one onto the other. The oceanic crust could feel resistance slower and sticks like a machine, without oil the pressure builds up and suddenly the plates is formed forward and the pressure is released in the form of wave. San-Andres fault is one of the best examples of Transform plate boundary. From the recent study, around two hundredsearthquakes strike SouthernCalifornia's SaltonSea due to San-Andreas Fault.

Basically, there are three types of sesmic waves: P (primary) waves, S (secondary) waves and Surface waves.When an earthquake occurs the P-waves, S-waves and surface waves are recorded on the seismograph and displayed on a seismogram simultaneously. P-waves are the body wave and are longitudinal wave just like the sound wave, causing compression and expansion of particle. That is why the buildings on the earth surface vibrate to the direction as the wave propagates.Its speed is almost six kilometers per second. P-wave can travel through solid, liquid and gas all three media. S-waves are transverse wave, so the particles vibrate to the direction perpendicular to the direction of wave propagation. Its speed is almost 3.5km/s. They only travel through solid. Surface wave are the only wave that travel on the surface of the earth, the slowest wave to arrive at a seismogram. They produce the ground roll, like the incoming ocean wave so the choppy surface wave causes more destruction during an earthquake. The surface waves are also called Love-wave or Reyleigh-wave. They have long wavelength and low frequency than both P and S-wave.

Various scales have been proposed to estimate the magnitude and intensity of earthquake. Among them two scales are much popular: Richter scale and Moment Magnitude scale.

Richter scale

The Richter scale was first discovered by Geologist, Chales Richter in 1935 which measures the size of the earthquake by defining magnitude as the logarithm of ratio of amplitude of sesmic wave to arbitrary minor amplitude. It is based on the method of first principle which is described below.

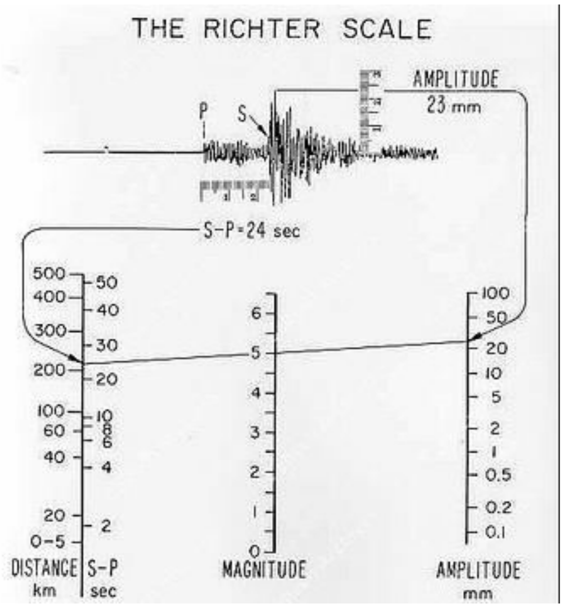

Figure 2: *Determination of magnitude of earthquake using the Richter scale.*

In the figure above, the wave is traced on the sesmograph during an earthquake. From the traced waveform we can see the time lag between the P-wave and S-wave as the P-wave comes faster in the sesmogram. The time lag helps to find out the distace of epicenter from the station. The exact location can be found by using the geographical map with the record of various stations. The intersecting point below gives the exact location of the epicenter. The height of the secondary wave is plotted on the right most axis and epicenter distace on the left most axis. On drawing the straight line the point of intersection on the middle axis represent the magnitude of the earthquake. As the scale is logarithemic, the magnitude will be 10 times stronger than the preceeding value. So from the basic mathematics, we can say that 8.7 magnitude earthquake is seven hundreds ninty four times bigger than that of 5.8 magnitude earthquake.

Moment Magnitude scale

Moment Magnitude scale is the logarithemic scale which measures the size of the earthquake in terms of how much energy is released during that event. Mathematically it is defined as the product of rock rigidity, distance the block slips relative to other block and area that ruptured between the blocks.

$$\text{i.e.} M=\mu * D * A$$

Where, M = rigidity

D = distance that the block slips-relative to the other block.

A = area that ruptured between the blocks.

Here, D and A can be determined by mathematical modeling of seismograms.As with the Richter scale, an increase of one step on this logarithemic scale corresponds to a $10^{1.5} \approx 32$ times increase in the amount of energy released and an increase of two steps corresponds to a 10^3 = 1000 times increase in energy. Thus, an earthquake of M_W of 7.0 contains 1000times much energy as one of 5.0 and about 32 times that of 6.0.

Forecast and prediction

In the context of earthquake, the term forecasting and prediction are differentiated in a sense that earthquake forecasting is concerned with the probabilistic assesement of general earthquake hazard including the magnitude and frequency of damaging earthquakes in a given era over years or decades. Predicting the earthquakes means the specification of the time, location and magnitude of future earthquakes within defined limits.Geophysicists has found some key scientific facts which can be used to predict and forcast the earthquake:

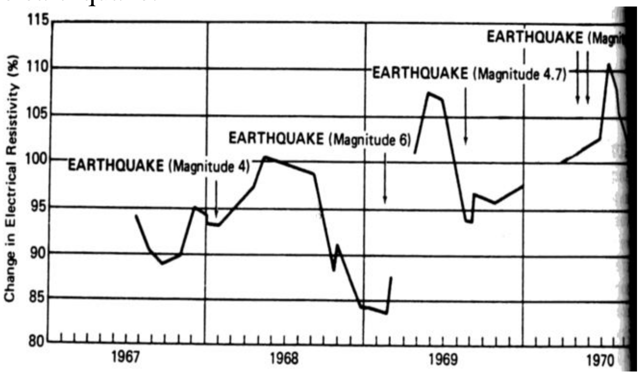

Figure 3: *Changes in electrical resistivity of the earth's crust before an earthquake.*

1) Changes in electrical resistivity before earthquakes have been reported in United States, Russia and China. The graph below indicates the change in electrical resistivity just before the earthquakes.

2) Speed of primary seismic waves may decrease for months and then increases to normal before earthquake.

3) Anamolous uplift or subsidence of the sea is also hint for the prediction.For example, in 1964 during an earthquake of magnitude 7.5 near Nigata, Japan anamolous uplift of the earth crust was noted.

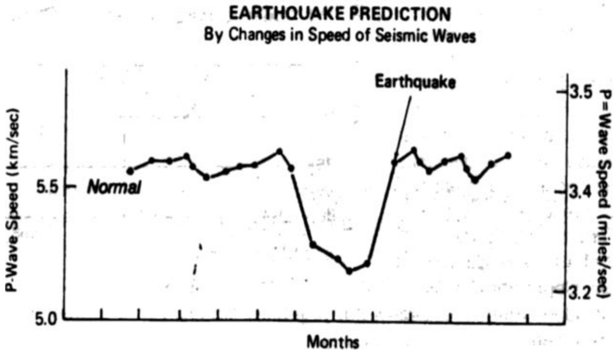

Figure 4: *Special pattern of the fluctuation of speed of primary wave before an earthquake.*

Conclusion

Since the first great earthquake in Liston, Portugal about two hundred sixty years ago, there have been various researches in the related topics of earthquake. At least eight large earthquakes have been successfully predicted since 1965. Now it is our imperative challenge on scientific reincarnation of modern science, with the precise detailed knowledge and gathered information on related earthquake history to exactly pin-point the upcoming disastrous event and which could minimize the collateral damages to our edifices with the help of Physics.

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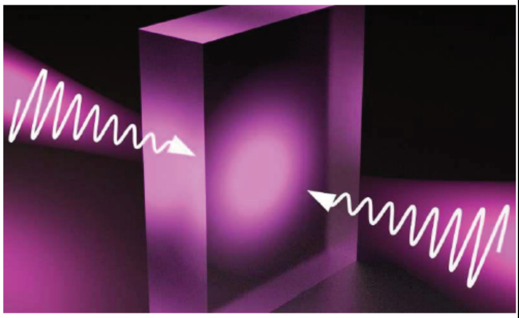
Scientists make transparent materials to absorb light



A group of physicists from Russia, Sweden and the U.S. has demonstrated a highly unusual optical effect. They managed to "virtually" absorb light using a material that has no light-absorbing capacity. The research findings, published in Optica, break new ground for the creation of memory elements for light.

The absorption of electromagnetic radiation, including light, is one of the main effects of electromagnetism. This process takes place when electromagnetic energy is converted to heat or another kind of energy within an absorbing material (for instance, during electron excitation). Coal, black paint and carbon nanotube arrays—also known as Vantablack—appear black because they absorb the energy of the incident light almost completely. Other materials, such as glass or quartz, have no absorbing properties and therefore look transparent. ***Read more at: https://phys.org/news/2017-11-scientists-transparent-materials-absorb.html#jCp***

From Ordinary Crystallography to the

Development of Quasicrystals

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ABSTRACT

Even though there is the absence of five fold rotational symmetry in a crystal lattice, materials having no translational symmetric lattice showing five fold symmetry axes do exist in nature. Quasicrystals are such examples that show the aperiodicity in lattice but have long-range order parameter. New generation of crystals, which not only defied the norms but also changed the entire definition of crystals, are discussed in the article.

Background

The decade of 1980 was very important for the world of physics and chemistry due to surprising discoveries on the structures of matters and their properties. Discovery of fullerene (1985) and the discovery of high-temperature superconductivity (1986) has now redefined the way of our thinking about the properties of matters. Discovery of fullerene suggested the new crystalline form of carbon, completely different than diamond, and graphite. People did not believe that one could have high-temperature superconductivity beyond 30K [1].

Discovery of quasi-crystals (1984), for which Dan Shechtman was awarded the Nobel prize in chemistry in the year 2011, was another amazing breakthrough, which challenged the concept of crystals that was generally believed.

Discovery

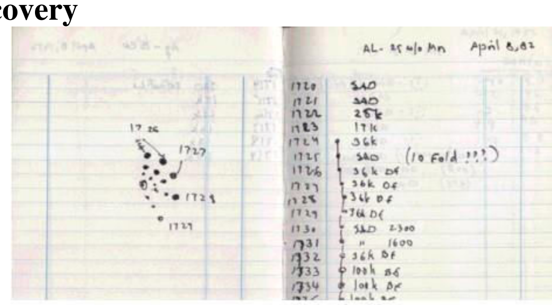

Figure 1: *A page from the diary of Shechtman at the day of the discovery of quasicrystals [2]*

It was the morning of 8th April, 1982, an image appeared in the electron microscope of Dan Shechtman which showed that atoms in the crystals were packed in a pattern, but the pattern was **not repeating** i.e. the crystal **without periodicity** was observed. This discovery became extremely controversial since it was against the conventional wisdom of that time. It defied the laws of the ordinary crystallography established in 1912 basically by Von Laue from X-ray diffraction.

At that time, the international Union of Crystallography defined crystal as: *"a substance, in which the constituent atoms, molecules, or ions are packed in a regularly ordered, repeating three-dimensional pattern"*. All the crystals studied during 70 years from 1912 to 1982 were found to be ordered and periodic. Hundreds of thousands of crystals studied were all **ordered** and **periodic**. It had become very difficult for him to convince his colleagues about his findings and he was asked to leave his research group. Only after two years of incessant battle, he was able to publish the result in a paper[3]. The name 'quasicrystals' was coined in a paper published by D. Levine *et. al*.[4] in the same year.

The ideal or the perfect crystal cannot be grown at all. There always exist some imperfections and defects on the crystals which are even necessary for the thermodynamic stability of crystals. The space group symmetry is one of the important features of crystals. Total 230 space groups have been reported till now each of which is related by the symmetry operations. Among different rotational symmetries, only 2-, 3-, 4- and 6-fold axes were allowed and 5-, 7- and higher rotational axes were not allowed in the ordinary crystallography. The discovery of new crystal was such which had so called "not allowed" rotational 5- fold axis. Electron diffraction from the icosahedral phase has five-fold rotational axes and is not **periodic.**

In Shechtman's work, rapidly solidified alloys of *Al* with 10-14% *Mn* were shown to have long-range orientational order but with an icosahedral point group symmetry. The crystal was inconsistent with lattice translations. According to elementary crystallography, the five-fold axes are inconsistent with the translation order. But as multiple twins, crystals of five-fold axes may occur. They, by means of X- ray diffraction and experiments on electron microscope, concluded that the icosahedral phase does not consist of multiply twinned regular crystal structures [3].

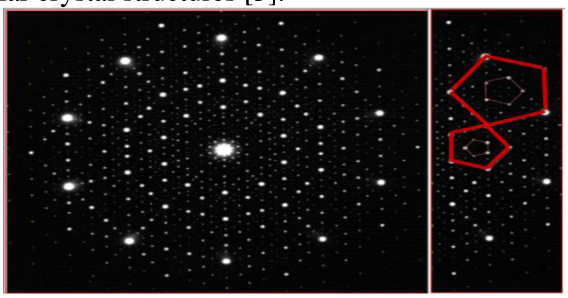

Figure 2: *The electron diffraction pattern of an icosahedral quasicrystal. Note the presence of perfect pentagons highlighted in the diagram to the right. The linear scale between pentagons is and scale between a pentagon inscribed in another is where is called the "golden ratio".*

The sample showed not only the 5- fold but also 2- fold and 3- fold axes, which proved the symmetry of the sample, is not merely the 5- fold but an icosahedral. Shechtman was not unaware of forbidden 5-fold symmetry so his discovery must be taken as the result of his excellent electron diffraction work and the passion. A long time after the discovery, he had to spend a lot of time to convince his colleagues that the crystal has local icosahedral symmetry rather than the twinning shown in the figure below.

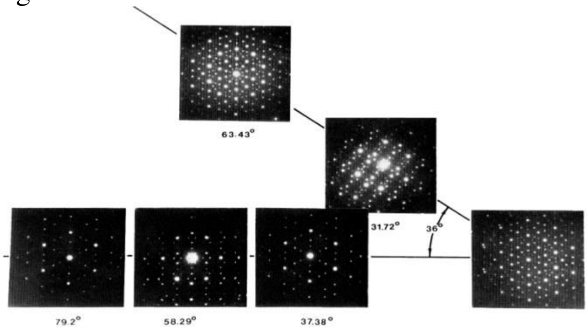

Figure 3: *Selected area diffraction patterns taken from the single grain of icosahedral face [2]*

Through the discovery of quasicrystals, Shechtman made the whole scientific community reconsider their ideas about crystals. And eventually, the definition of crystals was changed to '*any solid having an essentially discrete diffraction pattern*.'

What are Quasicrystals?

Quasicrystals are characterized by the **aperiodicity** (against to ordinary crystals, which all were periodic) in translation but exhibiting long-range order in the diffraction experiment. The lack of translational periodicity is the distinguishable feature of quasicrystals. Interestingly, the symmetry property of quasicrystals is related to so called **"self-similarity by scaling"**. Self-similarity is an important property of non periodic tiling where the same pattern occurs at large and large scale. The idea of self-similarity can be understood by observing the leaf of fern plant in which the whole leaf is similar to its small part of the leaf. Several approaches showed that symmetries which are not crystallographic in 3D can be symmetric if treated in the higher dimensions.

Quasicrystals have low surface energies which make them resistant to corrosion and adhesion and also the low friction coefficients. These properties make them be useful for making non sticky cooking wares. By manipulation its property, called photonic bandgap, improved camouflage techniques can be developed. Basically in periodic crystals, the electrical and thermal properties are influenced by the motion of electrons and phonons in periodic potentials. Due to the lack of periodicity, the electrical and thermal properties of quasicrystals are more likely found in glasses rather than the normal crystals [5].

The naturally occurring quasicrystalline mineral icosahedrite has been found in a sample obtained from the Khatyrka River in Chukhotka, Russia. Quasicrystals, discovered at first by Shechtman in his laboratory were intermetallics. After that, hundreds of intermetallic systems have been shown to yield quasicrystals. After the discovery, large number of experiments over the world is concentrated on the study of other properties like magnetic, optical, thermal, electrical etc. of the quasicrystals. At present, it is the most emerging branch for the new researchers interested in condensed matter physics.

Penrose tiling

The concept of Penrose tiling is very important while discussing the aperiodicity. Tiling is a process of filling the two-dimensional plane by plane figures such that there should be no gap between the tiles and no tiles should overlap. If the plane is filled with structures like triangle, square, regular hexagon, etc., the resultant tiling repeats itself at a regular interval and is called the periodic tiling. The periodic tiling can be achieved by translating the tiles in a given direction thus it has a translational symmetry.

It is also possible to fill the plane by the set of tiles which doesn't repeat at a regular interval and has not the period. Such tiling is called the non-periodic tiling. Penrose tilings are the examples of non periodic tiling having no translational symmetry. There are several ways of non-periodic tiling. The original pentagonal Penrose tiling, often denoted by (P_1) consists of five-pointed star, a boat and a diamond as shown in figure (4). The kite and dart tiling (P_2), shown in figure (4) consists of the tiling by specially constructed kites and darts such that the ratio between tile lengths must be equal to the golden ratio. The P_3 type of tiling called the rhombus tiling uses the pair of tilings of equal sides but with different angles. Quasicrystals are the physical implications of Penrose tiling producing the discrete Bragg's diffraction pattern showing both five-fold symmetry and long-range order too [6].

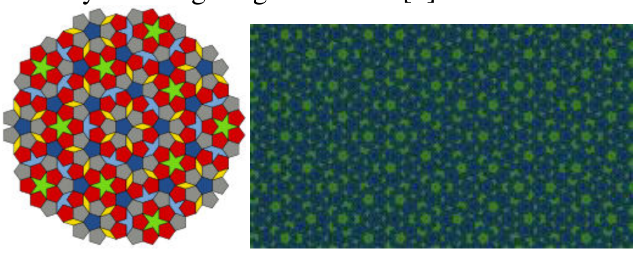

Figure 4: *P1 type of Penrose tiling (up) and P2 type of Penrose tiling (down) [5].*

At a glance

It was our pleasure that the noble laureate Dan Shechtman came to Nepal in the year 2016, during the 13th International Conference on Quasicrystals (ICQ13). He visited our Central Department of Physics too.

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The Dream of A Final Theory

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ABSTRACT

In this article, we will discuss about the journey of the development of physics. We begin from the rational argument of Galileo to the present day understanding of physics and discuss about the possibility of achieving the final goal of understanding the core reality of our universe citing it to be the destination point of the present day physics.

Magnificant Journey

Physics is the study of nature, which governs the fundamental working of our universe. From the scientific point of view, our universe has an origin and follows a specific pattern. This facilitates us to comprehend our universe in few bunches of equations or even a single equation. It is to be noted that mathematics follows physics in a very parallel way. Mathematics is nothing special or specific, it is just the flow of patterns without any end.

