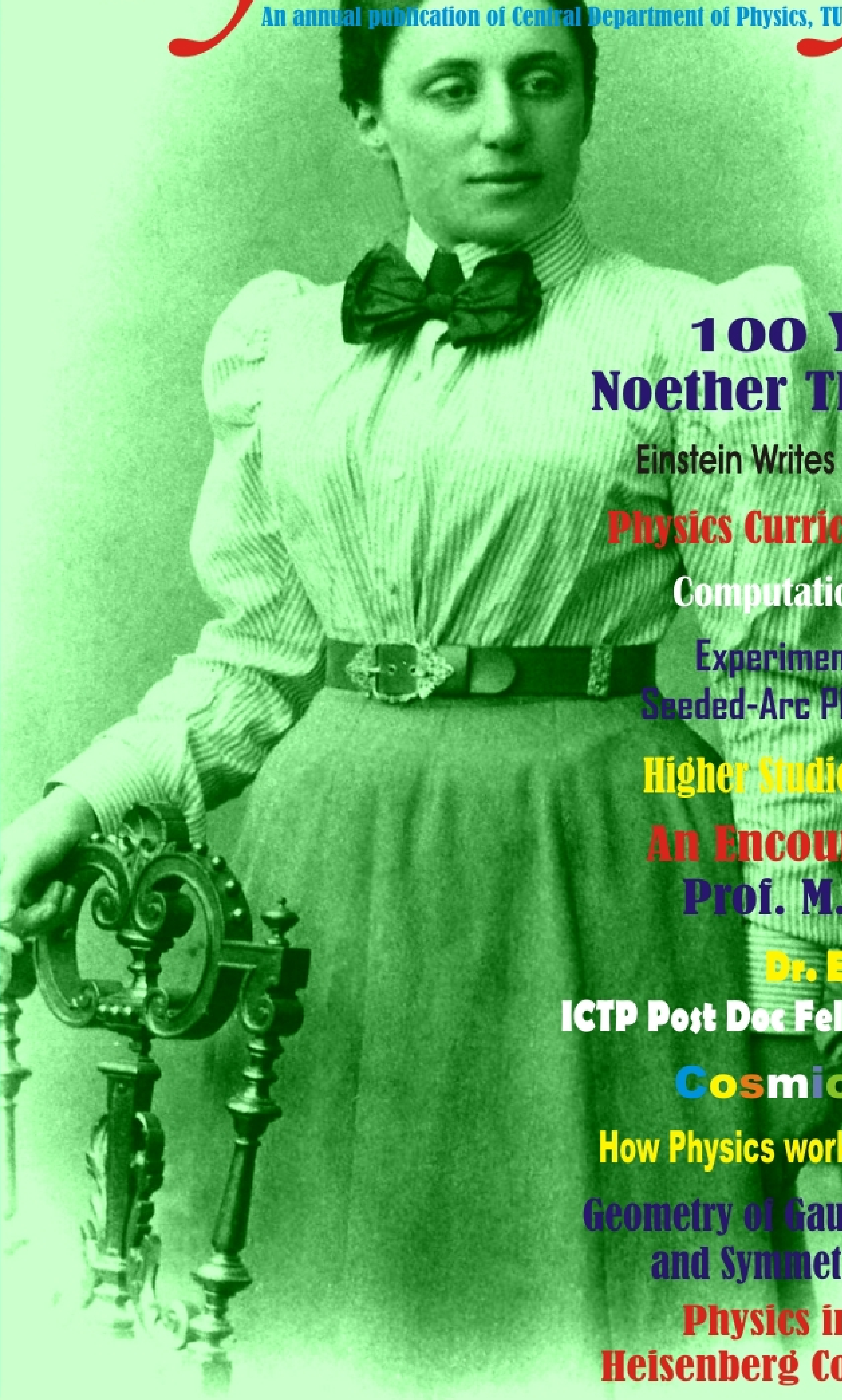
Volume X, 2016

Symmetry

An annual publication of Central Department of Physics, TU



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Dedicated to Amalie Emmy Noether, a female physicist who formulated Symmetry Principle

Dedicated to

Amalie Emmy Noether

Born: 23 March 1882 in Erlangen, Bavaria, Germany
Died: 14 April 1935 in Bryn Mawr, Pennsylvania, USA

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Editorial

Human understanding of nature advances through studies and researches in basic science. It may appear unattractive as it demands a lot of time, effort and money with seemingly no great use but it is these researches and discoveries in basic science that will eventually lead to the development of all great technologies. We are so much habituated with the comfort provided by these modern technologies that life without them is hard to be imagined.