The rational physics began with Galellio in 16th century when he came up with an idea of inertia of motion. Newton followed the idea of inertia and related it with mass thereby formulating the famous "*Newton's laws of motion*". He also defined the dynamics of celestial bodies in terms of the gravitational force following the inverse square law. At that period of time, physicists thought in terms of moving mass, collisions and exchange of momentums as defined by the Newton's laws of motion; the entire universe was thought to be governed by this Newtonian picture.

Figure 1: *Einstein Field Equation remarkedly extended the concept of energy-momentum to the geometry of space-time.*

In the 18th century, the viewpoint of mechanical dynamics went deeper with Lagrange's formulation of mechanics. He considered the idea of system and field to be fundamental and Newtonian interactions as just the effect. Moreover, the Hamiltonian formulation gave emphasis on the entire dynamical path of the system considering the field view point. The inclusion of momentum as the generalized variable made the mechanical system more predictive and later on paved the way for quantization on 20th century. In 19th century, the most important discovery was unification of electromagnetism. Maxwell's unification of electromagnetism gave one of the most beautiful discoveries of physics: electromagnetic waves. Sadly, Maxwell himself could not understand the Maxwell's equation completely. This was a tragedy of 19th century.

However, in early 20th century, Einstein unified the laws of inertia with Maxwell's equation formulating special theory of relativity (STR); eventually, formulated the most famous equation$E = mc^2$. In the same way, he expounded that the Newtonian gravity was not compatible with special relativity. Thus, he then came up with the most groundbreaking idea: the "*Principle of equivalence*". After 10 years of STR, he formulated the general theory of relativity (GTR), where he established gravity not to be as a force but as the curvature in space-time. Eventually, STR and GTR modified the understanding of earlier centuries notion. Newtonian viewpoint considered space and time as separate and absolute entities; whereas, STR explicated both the space and time to be related to each other forming the entity called "space time". And GRT showed that space-time geometry curves with the presence of nearby mass, and thus, the entire celestial dynamics was no more due to the Newtonian gravitational interactions. In fact, all the celestial bodies were just following the shortest possible path in the curved space-time rather than interacting with each other as described by Newton.

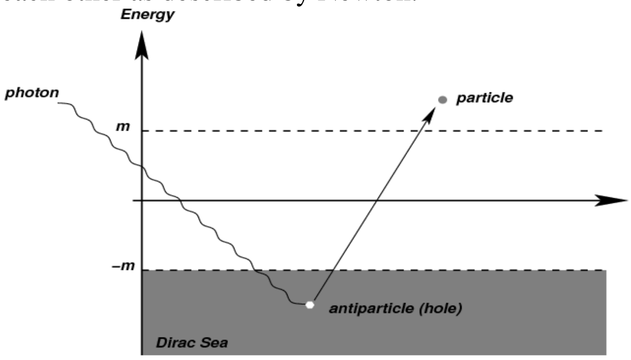

Figure 2: *Dirac surprised everyone by saying the negative energy state for antiparticle, which exists in the observable Universe.*

20th century also began with Planck's idea of "*quanta*", whereas, Einstein was ingenious enough to generalize the idea of quantization of electromagnetic wave explicating the photoelectric effect. Bohr came up with the groundbreaking idea of quantized orbit, which posted the imprint of quantization of energy, momentum, and founded the basis of quantum mechanics. In early 1920's, De Broglie formulated matter wave and Schrodinger derived its equation. But what was waving? It was the conundrum of that time. According to Max Born, waving was the probability of finding the particle in the definite region was waving. Heisenberg, in the same fashion, showed the unpleasing limitation of nature formulating the uncertainty principle. Altogether, the physics community came up with an idea of Copenhagen interpretation of quantum mechanics which considered observer and measurement to be the fundamental aspect of quantum reality.

In late 1920's, Schrodinger wave equation was combined with STR resulting the Klein Gorden formalism and Dirac equation. That led to the first theoretical understanding of intrinsic spins of fundamental particles and perhaps the most important discovery of particle physics: antiparticle. Dirac explained the obtained negative energy to be of physical importance, and the antiparticles were defined as an unoccupied state of the negative energy (Dirac hole). Dirac's relativistic quantum picture (interaction picture) entered into the beginning of the quantum field theory. Similarly, quantization of Maxwell's equation was done after the formulation of renormalization techniques (independently by Richard Feynman and J Schwinger), which solved the problem of infinities occurring in quantization. Hence, formed the field of quantum electrodynamics (QED)! Then, the fundamental particles theorized with the idea of quantized fields consisting of virtual particles and exchange forces. Physicists then began to merge interactions, formulating the gauge theory which stands on the base of Noether's theorem. Electroweak theory, the combination of electromagnetism and weak interaction, was done eventually. Presently, we have the standard model to explain all the fundamental particles and the four fundamental interactions: electromagnetic, gravitational, weak, and strong.The electroweak interaction and strong interaction are modelled in gauge group SU(3) x SU(2) x U(1).

Finally, we have the gluonic field for strong interaction between quarks, weak field comprising W-Z bosons and commonly known electromagnetic and gravitational fields. Similarly, we also have higgs field filled all over the space such that any particle interacting with the field possess mass relative to the intensity of interaction.

To put abovementioned facts in a nutshell, the final goal of present day physics is to unify all the four interactions into a same gauge theory. This will probably end the chapter of our understanding. But will it.....? The solution of this riddle is really difficult to find but not impossible. We haven't been able to quantize gravity successfully. Many attempts have formulated different models like string theory, M theory, super symmetric models, etc.; however, all of them have failed to give experimental verifications. The astronomical observations leading to the model of "*dark matters*" and "*dark energy*" have always questioned over the firm foundation of GTR; that means GTR may not also be the profound theory of gravity. Hence, a new theory on gravity may be indispensible to deal our universe profoundly. In addition, we can even question on the measurement based foundation of our quantum theory i.e. our quantum theory may also need a profound modification on its foundation. Moreover, *Godel's Incompleteness theorem* of mathematics makes us think mathematics may not also be perfect enough to define the complete truth of nature.

To sum up

Dealing positively, if our universe is a well defined process, we must have a specific model or equation or formulation to define it. The physics, in fact, should end at the most fundamental point of our knowledge such that there remain no more core chapters to unfold. Hopefully, we will be able to see the end of physics conundrum within our lifetime.

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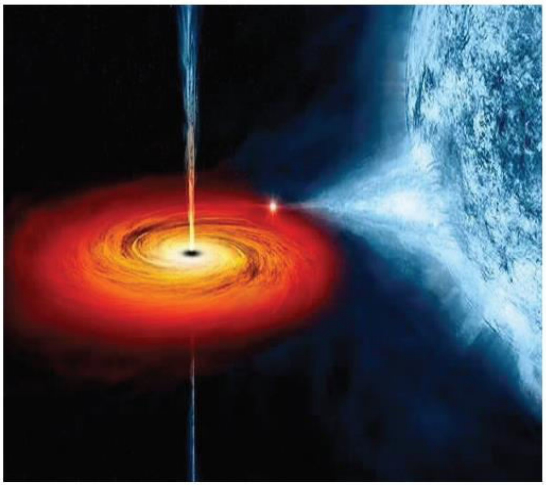
Physicist explores the possibility of vestiges of a universe previous to the Big Bang

The Big Bang theory is the best known and most accepted explanation for the beginning and evolution of the universe, but it is hardly a consensus among scientists. Brazilian physicist Juliano Cesar Silva Neves is part of a group of researchers who dare to imagine a different origin. In a study recently published in the journal General Relativity and Gravitation, Neves suggests the elimination of a key aspect of the standard cosmological model: The need for a spacetime singularity known as the Big Bang.



Detection of Gravitational Waves: New Perspective to view the Universe

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ABSTRACT

The detection of Gravitational Waves after the 100 years of Einstein's prediction in his General Theory of Relativity marks one of the groundbreaking astrophysical discoveries of past century. This article attempts to quench the quest about Gravitational Waves and detection of them by LIGO. Nobel prize in physics for 2016 is awarded for this discovery. We also strive to explore how detection of Gravitational Waves facilitates us to study the universe.

Introduction

Sir Isaac Newton pictured Gravitation through some sort of force that objects pull each other and mathematically described that force. However, he could not articulate the mechanism of exerting its influence. Albert Einstein came along and articulated the idea that this force is communicative in his General theory of Relativity. GeneralTheory of Relativity explicates gravitation as a consequence of the curvature of space-time, while in turn space-time curvature is a consequence of the presence of matter. Space-time tells matter how to move, and matter tells space-time how to curve. Anything with mass and/or energy causes the distortion on Space-time fabric. When the mass accelerates changing the distortion, create ripples (like the movement of the waves away from stone thrown into the pond) in the fabric of space itself. Those ripples on Space-time fabric are known as Gravitational Waves.

How Gravitational Waves are produced?

Every accelerating object having mass can produce the Gravitational Waves. The amplitude of wave is proportional to the mass of the accelerating object. The Gravitational waves produced by the things on the Earth are too small to detect. It isn't remotely possible to generate the detectable Gravitational wave by any tools of Earth.The only waves we can detect are those produced by nature due to catastrophic events: colliding black holes, the collapse of stellar cores (supernovae), coalescing neutron stars or white dwarf stars, the slightly wobbly rotation of neutron stars that are not perfect spheres, and the remnants of gravitational radiation created by the birth of the Universe itself.

Laser Interferometer Gravitational wave Observatory (LIGO)

Laser Interferometer Gravitational-wave Observatory aberrated as LIGO is an observatory consisting of two widely separated Interferometers, one in Hanford, Washington and next on Livingston, Louisiana designed to detect Gravitational Waves as predicted by Einstein's General Theory of Relativity.LIGO is sensitive enough to detect change in distance between its mirrors up to 1/10,000th the width of a proton and has the world's largest vacuum chamber after Large Hardon Collider, Switzerland.

It has two "*blind*" perpendicular, L-shaped arms with 4 km long vacuum tunnel.A powerful laser is splits and travels down to two identical tunnels, bounces off mirrors at the ends of these tunnels, and returns to recombine. If the two arms of the interferometer are exactly the same length, the light travelling down the tunnels will take the exact same amount of time to make this trip, and the beams will combine to create no signal in the detector. However, if a gravitational wave changes the length of the interferometer arms, the light will take a little more time to travel down one arm compared to the other, resulting in a signal when the beams recombine. When Gravitational Waves passes through the observatory, it stretches one arm and compresses the next. By measuring the interference of the lasers physicist can measure precisely whether the space in between has stretched or compressed.

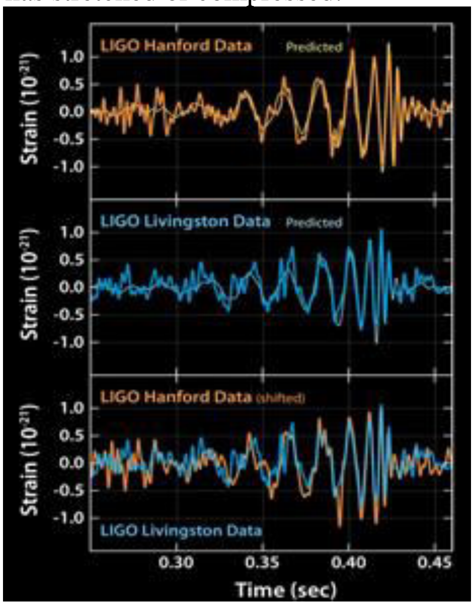

Figure 1: *Plot of signals of Gravitational Waves detected by the twin LIGO observatories at Livingston, Louisiana, and Hanford, Washington.*

On September 14, 2015, the LIGO detectors made the world's first direct detection of gravitational waves, heralding a new era in astronomical exploration. The gravitational waves detected were generated by two black holes colliding and merging into one nearly 1.3 billion light years away.

These plots show the signals of gravitational waves detected by the twin LIGO observatories at

Livingston, Louisiana, and Hanford, Washington. The signals came from two merging black holes, each about 30 times the mass of our sun, lying 1.3 billion light-years away.

The top two plots show data received at Livingston and Hanford, along with the predicted shapes for the waveform. These predicted waveforms show what two merging black holes should look like according to the equations of Albert Einstein's general theory of relativity, along with the instrument's ever-present noise. Time is plotted on the X-axis and strain on the Y-axis. Strain represents the fractional amount by which distances are distorted.

As the plots reveal, the LIGO data very closely match Einstein's predictions.The final plot compares data from both detectors. The Hanford data have been inverted for comparison, due to the differences in orientation of the detectors at the two sites. The data were also shifted to correct for the travel time of the gravitational-wave signals between Livingston and Hanford (the signal first reached Livingston, and then, traveling at the speed of light, reached Hanford seven thousandths of a second later). As the plot demonstrates, both detectors witnessed the same event, confirming the detection.(Cited from :-https://www.ligo.caltech.edu/)

New Era of Astronomy

Till the date, the only way of observing Universe was through Electromagnetic Spectrum (Radio waves, Light & so on).But the recent detection of Gravitational waves has opened our eyes wider to view the universe. With Electromagnetic Spectrum, we are unable to trace the very early universe as it was filled with opaque plasma of protons and electrons that absorbed any electromagnetic waves. The case is different with gravity. It cannot be shielded being a universal attractive force as there's no such things that can absorb gravitational waves.This means that gravitational waves (unlike electromagnetic waves) could, in principle, be left over from the very early Universe. Although these would be very scrambled and attenuated by now, perhaps they will still contain meaningful information about the beginning of the Universe.

Gravitational waves may even point the way toward a grand unified theory of the universe. Theory suggests that at some point in the universe's history, all four fundamental forces were united into a single force. As the universe expanded and cooled, the forces split off from one another in a series of as-yet poorly understood events.

Path to explore other mysteries like short gamma-ray bursts – mysterious and incredibly bright electromagnetic phenomena. They might also facilitate to comprehend where much of the universe's heavy elements, like uranium, thorium and gold, are forged.In addition, the signals from black hole mergers could assist us in discerning the nature of dark energy.

Summary

It's the first time the universe has spoken to us through gravitational waves. Further detection of Gravitational, for sure, will help us to unravel the mystery behind the law that governs our universe through the beginning.

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EXPERIMENT SHOWS THAT arrow of time IS A relative CONCEPT, NOT AN absolute ONE

An international team of researchers has conducted an experiment that shows that the arrow of time is a relative concept, not an absolute one. In a paper they describe their experiment and its outcome, and also explain why their findings do not violate the second law of thermodynamics.

The second law of thermodynamics says that entropy, or disorder, tends to increase over time, which is why everything in the world around us appears to unfold forward in time. But it also explains why hot tea grows cold rather than hot. In this new effort, the researchers found an exception to this rule that works in a way that doesn't violate the rules of physics as they have been defined.

The experiment consisted of changing the temperature of the nuclei in two of the atoms that exist in a molecule of *trichloromethane* - hydrogen and carbon - such that it was higher for the hydrogen nucleus than for the carbon nucleus, and then watching which way the heat flowed. The group found that when the nuclei of the two atoms were uncorrelated, heat flowed as expected, from the hotter hydrogen nucleus to the colder carbon nucleus. But when the two were correlated, the opposite occurred—heat flowed backward relative to what is normally observed. The hot nucleus grew hotter while the cold nucleus grew colder. This observation did not violate the second law of thermodynamics, the group explains, because the second law assumes there are no correlations between particles. ***Read more at: https://phys.org/news/2017-12-arrow-relative-concept-absolute.html#jCp***

Once Again Spin Revisited

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ABSTRACT

The main idea of this article is to introduce the idea of spin in synchronized way. We first view spin through the classical picture. And we finally extend our observation to the relativistic quantum mechanics which concludes spin to be the fundamental property of all the elementary particles of natur.

Spin is the fundamental property of quantum particles. It explains their nature and categorization in the standard model of particles. The spin of quantum particles such as an electron is profoundly different from that of classical particles. Development of the concept about spin of an electron came with the observation of fine spectra of radiation when a hydrogen atom was placed in the magnetic field. But modeling the spin in theoretical picture classically is very difficult. Classically if we consider an electron to be a point particle, its intrinsic angular momentum vanishes unless its angular velocity 'ω' is infinitely large. So classically, quantum particle to possess intrinsic angular momentum cannot be considered as a point particle, instead, they must be considered a tiny spinning sphere. But under the consideration of finite size, the particles like electron to attain the experimental intrinsic angular momentum ħσ/2 require the surface of particle moving with velocity greater than speed of light but this is not possible. So we require more deep quantum mechanical treatment to tackle the problem.

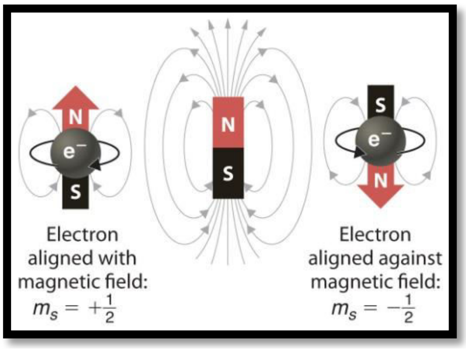

Figure 1: *Spin of an electron in the magnetic field.*

We know the quantum version of $\mathbf{L} = \mathbf{r} \times \mathbf{p}$ gives the orbital angular momentum of the particles like an electron moving in an orbit around the nucleus. Even if a point particle having zero momentum ($\mathbf{p} = 0$) has zero orbital angular momentum, its total angular momentum is not zero. This is because of the angular momentum due to the intrinsic spin of that particle. Thus the spin of a particle is what is left after the contribution of the orbital angular momentum to the total angular momentum has been removed. Therefore, we can say that the spin of a particle is its intrinsic angular momentum associated with the internal degree of freedom of that particle.[1] The spin of a particle neither stops nor increases but its orientation may change[2]. Pauli gave the spin operator of an electron as $\mathbf{S} = \hbar\boldsymbol{\sigma}/2$, where $\boldsymbol{\sigma}$ is Pauli spin matrix. The above explanation about spin is in non-relativistic quantum mechanics. Klein-Gordon equation is the first relativistic quantum Schrödinger wave equation that mixed special relativity with quantum mechanics and equation and is given as

$$\Box^2\Psi = \frac{m_0^2c^2}{\hbar^2}\Psi$$

The probability current density given by this Klein-Gordon equation is negative and the time derivative in this equation is in second order. Paul Dirac gave the famous Dirac Equation to ridicule this problem which is given by

$$(i\hbar\frac{\partial}{\partial t} + i\hbar c\hat{\alpha}\cdot\nabla - \hat{\beta}m_0c^2)\Psi = 0$$

Where,

$$\hat{\alpha} = \begin{pmatrix} 0 & \hat{\sigma} \\ \hat{\sigma} & 0 \end{pmatrix} \text{ and } \beta = \begin{pmatrix} 1 & 0 \\ 0 & -1 \end{pmatrix}$$

The orbital angular momentum of an electron satisfying Dirac Equation in central field is not conserved quantity i.e. angular momentum does not commute with Dirac Hamiltonian. To make the orbital angular momentum conserved quantity, we need to add a new term to the orbital angular momentum. This added term is intrinsic angular momentum, i.e. $\mathbf{S} = \hbar\boldsymbol{\sigma}/2$. Hence Dirac successfully proved that the spin of an electron is its intrinsic property.[3]

However, we can explain the true meaning of the spin of the particles in relativistic quantum field theory. In relativistic quantum field theory, a field is introduced to every particle species, which transforms under the Lorentz transformation in a non-trivial way. Then, the field already carries spin. If we can quantize a field, then field operator can create or annihilate a particle of definite spin. Therefore the spin of a quantum particle is just a property there when you introduce a field to it. For example, if you get a quark by quantizing a quark field, the quark field already carries spin. The question, which can arise now, is how do we choose spin when we introduce a field? A re-normalizable quantum field theory can deal with only spin 0, ½ and 1. If the gravity is quantized consistently, a particle with spin-2 called graviton will be found. But till now no one has been able to do this work.[2]

Particles like Higg's boson and Pion having spin-0 are called scalars and are governed by a relativistic wave equation called Klein-Gordon Equation. Particles like electrons, neutrinos, quarks, etc having spin-1/2 are called spinors and are governed by the famous Dirac Equation. Similarly, particles like photons, W's and Z's having spin-1 are called vectors and explained by another relativistic Schrödinger wave equation discovered by Alexandru Proça. Hopefully, in future, we expect to have a single relativistic Schrödinger Equation explaining all spin particles.[6]

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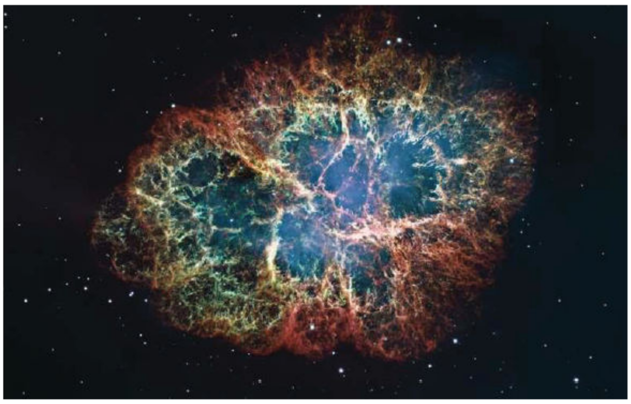
REACHING FOR NEUTRON STARS:

Research finds thick skin of atomic nucleus



For more than a decade, a cross-disciplinary team of chemists and physicists in Arts & Sciences at Washington University in St. Louis has been chasing the atomic nucleus. With progressive studies, they moved up the element chain to Calcium-48, an extremely rare solid commodity that has more neutrons than protons and, as such, carries a hefty price tag of $100,000 per gram. It is a quirky material, with this particular study taking Washington University chemists Robert J. Charity and Lee G. Sobotka from Duke's Triangle Universities Nuclear Laboratory to the Department of Energy's Los Alamos (N.M.) National Laboratory.

"If you leave it on a table, it turns to powder," said co-author Charity, a research professor of chemistry in Arts & Sciences. "Calcium oxidizes very quickly in air. It was a worry."

Ultimately, three grams of Ca-48 helped to produce a double-edged finding for Charity and co-author Willem H. Dickhoff, professor of physics. Their team discovered both a framework to predict where neutrons will inhabit a nucleus and a way to predict the skin thickness of a nucleus. In their research published Nov. 29 in Physical Review Letters, they predicted how the neutrons would create a thick skin, and that this skin of Ca-48—3.5 femtometers (fm) in radius—measured 0.249 + 0.023 fm. To convert that into centimeters, it would measure 2.49×10^{-14} cm. The researchers say the key finding is that the skin is thicker and more neutron-rich than previously believed.

"*That links us to astrophysics and, in particular, neutron-star physics,"* Dickhoff said of the research results. "The Los Alamos experiment was critical for the analysis we pursued. In the end—because it has this additional set of neutrons—it gets us to information that helps us to further clarify the physics of neutron stars, where there are many more neutrons relative to protons.

"And it gives us the opportunity to predict where the neutrons are in Ca-48," Dickhoff said. "That is the critical information, which leads to the prediction of the neutron skin."**Read more at: https://phys.org/news/2017-11-neutron-stars-group-framework-thick.html#jCp**

Contribution of Women to Physics

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ABSTRACT

Women have made great achievement to science from the earliest times. The involvement of women in the field of medicine occurred in several early civilizations and the study of natural philosophy in ancient Greece was open to women. Women contributed to the proto-science of alchemy in the first or second centuries AD. Although gender roles were largely defined in the eighteenth century, women experienced great advances in science. During the nineteenth century, women were excluded from most formal scientific education, but they began to be admitted into learned societies during this period. In the later nineteenth century the rise of the women's college provided jobs for women scientists, and opportunities for education. Despite facing challenges, pioneering women scientist made contribution to physics between 1876 and 1976. Nevertheless, most of these women were systematically left out of history books. Some of the women changed the history of physics.

Chien-shiung Wu

Chien-shiung Wu was invited to work on the secret Manhattan Project, where she made significant contributions to the war effort and began making improvements in the equipment used to measure radioactive materials. That was only the beginning, and, as this volume explained, Wu went on to make many important contributions in physics. Wu had to stand up against discrimination against women and Asians. As she worked in her lab and as she taught classes, her remarkable abilities allowed her to overcome these impediments. Her talent and work ethic also allowed her to examine some of the most important problems of the time. Nuclear physics was still in its adolescence, and Wu's contributions helped shape the world in which we live today. Wu showed that parity is not conserved, bringing about a revolution in physics. , This enabled physicists to understand the true for the current understanding of how elementary particles behave. As soon as Wu arrived in the United States, Wu took up the fight against these injustices. She was elected as president of American Physical Society and used that position to promote physics to women. Although she died of a stroke on February 18, 1997, in Manhattan, Wu lives on through her students and her work. Beyond the actual results she obtained, Her extremely high standards are still with us, a legacy that will never die.

Vera Cooper Rubin

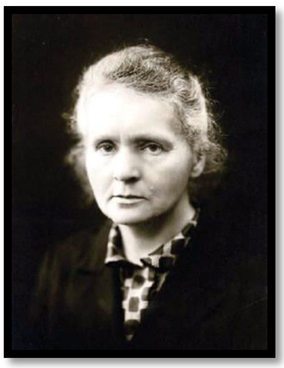
Vera Cooper Rubin (July 23, 1928 – December 25, 2016) was an American astronomer who pioneered work on galaxy rotation rates. She uncovered the discrepancy between the predicted angular motion of galaxies and the observed motion, by studying galactic rotation curves. This phenomenon became known as the galaxy rotation problem. Although initially met with skepticism, Rubin's results were confirmed over subsequent decades. She transformed modern physics and astronomy with her observations showing that galaxies and stars are immersed in the gravitational grip of vast clouds of dark matter. Her work helped usher in a Copernican-scale change in cosmic consciousness, namely the realization that what astronomers always saw and thought was the universe "*is just the visible tip of a lumbering iceberg of mystery*."

Jocelyn Bell Burnell

Dame Susan Jocelyn Bell Burnell (born 15 July 1943) is a Northern Irish Astrophysicist. As a postgraduate student, she discovered the first radio pulsars while studying and advised by her thesis supervisor Antony Hewish for which Hewish shared the Nobel Prize in physics with astronomer Martin Ryle, while Bell Burnell was excluded, despite having been the first to observe and precisely analyse the pulsars. Bell Burnell was elected as President of the Royal Society of Edinbergh in October 2014. In March 2013 she was elected Pro-Chancellor of the University of Dublin.

Marie Curie

Marie Curie, the first woman to receive a Nobel Prize in 1903 (physics), went on to become a double Nobel Prize recipient in 1911 (chemistry), both for her work on radiation. Forty women have been awarded the Nobel Prize between 1901 and 2010. 17 women have been awarded the Nobel Prize in physics, chemistry, physiology or medicine. When asked to name an important woman scientist, most people would only hesitate a short time before answering, "Marie Curie." The reasons seem obvious. Marie Curie made one of the most important theoretical breakthroughs of the twentieth century when she postulated that radiation was an atomic rather than a chemical property



Marie Skłodowska Curie (7 November 1867–4 July 1934), was a Polish and naturalized French Physicist who conducted pioneering research on radioactivity. She was the first women to win Novel prize, the first person and only woman to win twice, the only person to win a Nobel Prize in two different sciences, and was part of the Curie family legacy of five Novel Prizes. She was also the first woman to become a professor at the University of Paris, and in 1995 became the first woman to be entombed on her own merits in the Panthenam in Paris.

She shared the 1903 Novel Prize in Physics with her husband Pierre Curie and with physicist Henri Becquerel. She won the 1911 Novel Prize in Chemistry. Her achievements included the development of the theory of *radioactivity*, techniques for isolating radioactive isotopes, and the discovery of two elements, polonium and radium. She founded the Curie institute in Paris and in Warsaw, which remain major centres of medical research today.

Sandra Moore Faber

Sandra Moore Faber (born December 28, 1944) is a University of Astronomy and Astrophysics at the University of California, Shanta Cruz and works at the Lick Observatory. She has made important discoveries linking the brightness of galaxies to the speed of stars within them and was the co-discoverer of the Faber-Jackson relation. Faber was also instrumental in designing the Keck telescope in Hawaii.

Hedy Lamarr

Hedy Lamarr (born Hedwig Eva Maria Kiesler, November 9, 1914– January 19, 2000) was an Austrian and American film actress and inventor. Lamarr appeared in numerous popular feature films, including *Algiers* (1938), *I Take This Women* (1940), *Comrade X* (1940), *Come Live With Me* (1941),H. M. Pulham, *Esq.* (1941), and Samson *and Delilah* (1949).

At the beginning of World War II, Lamarr and Composer George Antheil developed a radio guidance system for Allied torpedoes, which used spread spectrum and frequency hoping technology to defeat the threat of jammng by the Axis powers. Although the Us Navy did not adopt the technology until the 1960s, the principles of their work are now incorporated into modern Wi-Fi, CDMA, and Bluetooth technology, and this work led to their induction into the National Inventors Hall of Fame in 2014.

Ursula Franklin

After earning a PhD in experimental physics in Berlin, Ursula Franklin move to Canada, Eventually becoming the first Female professor in the university of Toronto's Faculties Of Engineering. A tireless pacifist, feminist

and human rights advocate, her works on nuclear blast fallout led to the end of atmospheric weapons testing.

Fabiola Gianotti

Fabiola Gianotti (born October 29, 1960) is an Italian Physicist, currently CERN (European Organization for Nuclear Research)

Director-General and the first woman to hold this position. Her mandate began on 1 January 2016 and runs for a period of five years

Since 1996, following several postdoctoral positions, including a fellowship at CERN, she has been a research physicist in the Physics Department of CERN, the European Organization for Nuclear Research, and since August 2013 an honorary Professor at the University of Edinburgh.She is also a member of the Italian Academy of Sciences, foreign associate member of the US National Academy of sciences and foreign associate of the French Academy of science.

Gianotti has worked on several CERN experiments being involved in detector R&D and construction, software development and data analysis. Gianotti is the author or co-author of more than 500 publications in peer-reviewed scientific journals. She has given more than 30 invited plenary talks at the major international conferences in the field.

As far as contribution of women in physics is a huge. Some of the women physicist, we can not forget them ever. Lise Meitner helped in discover of nuclear fission. Emmy Noether was a pioneer of abstract algebra. Cecilia payne Gaposchkin found that Sun is mostly of hydrogen and helium. Lene Hau slowed a beam of light down to the pace of a fast bicycle ride. Then, in 2001, the Danish Physicist stop light completely. Now famous work holds important implications for quantum computing and quantum cryptography.

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The Mystery of Higgs Boson

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ABSTRACT

The discovery of Higgs boson in 2012 has open many roads on the journey to further understanding of the fundamental particles and forces of nature. Higgs energy field exists everywhere in the universe. Scientists believe that the Higgs boson is the particle that gives all matter its mass. The main objective of this article is to describe how the mass obtained in the fundamental particle .

Introduction

The universe is composed of space, energy, and matter. Here, space is a dynamic entity which is continuously expanding. Energy and mass are completely compatible with each other given by the famous energy mass relation $E = mc^2$. In the standard model, the mass possessed by the fundamental particles has always been a huge matter of concern among the physicists. This model describes three types of forces: electromagnetic interactions, which relates to electric and magnetic fields; strong interaction, which binds atomic nuclei; and the weak nuclear force, which governs the beta decay.

Sheldon L. Glashow, Steven Weinberg, Abdus Salam – the Nobel Prize-winning physicists of 1967, unified the two of four forces of nature, electromagnetism and weak nuclear force. The force carriers of electromagnetism are massless photons but the W and Z bosons are force carriers of the nuclear weak force which are about hundred times as massive as protons. The explanation of the reason behind the massive nature of W-Z bosons seemed as a huge hurdle in the 1960s. It was also believed that the cause of electroweak symmetry breaking was electroweak interaction but the actual reason was unknown [1].

To solve this problem, Peter Higgs proposed an idea of Higgs mechanism in a field existing throughout the space called Higgs field. The Higgs field breaks the certain symmetry of the electroweak interaction and makes the W-Z bosons massive. In July 2012, physicists announced from Large Hadron Collider (LHC), the Higgs boson and its mass lie in the range between 125 and 127 GeV/c^2.The Large Hadron Collider (LHC) is the world's largest and most powerful particle accelerator. This LHC recreated conditions that have not existed in the universe since after the big bang. Thus, Nobel Prize committee announced 2013 Nobel Prize to Francois Englert and Peter Higgs for such contribution. The center of the 2013-Nobel prize in physics was the standard model of particle physics which describes how the world is constructed.

Higgs bosons are also referred to as "*the God particle*" because it is believed to be the cause of the "Big Bang" that created the universe . The discovery of Higgs boson confirms previous theories surrounding matter and how it works in compliance with the universe. A trillionth of a second after said Bang, an energy force described by scientists as the Higgs field was turned on and as the universe grew, so did the field. It's this field that began to impart mass on its subjects and was used to discover the Higgs boson.When electroweak symmetry breaks, three of the four degrees of freedom from the original Higgs doublet are Goldstone modes, but these are the ones that are paired up and make the vector bosons massive. There is one degree of freedom left, and that is the Higgs boson.

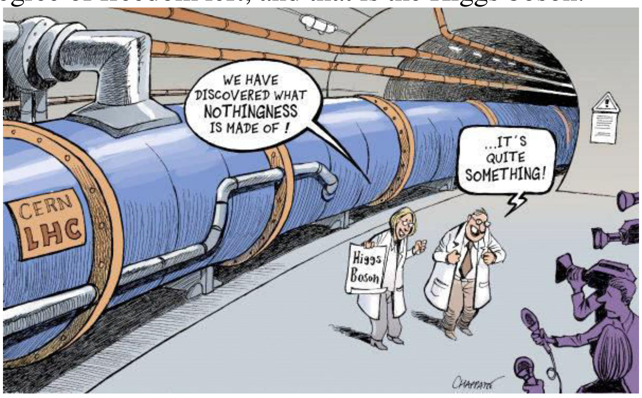

Figure 1 : *The cartoon of the Higgs boson and LHC*

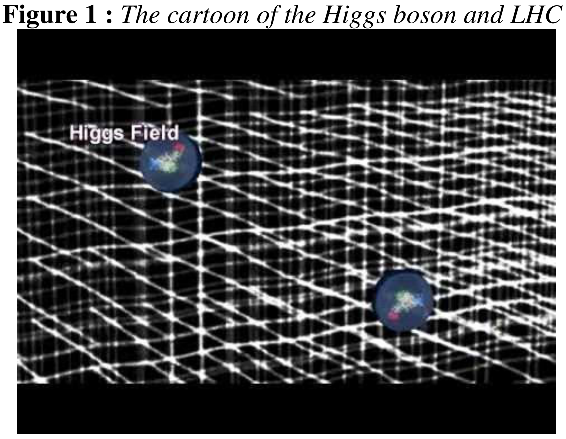

Figure 2: *The portrait view of the particles in Higgs field.*

According to distinguished scientist Chris Quigg, quantum field theory is one of the great recent achievements of modern physics. The weak and electromagnetic interactions are understood to arise from a common symmetry. Symmetry is one of the most important concepts that deal with the phenomena of nature. It connects the physical theory with mathematics and the extent to which mathematics suggests the study of the law of nature with the logical view. Symmetry can be exact, approximate or broken and all of these symmetries take a great meaning for the connection of physics with mathematics. The exact symmetry means unconditionally valid, approximate symmetry means valid under certain condition and broken symmetry means a different thing, depending on how the object are considered physically [2].

One of the most important concepts about mass is the coupling spring of the particles which interacts with the Higgs fields. As we know, $m = f/(h/c^2)$, the more the particle oscillates in the field, more mass is given out of this field. So, we can use this simple concept as an analog with the spring system of particle that executes the simple harmonic motion.

When a particle enters into the Higgs field, they interact and oscillate in the field. The Higgs field is thought to be everywhere in the universe. Without its existence, particles would have no mass and would float around in the space freely at the speed of light. That means the gravity would not exist because the mass would not be there to involve in the interaction. Thus, Higgs mechanism provides mass to the fundamental particles of nature or in fact to all the constituents of the universe [3].

Conclusion

Fifty years ago, physicists had no idea why some particles had mass and other particles didn't. They have been searching for the Higgs field ever since. Particles that interact with Higgs have field. The electrons barely react with field due to the very small mass they possess. The quarks interact more strongly with the field as they have large mass in comparison to that of the electrons. W and Z bosons plod through the Higgs field as they have thousands of times more mass in comparison to both the electrons and quarks. However, the massless photons and gluons do not interact with the field at all. Thus, the more strongly a particle interacts with Higgs field, the more massive it is.

In conclusion, the discovery of Higgs boson in 2012 has opened many roads on the journey to further understanding of the fundamental law of nature. Hopefully, we can expect to unfold many more mystery chapters of our nature as the continuation of this discovery.

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The mysterious star MWC349

Molecular clouds in interstellar space can sometimes produce natural masers (the radio wavelength analogs of lasers) that shine with bright, narrow beams of radiation. Regions of active star formation generate some of the most spectacular such masers—in one case radiating as much energy in a single spectral line as does our Sun in its entire visible spectrum. In these sources, the maser radiation comes from molecules like water or OH that are excited by collisions and the radiation environment around the young stars.

In 1989, maser emission from atoms of atomic hydrogen gas was discovered around the star MWC349, a source with a disk of ionized material that is seen edge-on and a bipolar outflow. The emission is extremely bright and varies in time, the result of sensitivity to changes in the detailed excitation processes. Subsequent observations over the decades have found numerous masing hydrogen lines around this star, allowing scientists to model the emitting region more carefully. MWC349 has two particularly mysterious features. First, it is an almost unique example of a hydrogen maser source, Despite decades of searching for similar sources, only a few other examples have been found, and they are all much fainter and less dramatic. The second is that its age is not known: it has been suggested to be a very young star still approaching the main-sequence, or an evolved star well into its main-sequence evolution. The consensus so far—that it is old—comes from the fact that there is another star only a few arcseconds away from it and possibly a binary companion. That star is older, about five million years, and so the MWC349 itself must be that old as well. But the evidence is confusing, and the rare and unusual nature of the object makes its age classification an astronomical priority.

Read more at: https://phys.org/news/2017-12-mysterious-star-mwc349.html#jCp

The Lunar Laser Ranging Experiment

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ABSTRACT

The Lunar Laser Ranging (LLR) experiment, which is a part of "The Apache Point Observatory Lunar Laser Ranging Operation (APOLLO)" mission, measures the distance between earth and the moon, using laser-ranging technique.

Background

In this technique, the time for reflected laser light, which is fired from earth aiming at the retro reflectors planted on the moon during the APOLLO program in 1969, is measured. Then one can calculate the distance between earth and the moon using mathematical equation. Successful LLR measurements to retro reflectors were first reported by 3.1 meter telescope at Lick Observatory, Air Force Cambridge Research Laboratories in Arizona.

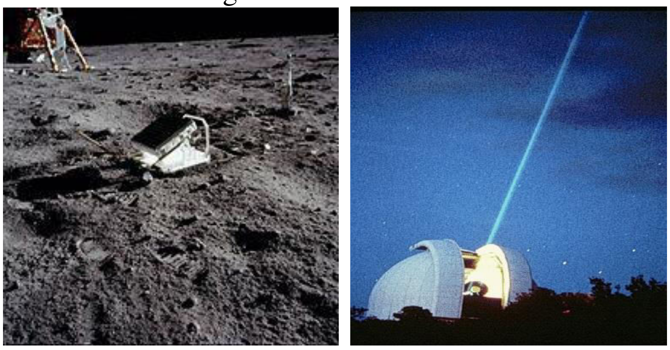

Figure 1: *Retro reflector planted on the moon APOLLO observatory*

Scientific motivations for LLR

A variety of Observations and theoretical explanations including the apparent acceleration of the expansion of the Universe, the possible existence of extra dimensions, the attempts to reconcile quantum mechanics and gravity, and lately the applications in the field of Gravitational Waves, provide motivations for improved tests of the fundamental aspects of gravity.

Chief components and layout of the LLR

The APOLLO system consists of the following primary subsystems

- Laser
- Optical system including beam switching optic
- Avalanche **photo diode** array detectors
- Timing electronics (clocks, counters, time to digital converters)
- Environmental monitoring and thermal regulation system

Laser Description

The laser is directly mounted on optical bench of the telescope so that laser moves with telescope. Two powerful flash lamps produce lasers in infrared regions. Electronics are designed to concentrate and make a pencil beam laser. Furthermore, the frequency of the laser is also doubled so that it appears green to human eyes. The narrow beam is designed to spread out at 3.5m diameter as it emerges out from telescope, which makes it safe enough for human eyes and skin, or to satellites and airplanes. Retro reflectors planted on moon are designed to reflect the laser pulses in the direction of incident beams, which makes it easier and accurate enough to calculate time interval.

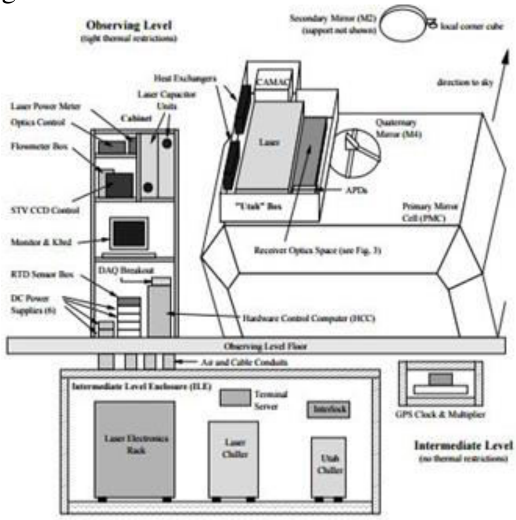

Figure 2 : *Schematic layout of APOLLO apparatus.*

The laser used is a Leopard solid-state microsecond product from Continuum Lasers. Pumped by flash lamps at 20 Hz, 1.064 micrometer laser emission from the Nd: YAG rod in the oscillator is shaped into 120 ps pulses (FWHM) via the combined efforts of an acoustic-optical mode-locker, a solid state saturable absorbed, and a Gas wafer to clamp the pulse energy. A double-pass amplifier boosts the cavity-dumped 1 MJ pulse to ~ 250 MJ, after which a second-harmonic-generator crystal frequency doubles the light at approximately 50% efficiency to produce 115 MJ pulses of 532 nm light with pulse widths of about 90 PS (FWHM). Heat from the laser rods is carried away by demonized water flowing at a rate of approximately 6 liters per minute, taking away ~ 1300 Watts of thermal power. When the laser is scheduled to be used, the airports are notified to publish an alert to all pilots to avoid the area of observatory's airspace. The laser beams are diffused enough that don't damage aircraft or blind pilot's eyes but it can disrupt the night vision which is really bad if that happens. Therefore, two spotters are kept outside to look after the airplanes or helicopters that ignore the notice. Each spotter has a switch, which they must use to shut off lasers if they spot such aircraft.

Measurement Process

The laser beam is pulsated at 20 pulses per second or 20 Hz with each pulse consisting 10^{17} photons. A run is considered successful if one can detect a single photon that is reflected back every 20 pulses. This makes us able to measure the total time taken by laser beam for a complete round trip from earth to moon and moon to earth, let it be T. The distance between Earth and Moon (*D*) is obtained by using formula: $D = c \times T/2$ s Where, *c* is the speed of light. The measurement of time interval is affected by location of the moon in the sky, the relative motion of earth and the moon, Earth's rotation, moon phases, lunar liberation, weather, propagation delay due to atmosphere, crustal motion and tides and relativistic effects. Out of 10^{17} photons projected, only one is received back on earth every few seconds, even under very good conditions. At the moon's surface, the beam is about 2.5 km wide, which makes the task like using a rifle to hit a moving coin 3 km away. And again as the background is not completely dark we may detect the photons from Sun, lunar surface or the Earth's atmosphere. The signal to noise ratio can be improved by following methods: Spectral filtering: Only allowing those photons to the detector which are very close to the laser frequency. Spatial filtering: Only considering those photos originating from a small region around the target i.e. keeping the field of view as small as possible. Temporal filtering: Only considering those photos which lie very close to the expected round trip travel time.

Results by LLR

The LLR currently provides the best tests of gravitational phenomenon such as,

1. The strong equivalence princip (SEP) : $\eta \sim 5\times10^{-4}$ sensitivity
2. Time rate of change of gravitational constant: $(dG/dt)/G < 10^{-12}$ yr^{-1}
3. Geodesic precision: 0.6% precision confirmation
4. Deviations from $1/r^2$ force law: $\sim10^{-10}$ times the strength of gravity at 108 meter scale
5. Rate of spiraling away of moon from earth ~ 3.8 cm per year.
6. The moon probably has a liquid core.

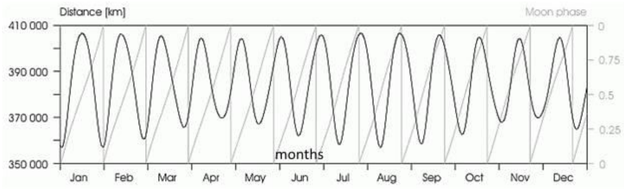

Figure 3: *Variation of distance with period.*

LLR also tests other gravitational and mechanical phenomenon, including for example Gravitomagnetism, a preferred frame effects, and Newton's third law. It is believed that LLR may provide a window into possible existence of extra-dimensions via cosmological dilution of gravity (Lue and Stark man 2003; Dvall et al. 2003). Besides, SEP, it tests weak equivalence principle (WEP) at the level of $< 1.3 \times 10^{-13}$, but the LLR constraint is not competitive with laboratory tests. In addition, LLR is used to define coordinate systems, probe the lunar interior, and study aerodynamics. These constraints on gravity are based on about 45 years of LLR data, although the precision is dominated by the last 15 years of data at 1-3 cm. APOLLO aims to improve tests of fundamental gravity by approximately an order of magnitude by producing range points accurate at the 1mm level. The plot below shows the variation of the distance between moon and the earth over 12 months in 2014. Moon phases: 0 = new moon, 0.25 = first quarter, 0.5 = full moon, 0.75 = last moons

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VOYAGER 1 FIRES UP THRUSTERS AFTER 37 YEARS

If you tried to start a car that's been sitting in a garage for decades, you might not expect the engine to respond. But a set of thrusters aboard the Voyager 1 spacecraft successfully fired up Wednesday after 37 years without use. Voyager 1, NASA's farthest and fastest spacecraft, is the only human-made object in interstellar space, the environment between the stars. The spacecraft, which has been flying for 40 years, relies on small devices called thrusters to orient itself so it can communicate with Earth. These thrusters fire in tiny pulses, or "puffs," lasting mere milliseconds, to subtly rotate the spacecraft so that its antenna points at our planet. Now, the Voyager team is able to use a set of four backup thrusters, dormant since 1980.

Is Time Travel possible?

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ABSTRACT

The cocept of time travel will be discussed and its possible implications will be described in this article.

Introduction

Time travel is the concept of movement (such as by a human) between certain points in time analogus to movement between different points in space, typically using a hypothetical device known as a time machine, in the form of a vehicle or of a portal connecting distant points in time .Time travel has long been a science fiction staple – and an affront to common sense. But physicists have not yet been able to prove or disprove that humans may one day be able to manipulate the fourth dimension."Time travel was once considered scientific heresy," writes Professor Stephen Hawking in the Daily Mail . "I used to avoid talking about it for fear of being labelled a crank." However, these days he's far less cautious, admitting he believes human will one day figure out how to travel into the future.

How could time travel be possible?

The question of time travel features at the interface between two of our most successful yet incompatible physical theories, Einstein's general relativity and quantum mechanics. Using both of these theories, scientists have suggested several ways they believe time travel could be possible – at least theoretically. These include:

Wormholes

Wormholes connecting different points in space and time might seem like the stuff of science fiction, but these mysterious tunnels are an actual feature of theoretical physics. Scientists have yet to find evidence of a wormhole in the cosmos, but the passages are mathematically possible according to Albert Einstein's theory of general relativity. In the same way that a piece of paper can be folded in half, general relativity states that high mass can bend the fabric of space itself. In 1935, Einstein and physicist Nathan Rosen postulated that this process could result in a bridge forming between two previously separate destinations in space-time. If general relativity holds true, then these "*Einstein-Rosen Bridges*," or wormholes, could act as shortcuts to the far off reaches of the cosmos without the luxury of directly observing a wormhole, scientists can only speculate on how they might operate. A common theory suggests that a black hole—a point in space-time where gravity is so strong that even light cannot escape—might serve as the entrance. This opening would connect to a tube, or "throat," that would empty from a theoretical "white hole," a point from which light and matter could exit. Still, chances are slim that this kind of wormhole could be used for space travel. The passages are likely to exist only on a tiny subatomic scale, and even if they were large enough to traverse, gravitational forces would cause them to collapse only an instant after they opened.

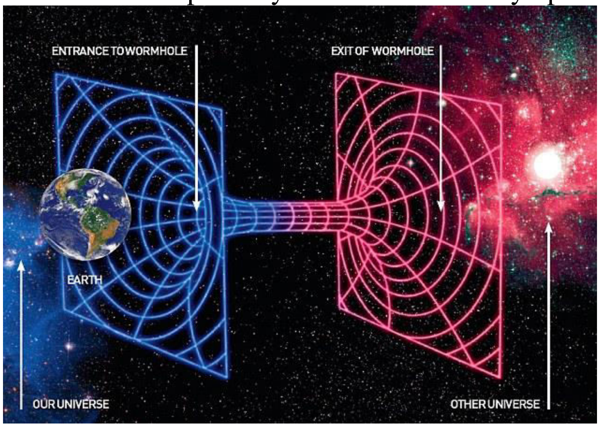

Figure 1: *Wormhole*

Scientists have theorized that wormholes made of a hypothetical exotic matter might contain enough negative energy to remain stable, but even then the addition of an outside object—like a spaceship—could cause the tunnel to fall apart.No wormhole has ever been discovered, and even if it was, it would be far too small for scientists to manipulate for the purposes of time travel – measuring just a billion-trillion-trillionth of a centimeter across. They also pose a significant risk, bringing with them the threat of sudden collapse, high levels of radiation and contact with dangerous exotic matter. Wormholes are unstable because of the feedback created by this radiation, explains Hawking. In the same way that excessive feedback between a microphone and a speaker will fry the equipment, a wormhole is damaged by the radiation feedback it generates. "As soon as the wormhole expands, natural radiation will enter it, and end up in a loop," he explains. "*So although tiny wormholes do exist, and it may be possible to inflate one someday, it won't last long enough to be of any use as a time machine*."

Travelling at the speed of light

Another possibility would be travelling at the speed of light, a constant, finite speed of 186,000 miles per second. As we approach the speed of light, our clock runs so slow we could come back 10,000 years in the future. But According to the laws of physics, nothing can travel as fast as the speed of light – let alone a spaceship. Even the Large Hadron Collider, the strongest particle accelerator in the word, can't make protons move that fast. If a proton did achieve that speed, it would need infinite energy to go any faster, and we don't have an infinite supply of energy. Also, the human body would not be able to withstand time travel at all, as travelling at nearly the speed of light would kill us.

Supermassive black hole

Described by Professor Hawking as natural time machines, black holes are so dense that they have a dramatic impact on time, slowing it down more than anything else in the universe. If a spaceship were to orbit a black hole, those on board would only experience eight minutes of time for every 16-minute orbit. "*Around and around they'd go, experiencing just half the time of everyone far away from the black hole. The ship and its crew would be travelling through time*," he explains. "Imagine they circled the black hole for five years. Ten years would pass elsewhere. When they got home, everyone on Earth would have aged five years more that they had."

Black holes are more practical than wormholes because they don't present the same paradoxes and won't be destroyed by feedback. "*But it's pretty dangerous*," concedes Hawking. "It's a long way away and it doesn't even take us very far into the future.

Reasons why time travel might just be possible

- Professor Ronald Mallett, from the University of Connecticut is building a real-life time machine! He intends to manipulate past, present and future by twisting space and time into a loop.
- Time travel has not been proven to be possible but it's also not been proven to be impossible.
- If matter could be moved faster than light then, according to special relativity, there would be some inertial frame of reference in which the object was moving backwards in time.
- Physicists at the University of Koblenz claim to have transmitted photons faster than the speed of light, using a phenomenon known as quantum tunneling.
- If a cylinder is infinitely long and spins fast enough about its long axis, then a spaceship flying around the cylinder could travel backwards or forwards in time.

What people really don't realize about travel is that there really doesn't exist a fourth dimension. A dimension is something that describes a specific wave function that are believed to divide existing hidden doorways in the universes structure that act simultaneous as a whole function of what we call reality. So the question is asked Is there really a fourth dimension? Is light speed a universal speed limit for earth or does life goes on? The answer to this divine question is 'Life goes on of course'. What seems to happen may not really happen at all.

A ship travels faster than light and observes things reversing backwards back into the past that it originated from like watching a clock run backwards or the origin of reality a its pathway it traveled from minutes before hand . But is that really what's going on? Is the universe of what's known as the fourth dimension really a dimension at all? What the captain sees in the ship traveling at time travel coordinates is reality passing up from itself. Or what Einstein's believes happens at that time. But in reality it doesn't happen that way at all. Your traveling so fast you can't observe the scene anyways you can't slow it down or speed it up what you will see if you could is momentum vibrating into shorter moment wavelengths of time that keep shortening more and more until reality reaches a point where it seems in the observation as though time has stopped. It will seem to stop but it doesn't - time just gets shorter and shorter and shorter as velocity in the ship gets faster and faster. The view Einstein illustrates as time traveling is just a description of the arrow of time running backwards. He explains it this way because 'light' seemed to him as a universal speed limit because it touches everything as being a special limit that can be directed for momentum and mass. The facts are - is that for time travel to happen as Einstein describes time stops. The ship is traveling at a velocity that it enters a new reality of time and space called a dimension and acts as a pathway between the past and the present. Directed by the description Einstein illustrates a time limit between the past and the present by means through velocity traveled in a spacecraft. But what he is observing is a physical illusion of what might be that happens if the speed of light were a speed limit - and the pathway by which it would continue if it were so. So a new question arrives. Does the universe really stop at light speed and does reality really assume back into the past? And is there really a dimension that will take you there? The answer is No. A wormhole takes you to a dead end because the space fabric tension projectiling the planets round upon won't allow passage through it. Space acts as a surface grid which not even planets or galaxies are allowed passage. Secondly, time is a human developed measuring techique for mathematics to measure a specific length using time for an equation. There exists no doorway back into the past. Spacetime as Einstein describes is a directive in a mathematical measurement that if placed on paper makes the universe past, present and future simultaneous. The passage through 'spacetime' does not take you through TIME itself at least not backwards into the past. The fastest pathway to china is straight through the earths core to the other side (the shortest distance) allowed to travel at the fastest time it takes to get there but it does not make the path a fourth dimension of space and time. Space and time are exactly that space and time. They do not entangle together to form a path in reality a reality that has sat for the universe for billions of years. Taking that shortest root to somewhere does not make that root a new dimension it only makes it that fastest root to the place of travel. Time travel in this respect means a passage through reality (matter/mass) from an out of the way manner and make reality intervene backwards or forwards and changing the universe's direction just for you the pilot of the ship even if it only means using just one of the planets time cycle like earths in relativity. It means devising a devise that changes the direction of (not time but reality (matter/mass) materialism that will allow you to pass through the realm (the universe) in a different direction of passage that already is permanent and exist in the structure of the universe is already. It means changing the way the material universe works and I don't think that is really possible. Time might be able to be used as a coordinates for such a thing but making it reality is beyond this day and age. Imagine viewing a passage way that allows to observe reality (atoms) and such structured passing backwards instead of forwards at a specific momentum. A vehicle for such a journey would have to be part of the realm and it doesn't seem to me that that is a passage of a new dimension. Does it you? Things vibrate towards a specific direction and obtain a specific result because of it. This I don't think can actually be even temporarily changed for even just a second of time. Traveling from place to place in everyday life is just that and the coordinates of time it takes for the ride is predetermined by reality and to be able to travel through this predetermined cosmic clock (or atomic clock which one) is really fast. This doesn't mean that time travel isn't possible. It only puts a lid of facts about the speed of light.

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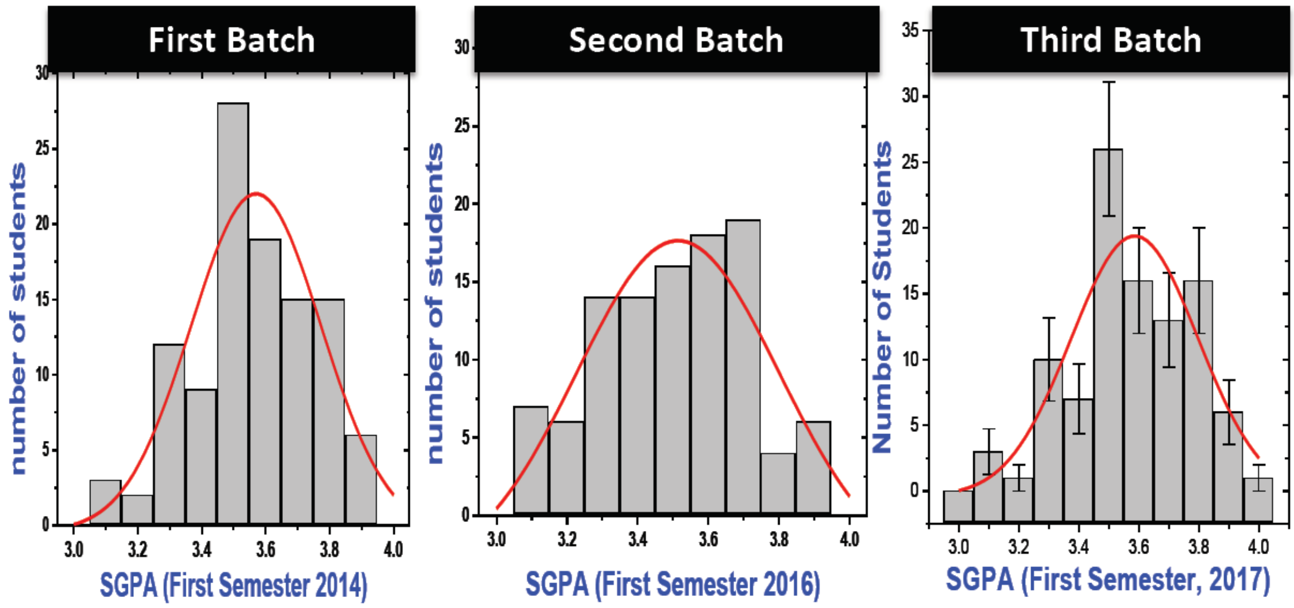
Results of First Semester: First Three Batch (2014-2016) of CDP



The distribution of SGPA score of first semester of first three batches of the semester system at CDP is shown above. The solid curve represents the Gaussian distribution. The Gaussian offset is found to be negative in second and third batches. A positive offset is need in order the improve mean SGPA.score.

	Fail	SGPA	sd	Pass%
First Batch	11	3.56	0.18	90.7%
Second Batch	13	3.49	0.21	90.0%
Third Batch	19	3.50	0.33	83.9%

The mean value of SGPA and pass percentage are given above. The result is satisfactory. In order to achieve 95% result with mean SGPA 3.60, a joint effort is needed among the students and faculties in future.

How Do Galaxy Obtain Angular Momentum?

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ABSTRACT

Universe is made of matter and vacuum. The largest aggregate of matter is the galaxy. It is found that the most of the galaxies are rotating, having angular momentum. The origin of angular momentum is still unclear. There are several ideas based on cosmology regarding the distribution of angular momentum in the clusters and superclusters of galaxies. We present an informative discussion regarding the rotation of galaxies.

Background

Ancient man asked questions such as "*What's going on around me?*" which then developed into "How does the Universe work?", the key question that cosmology asks. The cornerstone of modern cosmology is the belief that the place which we occupy in the universe is in no way special. This is known as the cosmological principle which assumes that universe is essentially homogeneous and isotropic, an idea which is both powerful and simple. Homogeneity basically relates with the idea that the universe at a given time is same if we are observing the universe from anywhere else and isotropic refers to the fact the universe looks identical in whichever direction we look. However, although the cosmological principle is valid for studying the universe as a whole on larger scales more than 100 Mpc, we know that it doesn't hold perfectly.

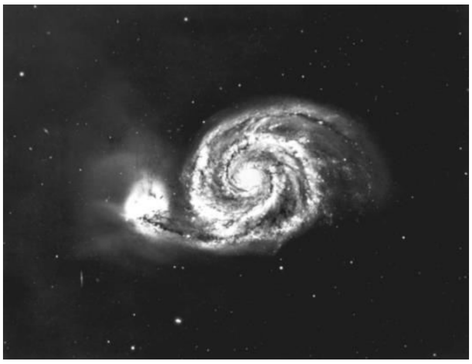

Figure 1: *A spiral galaxy from above: M51 (type Sc). The interacting companion is NGC5195. (Karttunen et al. 2007)*

The nearby universe is highly inhomogeneous, being made up of planets, stars and galaxies. The key idea in explaining the way in which structures evolve in the universe is gravitational instability. If material is to be brought together to form structures then a long-range force is required, and gravity is the only known possibility. Thus, gravity is the mechanism to form larger and larger structures.Gravitational instability is excellent for taking initially small irregularities and amplifying them, but it needs the initial irregularities to act upon. Where might they come from?

The origin of structure takes us back into the realm of the very early universe, because itappears that none of the established physics we know about is capable of makingperturbations. However, we do know of a mechanism that can. Inflation can generate irregularities capable of initiating structure formation. The mechanism is a remarkable one, being quantum mechanical in origin. Heisenberg's famous uncertainty principle tells us that even apparently empty space is a seething mass of quantum fluctuations, with particles continually popping in and out of existence. Normally we don't notice this as the time and length scales are so small, but during a period of inflation the universe is expanding so rapidly that any fluctuations get caught up in the expansion and stretched. While one set of fluctuations is being stretched, new fluctuations are always being created which will then themselves be caught up in the expansion. By the end of inflation, there are small irregularities on a wide range of different length scales. Gravitational instability then acts on these small initial irregularities, and eventually, much much later, they can form galaxies and galaxy clusters.

The galaxies are the fundamental building blocks of the universe. The galaxies are not smoothly distributed in space; rather, they form systems of all sizes: galaxy pairs, small groups, large clusters and superclusters formed from several groups and clusters.Observations by Hubble Space Telescope and ground-based instruments show that the first galaxies took shape as little as one billion years after the Big Bang, which probably took place about 13 billion to 14 billion years ago.There are two leading theories to explain how the first galaxies formed.One says that galaxies were born when vast clouds of gas and dust collapsed under their own gravitational pull, allowing stars to form. The other, which has gained strength in recent years, says the young universe contained many small "lumps" of matter, which clumped together to form galaxies. Hubble Space Telescope has photographed many such lumps, which may be the clue for the formulation of modern galaxies.

Galaxy Evolution Models

The evolution of galaxies is determined by the process due to which their structures and constituents have been changing with time. During early 1950's Gamow showed that the observed rotations of galaxies are important for cosmology. They postulated that the rotation of galaxies might be a clue of physical conditions under which these systems formed. Thus, investigating spatial orientation of galaxy planes is of importance, as various scenarios of formation and evolution of cosmic structures predict different distributions of angular momenta of galaxies, i.e., provide different predictions concerning orientation of objects at different levels of structure - in particular clusters and superclusters of galaxies. This provides a method for testing scenarios of galaxy formation. These existing theories are contradictory as to their predictions are completely different from each other. However, it is interesting to note that the predictions made by all existing theories are based on cosmology. Thus, it is very important to test these theories by a very good and carefully controlled database using appropriate methods and methods of analysis.

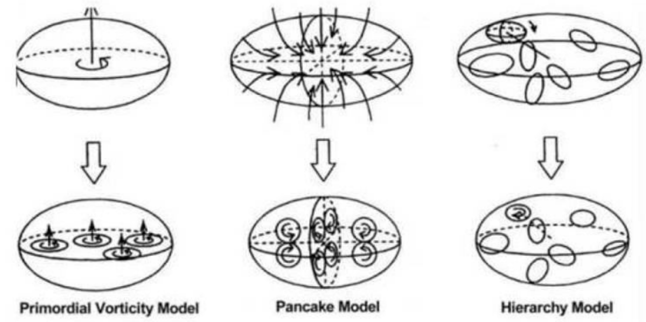

Figure 2: *Explanation of the different spatial orientations of angular momentum vectors of galaxies based on three existing models: Primordial Vorticity, Pancake and Hierarchy model. An arrow represents the preferred direction of the angular momentum vector of a galaxy in each model. (Kauch, 2004)*

Primordial Vorticity Model

The primordial turbulence predicts that the rotational axes of galaxies would be perpendicular to the main plane of a large-scale structure. In the turbulence scenario, first flattened rotating proto-clusterswere formed due to cosmic vorticity in the early universe and subsequent density and pressure fluctuations caused galaxies to form. According to the primordial vorticity theory, the presence of large chaotic velocities generates turbulence, which, in turn, produces density and pressure fluctuations. Density fluctuations on the scale of clusters ofgalaxies could be gravitationally bound, but galactic mass fluctuations are always unbound.

Pancake Model

The pancake model predicts that the spin vectors of galaxies tend to lie within the cluster plane. In the pancake scenario, formation of clusters took place first and it was followed by their fragmentation into galaxies due to adiabatic fluctuations. According to the non-linear gravitational instability theory, at early stages in the evolution of the hot universe there occurred slight deviations from homogeneity and isotropy in the expanding mixture of ionized matter and radiation. Then the evolution of small perturbations, when the effect of pressure on the motion of the matter can be neglected, causes the matter to disintegrate into thin, dense and gaseous condensations that are called `*pancakes*'- which have infinite density, with the surface density being finite.

Hierarchy Model

According to the hierarchy model the directions of the spin vectors should be distributed randomly. In hierarchy model also called `*bottom up scenario*', galaxies were first formed and then they obtained their angular momenta by tidal force while they were gathering gravitationally to form a cluster. Those galaxies grew by subsequent merging of protogalactic condensations or even by merging of already fully formed galaxies. In this scheme, one could imagine that large irregularities like galaxies grew under the influence of gravities from small imperfections in the early universe. The angular momentum transferred to a developing proto-galaxy by the gravitational interaction of the quadrupole moment of the system with the tidal field of the matter.

Li Model

A model involving galaxy forming in a rotating universe was proposed by Li in 1998. The galaxies acquire its angular momentum during their formation as a consequence of the conservation of angular momentum in rotating universe. He analysed the model of homogeneous, rotating and expanding universe, filled with ideal fluid, which additionally complies with the laws of energy and angular momentum conservation.Li's model remains valid only, provided that rotation occurs on a sufficiently large scale. Moreover, due to its scaling properties, Li's model can be applied to rotating protostructures of various initial size.

Ostriker Model

It was first proposed by Ostriker and Cowie and assumes that an early explosion sweeps theprimordial gas into a large dense shell of several tens Mpc, and galaxies are formed whenthe shell cools and fragments. Such explosions could be provided at super-massive stars orsuperconducting cosmic strings, or other kinds of objects. They estimated that structures (in the order of 100 Mpc) could be created by this chain reaction of explosions.

Conclusions

However the hierarchy model is getting popularity these days, the need of improved model that can explain the formation of globular cluster, dark matter halo in the galaxy is a must.

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Quantum Computer: Possibilities and Hurdles

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ABSTRACT

Fundamental of quantum computing system will be presented. In addition, problems with discoherence will be discussed.

Introduction

Quantum Computer is the modern computing device which uses the postulates of quantum mechanics on its basic circuital logic formalism. In the classical computer the basic logic of computation is 0 or 1 which indicates that the switch circulating is either 'OFF' or 'ON'. The current is either absent or owing through the wire. In the other words '0' gives low logic and '1' gives the high logic. The classical part of the logical understanding is that a switch always remains either OFF or ON .i.e. chooses a specific state. A switch can never be OFF and ON state at the same time. But the quantum mechanical viewpoint deals with the logic of superposition of states in which a switch is both OFF and ON at the same time, i.e. 0 and 1 exist at the same time. This fundamental logical state is known as 'qubit' corresponding the classical bit. A qubit can be mathematically expressed as

$$|\psi\rangle = a\,|0\rangle + \beta\,|1\rangle$$

or in a geometrical view point it is represented by the bloch sphere. Now discussing now quantum computing is superior than the classical method.

Let's begin with their fundamental operation method. Classical algorithm fol-lows steps in terms of bits perform one step of work at one time. Let us take a 3 bit number '101'. Classically it represent an information at a given instant of time . But it's correspondence in terms of qubits is the superposition all the possible three bit classical information. In classical bit 101, the no. of bit information is 1, whereas in quantum bits are 000, 010, 001, 100, 110, 011, 101, 111, the no. of bit information is 8, So, a n-bit classical number, classically possess only a single information . But same case in quantum computation. It possesses 2n number of classical bit informations. Thus, the working of quantum computation exponentially reduces the steps of operations which cannot be done using classical algorithm. But does it mean quantum computer eventually replace all of our classical computing device? The answer is 'no'. The logic behind it is that the outcome of quantum computation follows the collasping states principle of quantum mechanics. So, there can be many possible outcomes from the same operationas the probabilty of occurence of each outcome exists.

To counter this problem, the modern quantum algorithm i.e. Shor's algorithm proceeds with the repetetion of the same steps such that our final result is the outcome achieved after the averagee evaluation of alll possible states. In other words, the result of the computation corresponds to the most probable result which is found by repeated comparision of the outcoming results. But in classical computers like our laptops, cell phones, the result of computation is not probabilistic. If I want to play a song in my mobile it always plays the specified song. Our calculators always give the same answers for same inputs, whereas when the volume of calculation is just larger just like evaluating the database of a large population, calculating the global weather fluctuations, factorising large numbers et cetera, our classical computers become fine.

Eben the most powerful supercomputers can't perform as per the requirement. So, in order to carry out these heavy problems we need quantum computers.

What actually are Qubits?

Qubits are any dual state quantum logic. It can be spin up and spin down state of quantum mechanical particle like atoms, electrons. It can be horizontal and vertical polarisation of photons. And the main job of the physics to be able to have access within these state i.e. spin of atoms (say) and manipulate it as er the requirement. So for the efficient manipulation , we need to isolate these qubits from the environmental inference. i.e. operate in very very cold temperature. To influence the sins of thee atoms and electrons generally a very finely tuned magnetic field is preferred. The combination of qubits , ontogetheer form quantum gates which forms the building block of quantum computation.

Mathematically, the quantum gates are just unitary matrices and the entire computation process is the unitary transformation of input qubits The unitary nature of the gates refers to the reversible property of the operation. In summary during the quantum information processing we prepare a bunch of qubits, prepare all of form in zero states act on those qubits with some unitary matric and at the end we read out of all the qubits to get the information of the computation result. In the physical system we construct our unitary matrix after identifying the system Hamiltonian.

$$U = T\exp^{-i\int_0^t dt'\,[H(t')+\delta H(t')}], H \in H_S$$

Here the system Hamiltonian completely belong the system Hilbert space. But in actual case we obtain an extra case in the system Hamiltonian also known as residue Hamiltonian or garbage Hamiltonian. such that unitary takes the form.

$$U = T\exp^{-i\int_0^t dt'\,[H(t')+\delta H(t')}], H \in H_S$$

Here the extra term in the Hamiltonian is the result of the entanglement between our system and environment is known as decoherence. Now the total Hamiltonian does not just belong to the system Hilbert space but it with both the system and environment. Unfortunately, the decoherence destroys the unitary nature of the operation and our transformation matrix becomes non unitary hindering our entire computation process.

Solving Decoherence Problem

De coherence is the fundamental aspect of quantum reality. a system can never be isolated with it's environment. But the main problem lies with the indefinite parameters of environment. An environment represents a very fluctuating dynamics. So it detailed parameters are always unknown. a system has well defined Hilbert space. where as an environment doesnot so, the decoherence also causes the blurring of our knowledge about the state of the system. Decoherence causes the reduced density matrix of the system to become mixed, i.e the loss of phase coherence. It destroys all the interfering possibilities of the states and hence it is nearly impossible to reverse our computing dynamic (i.e non unitary).

Countering the Problem

The problem of decoherence can be dealed in two ways:
1) *Reducing the operation time:* If the qubits operation time is very short compared to decoherence time than possible destruction of the information can be reduced. This preserves the unitary of our computation. But it is very challenging work to do because environment is never completely predictive.
2) *Decoherence free subspace (DFS):* It sis the subspace of systems Hilbert space which remains una ected by decoherence. So the operations done within the DFS remains unitary. DFS is infact is a preparation to avoid decoherence rather than solving it.

Conclusion

Regardless of all the hurdles and difficulties many achievementshave been made in its advancement on daily basis. Many commercial companies like Google, IBM, and Microsoft etc are hugely investing privately on the project of quantum computation. This commercial competition is also boasting its accelerating development. Hopefully, we can say that our near future will take benefit from the development of quantum computers

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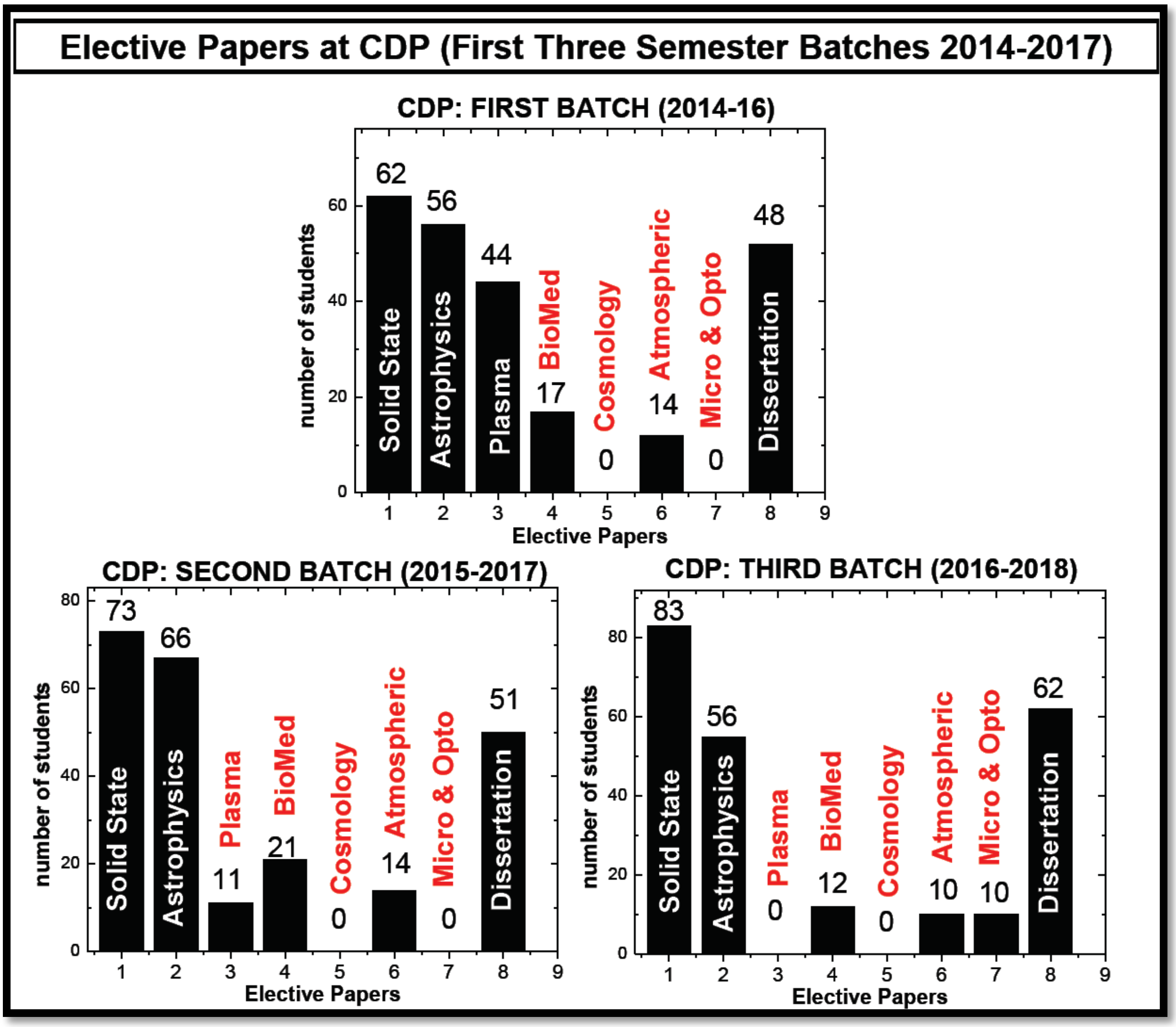


Nobel Laureate Prof. Dan Shechtman's Visit to CDP
21 September 2016

Nobel Laureate Prof. Dan Shechtman visited Central Department of Physics, Tribhuvan University, Kirtipur on 21 September 2016. Prof. Dr. Binil Aryal, HoD of CDP, TU welcomed Nobel Laureate. Prof. Dan Shechtman was conferred with the honorary membership in recognition of his contribution in the field of material science at Tribhuvan University. President and secretary of NPS Prof. Dr. Pradeep K Bhattarai and Prof. Dr. Narayan Pd Adhikari honored him. Prof. Dan Shechtman delivered a brief speech at the Seminar Hall of CDP. After this, he moved to the TU auditorium hall for a public talk. He delivered a talk on ***'Technological Entrepreneurship: Key to World Peace & Prosperity'*** on Vice Chancellor of TU, Prof. Dr. Tirtha Khaniya graced the program.

Message to students by Nobel Laureate Prof. Shechman

"*Nepal can inspire engineers, scientists, medical doctors and computer experts among others for the technological startups,*" he said, prescribing the angels, strategic partners, bootstrapping and venture capital funds could be the sources of investment for the startups. Good basic education to all as well as good engineering and science education, supportive government policy, free market economy and corruption-free society were the basic elements that always helped empowering the entrepreneurship, Prof Shechtman added.

"*Unstable economies and population growth as well as urbanisation and education to women are the major challenges to technological revolution,*" the professor of material science at Technion, a public research university in Haifa, Israel, shared.

Honorary Member of NPS to Nobel Laureate Prof. Shechman

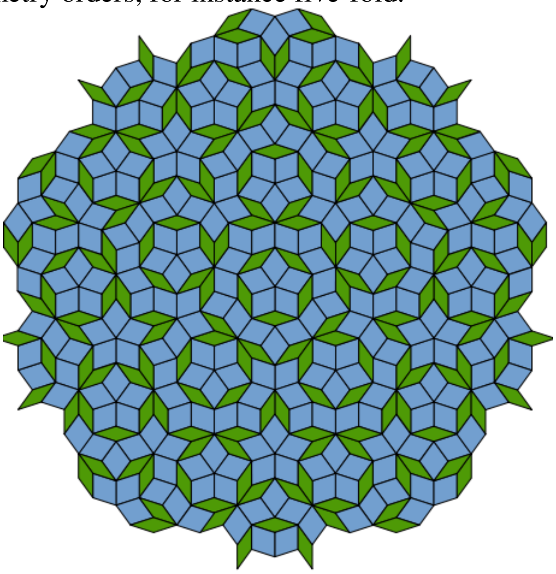
According to him, innovation which leads to entrepreneurship is mainly concerned with the national democracy, social equality and lack of fear from authority. The government could form a chief scientist office every ministries and also support individual innovative startups, he suggested.

Prof Shechtman also highlighted that there was a challenge for every nations to make school-going children like science. "*A real science education is the need of hour,*" he said. Saying that the trend of population growth moved from expanding to stationary, the scientists said that there was also challenge to manage an ageing population when the age-wise trend reached to a stage of contracting.

students clapping hands for guests

Prof. Dan Shechtman, the Nobel laureate of Chemistry 2011, arrived in Kathmandu to take part in the ICQ13, *13th International Conference on Quasicrystals*, held in Dhulikhel, a town near Kathmandu, in the presence of over 150 world scientists.

Shechtman had won the Nobel prize for the discovery of quasicrystals. A quasiperiodic crystal, or quasicrystal, is a structure that is ordered but not periodic. A quasicrystalline pattern can continuously fill all available space, but it lacks translational symmetry. While crystals, according to the classical crystallographic restriction theorem, can possess only two, three, four, and six-fold rotational symmetries, the Bragg diffraction pattern of quasicrystals shows sharp peaks with other symmetry orders, for instance five-fold.



Quasicrystal: Penrose Tiling

No doubt, the Nobel Laureates' story is a fascinating one: from his achievements and the hard work he has done to the roller coaster ride of his eventual success. In addition, Shechtman also shared many of his ideas, gave insights on how he thinks and much more. Only few people get the chance to meet such a great personality and the young researchers, we must say, our students are very lucky to get this once in a life time opportunity to meet Prof. Dan Shechtman.

Prof. Shechtman gave a live interview at Kantipur Television for Rise and Shine Program (https://www.youtube.com/watch?v=UOqbjazkXfE).

Prof. Shechtman had an interview with www.myrepublica.com and met with the Press. He delivered a lecture on "*Technological Entrepreneurship – A Key to World Peace and Prosperity*" at the Office of the Prime Minister and Council of Ministers. The lecture was attended by Secretaries and High Level Officers of the Government of Nepal including Acting Chief Secretary Mr. Tanka Mani Sharma. Ambassador Yaron Mayer also attended the lecture.

On the same day, a team of world scientists, led by Nobel laureate Prof. Dan Shechtman from Israel, paid a courtesy call on The Right Honourable President of the Federal Republic of Nepal Mrs. Bidya Devi Bhandari. H.E. Mr. Yaron Mayer, Ambassador of Israel to Nepal also accompanied the team. Ambassador Mayer handed over the letter of congratulations from His Excellency Mr. Reuven Rivlin, President of the State of Israel, which wished progress and prosperity of Nepal and Nepalese on the occasion of Constitution Day and National Day of Nepal.

A group photo with Nobel Laureate Prof. Shechman

Prof. Shechtman visited Kathmandu University and met with Prof. Dr. Ram K. Shrestha, the Vice-chancellor of the university. During his visit, he delivered a scientific lecture on "Quasicrystal." The lecture was attended by vice-chancellor, deans, senior faculty members and students of the university. On this occasion, Prof. Shechtman and Mr. Nadav Shemesh, from the Embassy, planted trees in the garden of K.U.

Welcome banner at the main gate of CDP

Prof. Shechtman's visit to Nepal has contributed in further enhancing the existing bilateral relations between Nepal and Israel to another level.

CDP Activities

International Conference on Shining from the heart of darkness: black hole accretion and jets (16-21 October, 2016)

Sixth in a series of astrophysical conferences held in Kathmandu (Nepal), the meeting will mainly focused on accretion physics and jet launching and evolution mechanisms in galactic and extragalactic sources. The objective of the conference is to address major observational and theoretical results on these topics for a wide range of cosmic sources. Emphasis has been given to multiwavelength studies of cosmic sources and to multi-messenger physics, gravitational waves in particular.

Students displaying posters

Aim of the conference was to address three fundamental issues, which are as follows:

- ❖ Is the size of the X-ray source in black hole accreting systems ~1-2 r_g or a few tens r_g?
- ❖ Is the source dissipating energy during accretion or most of the dissipation takes place in the lamppost?
- ❖ What is the dominant jet-launching mechanism in accreting sources?

There were 131 participants including 30 Nepalese students. Leading researchers of various areas delivered their research findings in the conference. They were Dr. Vladimir Karas, Dr. Matthew Benacquista, Dr. Marica Branchesi, Dr. Julien Malzac, Dr. Martin Elvis, Dr. Michele Trenti, Dr. Feng Yuan, Dr. Janusz Ziolkowski and Dr. Neil Gehrels. Four Nepalese researchers namely Dr. Sanjaya Paudel (Korea), Mr. Tek Pd Adhikari (Poland) and Mr. Padam Ghimire (Germany) presented their research findings. They completed M.Sc. (Physics) from CDP, TU.

Prof. Dr. Binil Aryal delivered a talk on '*Astrophysics Research Activities in Nepal*'. Prof. Aryal held discussions with a few professors for future research collaborations. Mr. Ajay Kumar Jha (Ph.D. scholar at CDP), Mr. Ek Narayan Paudel and Mr. Madhu Paudel presented their works in posters.

Prof. Aryal presenting his talk

The members of the organizing committee of the conference were as follows: Dr. Binil Aryal (Tribhuvan Univ., Nepal), Dr. Sergio Colafrancesco (Wits Univ. & SKA, South Africa), Dr. Stefanie Komossa (Bonn, Germany, Dr. Eliana Palazzi (INAF/IASF-Bologna, Italy), Dr. Andrzej Zdziarski (chair, NCAC, Poland), Dr. Janusz Ziolkowski (NCAC, Poland).

CDP Activities
Kathmandu Astrophysical School (24-28 October 2016)

Current research at the forefront of astrophysics takes advantage of larger and larger observational datasets and computer simulations of growing complexity. Yet, in this new era, the ability to understand complex phenomena with simple but meaningful physical ingredients is a critical skill to effectively navigate and explain the big data. The organizer of Black Hole Conference planned to held a week long 'Astrophysical School' to the students of Astrophysics in Nepal during 24-28 October 2017.

Speakers with student

Students of the first Kathmandu Astrophysics School (KAS16) will learn how to effectively solve diverse problems in multiple astronomical fields, ranging from stellar kinematics to cosmology, using basic order-of-magnitude estimates. Lectures were combined with problem solving activities, professional development seminars, and networking, with the goal of mentoring advanced undergraduate and beginning graduate students to improve their research and presentation skills.

The program contained both lectures and hand-on session. Students and faculties were engazed in such a way that they became like long time friends.

The School is aimed primarily to Nepali students currently enrolled in the Astrophysics MSc Program, but both recent graduates or perspective students may also apply. In addition, international applications from advanced undergraduate or beginning graduate students were expected.

Dr. Trenti delivering his lecture

The school was organized at the Seminar hall of Central Department of Physics Tribhuvan University, Kathmandu, Nepal. The organizers and faculty of the program were Michele Trenti (Chair) of University of Melbourne, Australia; Dr. Binil Aryal of CDP, TU, Nepal; Dr. Clare Kenyon of University of Melbourne, Australia; Dr. Nora Lützgendorf of STScI, Baltimore, USA and Andrzej Zdziarski of Polish Academy of Sciences, Warsaw, Poland.

CDP Activities
International Publications (2016-2017)

2017

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°, *ISST Journal of Applied Physics* **8** (1), 85-91 (2017).
3. S. N. Yadav, **B. Aryal**, W. Saurer, Preferred alignments of angular momentum vectors of galaxies in six dynamically unstable Abell clusters, *Research in Astronomy & Astrophysics (RAA)*, **17**, 7, 64 (2017).
4. A. K. Gautam, **B. Aryal**, Study of Dusty Environment around Carbon-Rich AGB Star in Far Infrared Maps at Latitude 150, *ISST Journal of Applied Physics* **8**(1), 92-96 (2017).
5. S. Ghimire and **N.P. Adhikari**, Study of structural and transport properties of argon, krypton, and their binary mixtures at different temperatures, *Journal of molecular modeling* **23** (3), 94 (2017).
6. S. Lamichhane and **N.P. Adhikari**, Basis Set Effect on Alkaline-Earth Fluoride Structures, *Journal of Computational and Theoretical Nanoscience* **14** (5), 2315-2318 (2017).
7. R Ghimire, **N. P. Adhikari**, **G Kaphle**, R Mani; Electronic and Magnetic Properties of Ba, Ni and BaNiO3: A First-Principles Study, *Bulletin of the American Physical Society* **62** (2017).
8. Y.P. Kandel and **N. P. Adhikari**; Diffusion of Zwitterion Glycine, Diglycine, and Triglycine in Water, *arXiv preprint arXiv*:1706.05491 (2017).
9. G. Thakur, **R. Khanal** and B. Narayan, Production of Copper Arc Plasma and its Characterization using a Movable Langmuir Probe, *Varanasi Management Review* **III**, 2, 27 (2017).
10. 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, Lee, *IEEE Transactions on Plasma Science*, **45**, 8, 2292 (2017).
11. B. Ghimire, D. P. Subedi and **R. Khanal**, Improvement of wettability and absorbancy of textile using atmospheric pressure dielectric barrier discharge, *AIP Advances* **7**, 8, 085213 (2017).
12. G. Thakur, **R. Khanal** & B. Narayan, Determination of Plasma Parameters by using Movable Langmuir Double Probe in Copper Arc Plasma, *Research Highlights* **IV**, 2, 20 (2017).
13. 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*, Vol. **36D**, Issue 1, 43 (2017).
14. 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**, 1, 53 (2017).
15. **P. B. Adhikari**, S. Sharma, K. N. Baral, V. Rakov, Unusual Lightning Electric Field Waveforms Observed in Kathmandu, Nepal, and Uppsala, Sweden, *Journal of Atmospheric and Solar Terrestrial Physics* **164**, 172 -184 (2017).
16. **P. B. Adhikari**, B. Bhandari, Computation of Electric Field from Lighting Discharges, *International Journal of Scientific & Engineering Research* **8,** 9, 147 (2017).

2016

1. D. Bhandari and **N.P. Adhikari**, Molecular dynamics study of diffusion of krypton in water at different temperatures, *International Journal of Modern Physics B* **30** (11), 1650064 (2016).
2. S. Pokharel, **N. Pantha** and **N.P. Adhikari**, Diffusion coefficients of nitric oxide in water: A molecular dynamics study; *International Journal of Modern Physics B* **30** (27), 1650205 (2016).
3. S. K. Yadav, S. Lamichhane, L. N, Jha, **N.P. Adhikari** and D. Adhikari; Mixing behaviour of Ni–Al melt at 1873 K, *Physics and Chemistry of Liquids* **54** (3), 370-383 (2016).
4. **P. B. Adhikari**, S. Sharma, K. N. Baral, Features of positive ground flashes observed in Kathmandu, Nepal; *Journal of Atmospheric and Solar Terrestrial Physics* **145**, 106 -113 (2016).
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7. S. Lamichhane, **G. C. Kaphle**, **N. P. Adhikari**, Electronic Structures and Magnetic Properties of NiAl and Ni3Al, *Quantum Matter* **5**(3), 356-361 (2016).
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10. S. N. Yadav, **B. Aryal**, W. Saurer, Spatial Orientation of Spin Vectors of Blue-shifted Galaxies, arXiv:1606.02881 (2016).
11. B. R. Adhikari, **H. P. Lamichhane** and **R. Khanal**, Temporal dependence of components of velocity of ions in a magnetized plasma sheath for different obliqueness of the magnetic field, *Proceedings of the 5th PSSI-Plasma Scholars Colloquium*, p. 32 (2016).
12. G. S. Thakur, **R. Khanal** and B. Narayan, Production and Characterization of Seeded-Arc Plasma for Different Materials of the Electrodes, *Proceedings of the 5th PSSI-Plasma Scholars Colloquium,* p. 41 (2016).

CDP Activities
Talk Program at CDP (2016-2017)

2017

1. **Dr. Dipendra Hamal**, Assistant Professor, Department of Natural Sciences (Physics), Kathmandu University, Dhulikhel and **Mr. Amit Acharya**, Under Secretary, Ministry of Industry, Singha Durbar, Kathmandu, Nepal delivered a talk entitled ***'Intellectual Property Rights (IPR) and its role in economic development of the country'*** on 19 November 2017.
2. **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.
3. **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.
4. **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.
5. **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.
6. **Dr. Ishan Pokhrel**, CERN, Geneva, Switzerland delivered a talk entitled ***'Analysis of data from the ATLAS detector of the LHC***'on 23 June 2017.
7. **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.
8. **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.
9. **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.
10. **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.

2016

1. **Dr. Keith Groves**, Senior Scientist, Institute For Scientific Research, Boston College, Boston, USA delivered a talk entitled ***'Space Weather Impact on GNSS***' on 15 December 2016.
2. **Dr. Patricia H Doherty**, Senior Scientist, Institute For Scientific Research, Boston College, Boston, USA delivered a talk entitled ***'Space Weather Effects GNNS Application***' on 15 December 2016.
3. **Dr. Michele Trenti**, University of Melbourne, Australia delivered a seminar on ***'The history of the Universe***' at the occasion of First Kathmandu Astrophysical School on 24 October 2016.
4. **Dr. Andrzej Zdziarski,** Nicolaus Copernicus Research Centre, Poland delivered a talk on ***'Black holes and accretion***' on the occasion of First Kathmandu Astrophysical School at 25 October 2016.
5. **Dr. Clare Kenyon**, University of Melbourne, Australia delivered a seminar on ***'Structuring and delivering a presentation***' at the occasion of First Kathmandu Astrophysical School on 25 October 2016.
6. **Dr. Nora Luetezendorf** of STScT, Baltomire, USA delivered a seminar on ***'Star clusters: Formation and multiple stellar populations***' at the occasion of First Kathmandu Astrophysical School on 27 October 2016.
7. **Dr. Tulashi Dahal**, Materials Scientist, Sheetak Inc., Austin, TX 78744, USA delivered a talk entitled ***'Experimental Studies on Thermoelectric and Mechanical Properties of Skutterudites***' on 7 November 2016.
8. **Prof. Dr. Dan Shechtman**, 2011 Nobel laureate visited our department and delivered a talk entitled '***Technological Entrepreneurship: Key to World Peace & Prosperity***' on 21 September 2016. The Vice Chancellor of TU Prof. Tirtha Raj Khaniya graced the talk program.
9. **Prof. Dr. Huanyang Chen**, College of Physics (Optoelectronics and Energy & Collaborative Innovation Center of Suzhou Nano Science and Technology), Soochow University, Suzhou, China delivered a talk on ***'Introduction to Metamaterial and Transformation Optics***' on 21 August 2016.
10. **Prof. Dr. Kazuki Koketsu** of Tokyo University delivered a talk entitled ***'Modern seismology and the Gorkha earthquake***' in our department on 12 August 2016.
11. **Prof. Dr. Velumani Subraminiam,** Profesor Investigador en Ingeniería Eléctrica(SEES), Centro de Investigación y de Estudios Avanzados del I.P.N.(CINVESTAV), Av. Instituto Politécnico Nacional, México delivered a talk on ***'GIGS based Solar Cells: A New Trend***' on 5 August 2016.
12. **Dr. David Kraljic**, Oxford University, UK delivered a talk on ***'How rare is the Bullet Cluster (in a ΛCDM universe)?***' on 15 July 2016.
13. **Mr. Nabin Rijal**, Research Assistant & Ph.D. Candidate, Department of Physics, Florida State University delivered a talk entitled ***'Astrophysical Lithium Problem, Standard Big Bang Nucleosynthesis & Nuclear Astrophysics'*** at our department on 20 May 2016.
14. ***Prof. Dr. Bhadra Man Tuladhar***, retired mathematician of Kathmandu University, delivered a talk entitled ***'Gravitational Wave***' on 22 April 20.
15. **Dr. Elisa Fratini**, post doctorate fellow, ICTP, Trieste, Italy delivered a talk entitled ***'Anderson localization and ultra-cold gases***' on 7 January 2017.
16. **Dr. Kate Shaw,** post doctorate fellow, ICTP, Trieste, Italy delivered a talk on ***'Standard Model of Particle Physics***' on 8 January 2016 on the occasion of master-class on experimental particle physics.
17. **Dr. Suyog Shrestha**, post doctorate fellow, Ohio State University, USA delivered a talk on ***'High Energy Physics Experiments***' on 8 January 2016 on the occasion of master-class on experimental particle physics.
18. **Dr. Joerg Stelzer** of Large Hadron Collider, CERN, Geneva, Switzerland delivered a talk on ***'Detecting Particles and reconstructing events***' on 8 January 2016 on the occasion of master-class on experimental particle physics.

CDP Activities
Plagiarism Checking at CDP

Plagiarism Checking Software at CDP

CDP has introduced plagiarism checking mechanism for the masters' dissertation from this year. The plagiarism has been checked for 48 masters' thesis. The CDRC made following criteria for the masters' thesis:

(1) The 30% tolerance level is fixed for masters' dissertation as a whole. The result and discussion section should have less than 10% tolerance level.

(2) The most cited book/literature should not be copied. The tolerance level should be less than 10% from such

The access to this software (PlagScan4.0) is donated by Dr. Ralf Gekelar, Germany. The HoD of the department is using this software.

Forty Eight Masters' Dissertation Checked

Forty eight masters' was submitted electronically during January to September 2017.

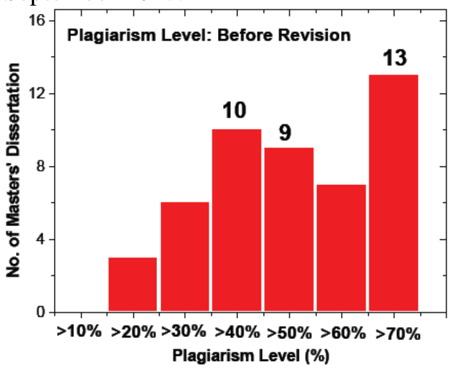


Figure 1: *Plagiarism level of 48 M.Sc. (Physics) dissertations.*

All these documents were checked. Only 9 dissertations showed less than 30% plagiarism level. These were accepted after the submission. The average plagiarism level was about 47%. The distribution of the status of plagiarism level is shown in Fig. 1. In the histogram, one can see the trend of copy paste from the book, literatures and web pages. The HoD of CDP communicated with all students and supervisors, tips regarding the reduction of plagiarism.

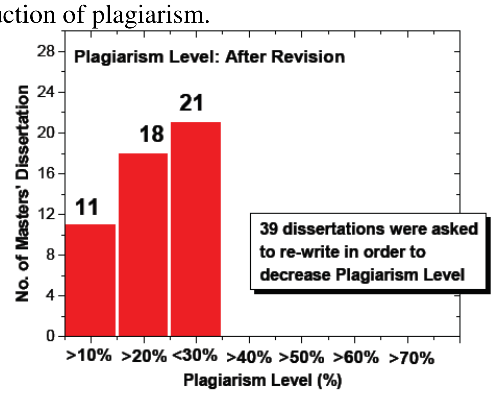


Figure 2: *Students are asked to reduce plagiarism level. They work hard to make it perfect.*

Thirty nine dissertations were sent back to the students asking re-submission after revision. Thirten dissertations were found to have plagiarism level more than 70%. This was very serious. Supervisors were asked to check dissertation carefully. They were asked to reduce plagiarism level. Most of the students re-submitted their dissertation within a month. Supervisors are found to be serious about the writings of their students. This was an achievement. CDP became the first central department who checked plagiarism level. CDP is going to prepare an electronic database of previous M.Sc. dissertations. In addition, masters' thesis is encouraged to publish in the national Journals so that it can be accessed through internet.

CDP Activities
Biannual Ph.D. Progress Report Presentation

Ph.D. Calendar

Ph.D. calendar of 2074-75 is as follows:

Month	Activity	Evaluation
Srawan	Research work	Seminar (Optional)
Bhadra	Research work	25 26 27 28
Aswain	5-30 Dashain Holiday	Seminar (Optional)
Kartik	1-10 Tihar-Chatt	Seminar (Optional)
Mangsir	Research work	
Paush	15-30	
Magh	1-15	
Magh	Research work	Seminar (Optional)
Falgun	Research work	
Chaitra	Research work	25 26 27 28
Baisakh	Research work	Seminar (Optional)
Jestha	15-30	
Asar	Working Month	

Bianual Ph.D. project report Presentation

CDP has srated biannual progress report presentation profram sinced last one year. It is compulsory for all Ph.D. students. In addition, all students should attend the program. The objective of presentation program is as follows:

1. To upgrade their presentation skill (slide preparation, delivery and the reasoning and answering techniques).
2. To share the knowledge and learn from each other, particularly with other Ph.D. students and their supervisors..
3. To motivate them for the publications in the peer reviewed Journal.

The CDRC has recommended the format of 15 minute presentation, as follows:

>> Title >> Motivation & Objectives
>> Progress of last semester >> On-going work
>> Plan for the next semester >> References

All 22 Ph.D. students presented their on-going research work during 25-28 Bhadra, 2074. Their presentation was much better than the previous year.

CDP Activities

New M.Sc. (Physics) Curriculum: Full Subject Committee Meeting

After the introduction of four year B.Sc. program in Tribhuvan University, Institute of Science & Technology recommended all scince subject committee to revise previous M.Sc. Curriculum and prepare a new curriculum for four semesters. The Physics Subject Committee held a several discussion regarding the modality of curriculum and finally come up with a 66 credit hour program for M.Sc. (Physics).

This curriculum is developed by the subject experts under consultation with subject standing committee and finalized by the physics subject committee full meeting held on 2073/12/27 (9 April 2017). Later, the curriculum of all four semesters is recommended by the Faculty Board, IoST, TU and finally approved by the Academic Council, TU.

Table 1: *Course structure of M.Sc. (Physics) program of TU. Here PR, EC, DS and TP corresponds to the practical, elective courses, dissertation and term paper, respectively.*

Sem	Courses (Theory)				PR	Elective Courses		DS	Term paper	Tot CH
1st	3	3	3	3	4	-	-	-	-	16
2nd	3	3	3	3	4	-	-	-	-	16
3rd	3	3	3	-	4	2	2/0	-	0/2	17
4th	3	-	-	-	4	4	4/0	0/6	2/0	17/17
	36 (54.5%)				16	12/6		0/6	2/2	66

There will be four semesters in two years. The semester duration will be 18 weeks (15 weeks for course work and 3 weeks for evaluation tests). A student should complete 66 credit hour (hereafter CH) courses in order to earn Master's degree in physics from Tribhuvan University. The credit hour distribution of courses in all four semesters is shown in Table 1.

Table 2: *List of* ***compulsory courses****, their course code andcredit hour (CH).*

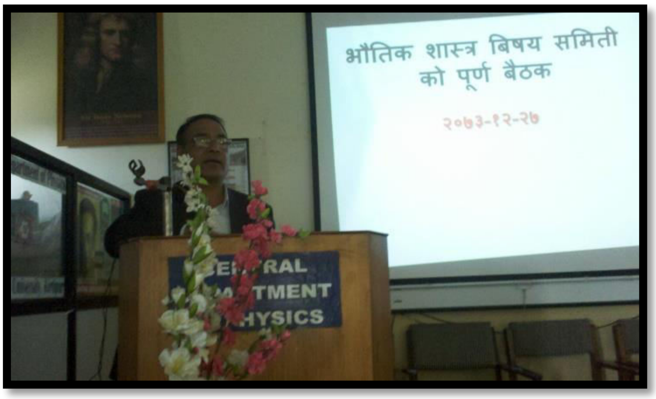
Sem	Code	Courses	CH
First	PHY501	Math Physics I	3
First	PHY502	Classical Mechanics	3
First	PHY503	Quantum Mechanics I	3
First	PHY504	Electronics	3
First	PHY505a	General Experiment	2
	PHY505b	Electronics Experiment	2
Second	PHY551	Quantum Mechanics II	3
Second	PHY552	Statistical Mechanics	3
Second	PHY553	Solid State Physics	3
Second	PHY554	Electrodynamics I	3
Second	PHY555a	General Experiment	2
	PHY555b	Electronics Experiment	2
Third	PHY601	Quantum Field Theory	3
Third	PHY602	Electrodynamics II	3
Third	PHY603	Math Physics II	3
Third	PHY604	Computational Physics Lab	4
Third	PHY605	Term Paper (III)	2
Fourth	PHY651	Particle Physics	3
Fourth	PHY653a	General Experiment	2
	PHY653b	Electronics Experiment	2
Fourth	PHY654	Term Paper (IV)	2
Total CH (Compulsory Courses)			54

A credit hour (CH hereafter) means teaching a theory course work for 60 minutes each week throughout the semester. For the laboratory work, 1 CH is equivalent to the 3 hours of lab work per week per semester. This course offers compulsory theoretical courses, laboratory work, computation work, elective and optional thesis/dissertation work in physics.

Table 3: *List of elective courses, their course code and credit hour (CH).*

Sem	Code	Courses	CH
Third	PHY611	Advanced Solid State Physics I	2
Third	PHY612	Astrophysics I	2
Third	PHY613	Atmospheric Physics I	2
Third	PHY614	Biomedical Physics I	2
Third	PHY615	Condensed Matter Physics I	2
Third	PHY616	Galactic Physics I	2
Third	PHY617	General Theory of Relativity	2
Third	PHY618	Microprocessor & Optoelectronics	2
Third	PHY619	Nano Physics I	2
Third	PHY620	Physics of Materials I	2
Third	PHY621	Plasma Physics I	2
Third	PHY622	Solid Earth Geophysics I	2
Third	PHY623	Entrepreneurship for Physicist	
Fourth	PHY661	Advanced Solid State Physics II	4
Fourth	PHY662	Astrophysics II	4
Fourth	PHY663	Atmospheric Physics II	4
Fourth	PHY664	Biomedical Physics II	4
Fourth	PHY665	Condensed Matter Physics II	4
Fourth	PHY666	Galactic Physics II	4
Fourth	PHY667	Gravitation & Cosmology	4
Fourth	PHY668	Microelectronics	4
Fourth	PHY669	Nano Physics II	4
Fourth	PHY670	Physics of Materials II	4
Fourth	PHY671	Plasma Physics II	4
Fourth	PHY672	Solid Earth Geophysics II	4
Fourth	PHY699	Dissertation	6

There will be an option between one of the elective courses and the dissertation. Student should have at least B^- grade in all credits of first semester as a regular student in order to enroll for the dissertation. The practical course in all semesters is compulsory.



Prof. Dr. Ram Pd Khatiwada, Dean of IoST, TU addressing full subject committee meeting

The first and the second semesters mainly focus on general theoretical courses as well as general experimental courses. The third semester mainly focuses on research oriented courses including computation courses. The fourth semester will be allocated for completion of the research work and the thesis writing or advanced courses. Elective courses will be offered by the Central Departments and other TU constituent and affiliated colleges on the basis of the availability of subject experts. In any case, at least 10 students are required to run an elective course. The physics subject committee may also develop new elective courses in the future.

Mode of Instruction

There will be 15 weeks (90 working days) in an academic semester. Additional three weeks will be added for the internal examination.

b) *Nature of the Classes:*

i) *Theory:* One theory paper of 3 CH will have 3 hours of lectures per week (45 minutes long four classes) throughout the semester. For a 3 CH course, there should be 60 theory classes in a semester.

ii) *Tutorial:* A tutorial class should be given per week per subject, mainly for the numerical, concepts, class tests, viva tests, discussions, etc. This class should be arranged for smaller number of students (up to 30). Altogether 15 hours tutorial classes should be held per semester per course (both theory and practical).

iii) *Practical:* One CH of lab work is equivalent to 3 hours lab work per week. One practical paper of 4 CH should have 12 hours of practical per week throughout the semester. The number of teachers in the laboratory classes depends on the number of laboratories and number of students as per TU rule (1 teacher for 10 students & at least one teacher in a laboratory)

c) *Attendance:* 80 percent attendance in the class (theory, practical, tutorial) is required.

Evaluation

The evaluation mode is 40% internal and 60% final examinations.

Internal Examination: The in-semester (internal) examination of theory papers shall have a total weight of 40% in each course. Students have to obtain 50% to pass the internal exam. The breakdown of in-semester exam will be as follows:

Class Attendance	**: 4%**
Home Work	**: 10%**
Mid-Term Test	**: 13%**
Final-Term Test	**: 13%**

The mid and final term exam will be held for one hour. The full marks of the mid-term and final-term exams are suggested to be in 100 marks (later it can be reduced to the 13%). The copy will be checked in marks. The examination copy can be showed to the students by the concerned faculties in the class. Though department will not publish results of internal examination publicly. In case a student remains absent in the internal examination due to serious illness will given one-time opportunity to appear in the exam if he/she is able to produce authorize medical certificate.

Final Examination: Institute of Science and Technology, Tribhuvan University will conduct final examination. The students will have to pass each course at each level separately. The final examination in each course will be a written examination as follows:

CH	Full Marks	Pass Marks	Exam Duration
2	30	15	2 hours
3	45	22.5	2 hours
4	60	30	3 hours

Final Examination question format for 3 CH compulsory courses is as follows:

Full Marks: 45 Credit Hour: 3	Pass Marks: 22.5 Duration: 2 hours
Attempt all questions.	
1. Long Question	[10]
2. Long Question OR Long Question	[10]
3. Short Question OR Short Question	[5]
4. Short Question	[5]
5. Short Question	[5]
6. Numerical 1	[5]
7. Numerical 2	[5]

The duration of practical examination will be **6 hours** for 2CH lab works. In case percentage of marks obtained by the students in the internal exam exceeds the end-semester (final) examination marks by 20 or more, the marks obtained in the internal examination will be reduced to 80%. The six hours final practical examination should be held according as semester calendar. Students are required to give two practical examinations per semester.

A term paper is compulsory for the students. It contains a seminar and a report of his/her research activities under the supervision of faculties. A student who opt dissertation, should give a pre-presentation before final VIVA examination. The final VIVA examination will be fixed by the dean office, which is a scheduled exam with internal and external examiners. The head of the evaluation committee will be HoD (in case of CDP), M.Sc. program coordinator and/or head of the department. The write up of project and thesis should be in a recommended format.

CDP Activities

TU Futsal Competition (2074)

As a part of extracurricular activities, Central Department of Physics, TU organized the TU Futsal Competition—2074 from Baisakh 18 to 20 at Kirtipur. Prof. Krishna Prasad Acharya, the chief guest of the opening ceremony, inaugurated the tournament with the concise and inspiring speech underlining the importance of sports on the all-round growth of students. Similarly, Harilal Bhattarai, the coordinator of the tournament, highlighted the purposes of conducting the futsal tournament and role played by the sports on the overall development of students. Before the kick off of official matches, a friendly match was played between distinguished teachers and students of Central Department of Physics. Prof. Dr. Binil Aryal, the special guest of the event, opened the friendly match by kicking the ball. The match was exhilarating enough to watch; the team of distinguished teachers won the game by one goal to nil.

CDP players with HoD and faculties

Sixteen teams participated in the tournament; the first game of the tournament was played between the host team and Central Department of Education (Math). The referee of the game was Ranjit Maharjan. Although all the participating teams demonstrated outstanding talents to win games, only two teams, by rules, managed to reach the finale. The final match between the host team and School of managements was absorbing and exciting to watch as each player evinced their sensational and electrifying knack. The School of Management clinched the title by beating the host team by 4 goals to 1.

Students celebrating with trophy!

The School of Management, T.U. clinched the first place. Host team secured the first runner up position of the tournament. As Central Department of Chemistry manifested sportsmanship throughout all the games, they were declared the disciplined team of the tournament. Bikram Dhoj Shrestha, the defender of the host team, was awarded the Man of the Series Award for his outstanding skills and contributions through out the tournament. On the other hand, Anupam Marasini, the striker of School of Management captured Highest Goal Scorer Award of the Tournament by scoring 17 goals. He was able to garner lavish approbations from the audience due to his sensational flair and clinical finishing. Similarly, Rudra Mani Dahal, goalkeeper of the host team, won the best goalkeeper of the tournament. He conceded just six goals and, interesting, scored two goals during the tournament, though he was a goalkeeper.

CDP team remained Runner-up!

Dr. Rajan Bhattarai, Parliament member, chief guest of the closing ceremony, performed the closing Ceremony of the TU Futsal Competition—2074. He lavishly appreciated all teams for their participation and expressed his genuine congratulations to the winner and first runner-up team. In addition, he encouraged students to participate in extracurricular activities for their overall development. Furthermore, Prof. Dr. Binil Aryal, special guest of the event, gave a succinct and inspiring speech underlining the importance of extra curricular activities on education. Also, he expressed his kudos to all the helping hands of the tournament. During the award ceremony, Prof. Dr. Biinil Aryal, Rajan Bhattarai, and Harilal Bhattarai awarded the trophy, certificates, and token of love jointly. Finally, Prakash Chalise, the host of the opening and closing ceremony, thanked all the members of the tournament for their direct or indirect support to make TU Futsal Competition—2074 a grand success, and declared the end of the tournament.

List of Our Graduates Leaving for USA during July-August 2017

S.N	Student's Name	University Name	E-mail
1	Bharat Giri	University of Louisville, Kentucky	rabin.g1988@gmail.com
2	Chhabi Gautam	Texas State University	gautamcb@ymail.com
3	Chitra Bahadur Karki	University of Texas at El Paso	chitrakarki55@gmail.com
4	Deewakar Poudel	Old Dominion University	dpud001@odu.edu
5	Gyanu Kafle	State Univ of New York, Binghamton	gkafle1@binghamton.edu
6	Jay Ram Paudel	Temple University	paudel.jay90@gmail.com
7	Krishna Acharya	New Mexico State University	acharyakrishna1989@gmail.com
8	Kunal Tamang	University of Miami at Florida	mekunal65@gmail.com
9	Madhusudhan pokhrel	Old dominian university	pokhrel.mdusdn@gmail.com
10	Mahendra Subedi	University of Texas at El Paso	reciprocatemee@gmail.com
11	Mahesh Koirala	Clemson University	mkoiral@g.clemson.edu
12	Mitra Mani Subedi	New Mexico State University	subedimitramani@gmail.com
13	Narayan Khadka	Kansas State University	knarayan47.14@gmail.com
14	Naresh Adhikari	Bowling Green State Univ,	adhikari.naresh06@gmail.com
15	Nawagyan Ghimire	Temple University	navagyan.g1@gmail.com
16	Nawaraj Paudel	Florida State University	newking9088@gmail.com
17	Peshal Karki	Clemson University	pkarki@g.clemson.edu
18	Phadindra Wagle	Oklahoma state University	jmswgl@gmail.com
19	Pramod Baral	University of Miami at Florida	pramod4918@gmail.com
20	Pushpa Raj Paudel	Kent state University	paudel.push@gmail.com
21	Rabindra Basnet	University of Arkansas	rabindrabasnet8@gmail.com
22	Rajendra Poudel	Auburn University, Alabama	paudelrajendra111@gmail.com
23	Rajendra Thapa	Ohio University	rajendrathapa8585@gmail.com
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25	Sanjib Katuwal	University of Florida	Katsanjib046@gmail.com
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29	Shyam Chauhan	Ohio University	sbdrchauhan@gmail.com
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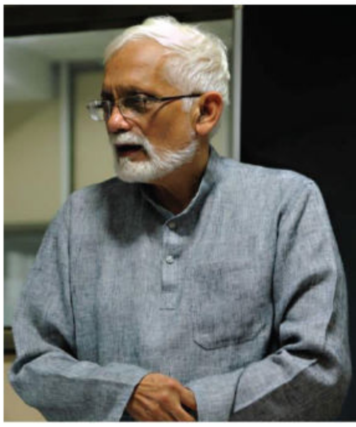
32	Sunil Ghimire	Iowa State University	ghimiresunil48@gmail.com
33	Suresh Thapa	Auburn University, Alabama	Thapa1s@cmich.edu
34	Susheel Pangeni	Wyane state University	gc0863@wayne.edu
35	Sushil Sigdel	Kansas State University	ssigdel18@gmail.com
36	Uttam Pyakurel	University of Albany, Newyork	Uttampyakurel125@gmail.com
37	Yadav Prasad Kandel	University of Rochester	kandelypg@gmail.com

__Note:__ Symmetry family congratulates all seniors and wishes for the success in the future study. Editorial board acknowledges Mr. Krishna Acharya and Mr. Yadav Prasad Kandel for this compilation. 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.

Lecture Series on Research Methodology at CDP



Prof. Dr. Subodh R. Shenoy, TIFR, India delivered 21 hours lecture series on '*Research Methodology*' to our faculties, Ph.D. students and masters' students during 6 November to 22 December 2017 at CDP, Kirtipur.

Prof. Dr. Subodh R Shenoy did his school studies at St Xavier's High School Ahmedabad, his B.Sc in Physics at the University of London, and his PhD at Yale University. After a return to India, he has been at TIFR Bombay; Institute of Physics, Bhubaneswar; University of Hyderabad; International Centre for Theoretical Physics (ICTP), Trieste, and IISER Trivandrum. He is presently a Visiting Professor at TCIS.

Faculties: Central Department of Physics, TU, Kirtipur

Prof. Dr. Binil Aryal

GOOGLE SCHOLAR (1 Dec 2017):

h-index: **11** i10-index**: 13** Citations: **518**

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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

Qualification

Post Doctorat :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)

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), in press (2017).
2. 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).
3. 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).
4. 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).
5. S. N. Yadav, **B. Aryal**, W. Saurer, Spatial Orientation of Spin Vectors of Blue-shifted Galaxies, arXiv:1606.02881 (2016).
6. **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)
7. **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)
8. **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)
9. **B. Aryal**, Winding sense of galaxies around the Local Supercluster, Journ. Research in Astronomy & Astrophysics (RAA) **11**, 293 (2011)
10. **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)
11. **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)
12. **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)
13. **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)
14. **B. Aryal**, S. Paudel & W. Saurer, Coexistence of chiral symmetry restoration and random orientation of galaxies, , Journ. Astronomy & Astrophysics (A&A) **479**, 397 (2008)
15. **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)
16. **B. Aryal,** S. R. Acharya & W. Saurer, Chirality of spiral galaxies in the Local Supercluster, Journ. Astrophysics & Space Science, **307**, p. 369-380 (2007)
17. **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)
18. **B. Aryal** & R. Weinberger, A new high latitude cone like far-IR nebula, Journ. Astronomy & Astrophysics **446**, 213 (2006)
19. **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)
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23. **B. Aryal** & W. Saurer, Morphological dependence in the spatial orientation of Local Supercluster galaxies, Journ. Astronomy & Astrophysics **432**, 431-442 (2005)
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27. **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)
28. **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. Jeevan Jyoti Nakarmi

GOOGLE SCHOLAR (1 Dec 2017): NOT FOUND

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Date of Birth : 2012–02–13
Place of Birth : Lagan Tole, Ka–2, 566, Kathmandu
Field of interest : *Laser Plasma Interaction, microwave discharge, Atomic and Molecular Optical Physics*
Qualifications : Ph.D. TU (2000)
: M.Sc. T.U. (1983)
PhD Thesis : Study of Magnetic field generation and its effect on the energy transport in the corona of laser fusion plasma

Selected Publications

1. Modeling of thermal transport using Fokker Planck equation in Laser Produced Plasma, Proceed ICPP (1996).
2. Effect of finite but weak electron inertia delay on plasma seath formation, PLASH, (2003).
3. An Introduction to Multiphoton Ionization and Study of ionization rate of Hydrogen Atom, IIIrd IUPAP International Conference on Women in Physics, Seoul South Korea (2008).

Prof. Dr. Om Prakash Niraula

GOOGLE SCHOLAR (1 Dec 2017): NOT FOUND

E-mail : niraula@yahoo.com
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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
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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

GOOGLE SCHOLAR (1 Dec 2017): NOT FOUND

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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.
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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

GOOGLE SCHOLAR (1 Dec 2017):
h-index: **4** i10-index**: 2** Citations: **58**

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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 Recent 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. P. Gautam, R. K. Tiwari and **R. Khanal**, Fitting of total current curve in the plasma focus device (PF400) using Lee Code, BMC J of Physics **2**, 47 (2014)
11. "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)
12. "Effect of Convective, Diffusive and Source Terms in Self-Generated Magnetic Field due to Laser Plasma Interactions", S. Khanal and R. Khanal, The Himalayan Physics 5, 27 (2015)
13. "Introduction to Numerical Experiment on Plasma Focus using Lee Model Code", P. Gautam and R. Khanal, The Himalayan Physics 5, 136 (2015)
14. "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)
15. "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)
16. "Comparison of Plasma Dynamics in Plasma Focus Devices PF1000 and PF400", Amir Shakya, Prakash Gautam and Raju Khanal, Journal of Nepal Physical Society 3, 55 (2015)
17. "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)
18. 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 Adhikari

GOOGLE SCHOLAR (1 Dec 2017):
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: 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).

Mr. Ishwar Koirala

GOOGLE SCHOLAR (1 Dec 2017):

h-index: **3** i10-index**: 1** Citations: **37**

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Selected 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 ,Transport and Surface properties of molten Cd-Zn alloys, Journal of Science and Technology (JOST), 19:1 (2014)14-18
8. **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
9. B. Singh and **I. Koirala**, Size sensitive transport behavior of liquid metallic mixtures , Journal of Science and Technology (JIST) 20:2 (2015) 140-144
10. **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
11. I.S.Jha, **I.Koirala** ; B.P. Singh, Thermodynamic and structural investigations on mixing behavior of hetero-coordinated Al-based alloys in the fusion state, BIBECHANA **13**(2016)87-93.

Dr. Hari Pd Lamichhane

GOOGLE SCHOLAR (1 Dec 2017): NOT FOUND

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: 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 II[nd] 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

GOOGLE SCHOLAR (1 Dec 2017): NOT FOUND

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: 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 Publications

1. J. H. Kim, **B. R. Ghimire**, and H. Y. Tsai, Phys. Rev. B **85**, 134511, (2012).

Mr. Ajay Kumar Jha

GOOGLE SCHOLAR (1 Dec 2017): NOT FOUND

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Ph.D.(submitted) : Interaction Between Pulsar wind and the ambient Interstellar Medium
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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** and D.R. Upadhyay, Dust Structure Around Two Asymptotic Giant Stars at Latitude 32^o & 40.67 ", The Himalayan Physics , **6** & **7**, 41-47, (2017).
4. **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).
5. **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).
6. **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

GOOGLE SCHOLAR (1 Dec 2017):

h-index: **3** i10-index**: 1** Citations: **34**

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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. B. Aryal, and **G. C. Kaphle**, Study of structural and electronic properties of perovskites FeTiO3 and PbZrO3 at Cubic phase: TB-LMTO-ASA approach, Journal Of TUTA, University Campus, **9**, 21 (2016).
7. 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).
8. 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).
9. 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).
10. **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).
11. 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)
12. Structural and electronic properties of Perovskite Hydrides AcaH3 (CaH3), BIBECHANA **13**, 94-99 (2015)
13. 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. Nurapati Pantha

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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.

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 Presuure 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).

Mr. Tika Ram Lamichhane

GOOGLE SCHOLAR (1 Dec 2017): NOT FOUND

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Qualification : M. Sc., CDP (TU)-(1998-2001)
Ph.D. Scholar : IOST, CDP (TU), Title: Ultrasonographic and Computational Insight into the Thyroid Disorders.
Experience : Sixteen years teaching experience of Physics to the graduate/undergraduate levels and about five years research experience of Data Analysis and MD Simulations of Biomolecules.

Selected Publications

1. **Lamichhane T. R.** and Lamichhane H. P., Energy and Temperature Distributions of a Thyroid Hormone Receptor Protein by Nanoscale Molecular Dynamics Simulations, Amrit Journal, AJ1, 1(2017).
2. Acharya N. P., **Lamichhane T. R.** and Jha B., Quality Assurance with Dosimetry Consistancy in a Co-60 Teletherapy Unit, Journal of Nepal Physical Society, JNPS 4, 1: 88-92 (2017).
3. **Lamichhane T. R,** Pangeni S., Paudel S. and Lamichhane H. P., Age and Gender Related Variations of Pituitary Gland Size of Healthy Nepalese People Using Magnetic Resonance Imaging, American Journal of Biomedical Engineering, AJBE 5, 4: 130-135 (2015).
4. **Lamichhane T.R.** and Bhatt M.D., A Text Book of Engineering Physics, Seventh Edition, Sunlight Publication, Kirtipur, Kathmandu, Nepal (2017).
5. Jha L.N., Shrestha G.K., Baniya H.B., Nepal M.S., **Lamichhane T.R.** and Subedi M., Universal Physics - Part I, Second Edition, Published by Oasis Publication, Nepal (2013).
6. Jha L.N., Shrestha G.K., Baniya H.B., Nepal M.S., **Lamichhane T.R.** and Subedi M., Universal Physics - Part II, Second Edition, Published by Oasis Publication, Anamnagar, Kathmandu, Nepal (2013).
7. **Lamichhane T.R.**, Nepal M.S. Subedi M., Universal Practical Physics for Class XI and XII, First Edition, Published by Oasis Publication, Anamnagar, Kathmandu, Nepal (2013).
8. **Lamichhane T.R.,** Physics for Advanced Science Course, Second Edition, Nims, Bagbazar, Kathmandu, Nepal (2012).
9. Paudyal K., Baniya H.B. and **Lamichhane T.R.,** Numerical Examples in Engineering Physics, Second Edition, New Hira Books Publication, Kirtipur, Nepal (2010).
10. **Lamichhane T.R.**, Course Manual of Physics for Diploma in Engineering I/II, First Edition, Advanced College of Engineering, Kupondol, Nepal (2005).
11. **Lamichhane T.R.** and Bhatt M.D., Physics for Engineering Entrance Examination, First Edition,, FEEP-Advanced College of Engineering, Kupondol, Nepal (2004).
12. **Lamichhane T.R.**, DEA Objective Physics, First Edition, Dynamic Educational Academy, Thamel, Nepal (2004).

Mr. Rajendra Prasad Koirala

GOOGLE SCHOLAR (1 Dec 2017): NOT FOUND

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M.Sc. Thesis : Evaluation of Kidney size by Ultrasonography in Nepalese people

Selected Publications

1. **R P Koirala**, S Pradhan, S K Aryal, Ultrasonic Measurement of Kidney length in Nepalese People, Journal of Nepal Physical Society, vol **4** (2017)
2. P. Parajuli, J.P. Pandey, **R. P. Koirala**, B. R. Shah, Study of Electromagnetic Field Radiation from the Cell phone towers within Kathmandu valley, International Journal of Applied Science and Biotechnology (IJASBT),Vol-**3**(2) PP 179-187 (2015)
3. **R P Koirala**, Biophysics: Introduction and scope, scientific outlook monthly, Vol **I,** PP 37-38 (2013)
4. **R P Koirala**, M N Singh, PKhanal, Principles of Physics I, Asmita Books publishers, Nepal (2015)
5. **R P Koirala**, M N Singh, PKhanal, Principles of Physics II, Asmita Books publishers (2015)
6. **R. P. Koirala**, P. Khanal, Basic Physics for Health science (CTEVT), Asmita Books Publishers (2017)
7. **R. P. Koirala**, D. R. Gyanwali, Applied Practical Physics for Grade XI & XII, Asmita Books publishers & Distributers (2017).

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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).

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Publications

1. **H.S. Mallik** and B.P. Pokharel, "Study of Dielectric and PTCR effect of Semi-Wet Derived $(Ba_{0.88}Sr_{0.12})TiO_3$ Ceramics", Proceedings of IV National Conference on Science and Technology **2**: 1870-1877, 23-26 March 2004. Royal Nepal Academy of Science and Technology (RONAST), Kathmandu, Nepal.

2. L. P. Sah, **H. S. Mallik**, "Numerical Physics" for class- XII, 1st Ed., 2012 Buddha Academic Publishers & Distributors Pvt. Ltd., Kathmandu, Nepal.
3. L. P. Sah, **H. S. Mallik**, "Physics Practical Book" for class- XII, 1st Ed., 2011. Buddha Academic Publishers & Distributors Pvt. Ltd., Kathmandu, Nepal.
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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).

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Heartfelt Condolence to Our Madan Dai

A good heart has stopped beating, a good soul ascended to heaven.

You crafted our laboratory for about 26 years, helped thousands of students in several ways!

I hope that God brings you and your family the much-needed peace during this sad time.

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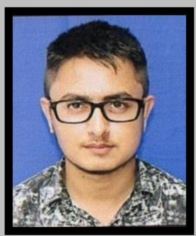

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Photos of CDP Family & Activities (2016-2017)

Symmetry Vol X releasing program


53rd Anniversary of CDP, (14 Mangsir, 2074)


VC Prof. Khaniya with Nobel laureate Prof. Shechtman at a talk program


Third Semester Students


Nepal Physical Society Gathering


First Semester Students


CDP: Futsal Runner-up


Editors with Dr. Suyog Shrestha of CERN


Welcome Preparation


CDP Family during Department's Anniversary


Participation from CDP: CERN Program at KU

Nobel Laureate Shechtman's Talk

Sarashwati Puja at CDP


Students enjoying picnic


HoD with students in a program

Central Department of Physics
Tribhuvan University
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