Where are we, as a country,in the global scenario of researches in science? We almost have no presence of any kind. Our country has political and other problems to address but that should not be a reason for continuously discarding science sector. Government should prioritize this sector and provide adequate fund for scientific research through Universities and research institutions which is long overdue. Lack of fund should not be a reason for a graduate student to downsize their research project and dissertation work and limit their creative thinking and intellectual energy. Students and researchers should get full backing in their research work from government institutions to have any chance of breakthrough in science and to see the culture of scientific research grow.

In the world today, few of the institutions that are doing front line basic science research are LSC, LIGO, CERN, ITER, NASA, ESA etc. Universities around the world are also putting up their efforts. As large experiments cost a lot of money and minds, it is common today, for many countries and institutions to collaborate together for a scientific project. ITER is a collaboration of 35 nations to build a large fusion device. CERN has 21 member states and many other associate member, observers, non-members with co-operation agreement, etc. It is running world's largest particle accelerator. It may not be feasible to dream of such large experiment being done in our country but we can collaborate with others and make way for our students and researchers to be a part of those big experiments.

While the whole country is lagging behind in science and technology, the participation of women in higher education in science is poor too. Throughout the world, the situation is similar in a sense that presence of woman is negligible in the field of scientific research, especially in physics. We will read about Emmy Noether in this issue of symmetry whose life story proves that women are also strongly capable of giving their contribution to the Scientific community whenever they get a chance even when deprived of due recognition. Women participation in Science should be encouraged. It is a shame if they have to endure any kind of sexual intimidation in lab, University or any other workplace that is generally full of men.

"Symmetry", as an annual magazine of CDP, was first published in 2005. It is quite a milestone that we have reached 10th volume. It has been 100 years since Noether proved her theorem on symmetry and conservation law called Noether theorem in 1915. This theorem is very important to understand the symmetry inherent in the nature. We are celebrating this milestone of hers' in this volume of Symmetry. We thank all the women who contributed towards the society as a physicist, or mathematician, or from any other profession and were hardly given the appreciation they deserved. We hope this magazine will motivate all, especially women towards physics.

The publication of 10th volume of Symmetry has been possible with the tireless effort from Prof. Dr. Binil Aryal, HOD of CDP, along with all the members of Symmetry Publishing Committee. We are similarly thankful to all faculty members for their encouragement and valuable suggestions. We also thank all students, staffs for their help and all the writers who provided their valuable articles to us.

Contents

Physics Curriculum at Tribhuvan University: Present and Future

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

ABSTRACT

A brief history and development of Physics curriculum will be presented. An overview of existing physics curriculum of B.Sc. (Four Year Annual System) and M.Sc. (Two Year Semester System) level will be discussed. There is possibility of improvements at both levels. A conclusion with a recommendation for the future will be presented.

Physics Curriculum Development

As physics major, students first develop a strong background in mathematics and the fundamentals of physics. Later, they will tackle advanced-level physics courses in such challenging fields as optics, thermodynamics, quantum mechanics, theoretical mechanics, electrodynamics, and solid state physics. In the junior or senior years, students will gain practical experience as you work with a faculty member to develop and complete a physics research project. The physics major at the undergraduate course offers two options: General Physics and Computational Physics. The general physics is designed for students who want to pursue graduate work in physics or a related field. The computational physics that emphasizes applied physics and computers; it is ideally suited for students who want to enter industry directly upon graduation. The outcomes include a mastery of: 1) domain knowledge in the fields of physics, 2) research methods and laboratory skills, and 3) communication skills including technical and informal communication.

The undergraduate Physics education in Nepal has been started since last 75 years. The curriculum has been revised several times. The subject experts were very less in number in the beginning. The policy regarding the curriculum development was at the preliminarily level. Now the situation has been changed. There are basically three levels (from school to the University) for the curriculum development:

(1) **School level physics content:** Ministy of Education is responsible for curriculum development. There is no such permanent group of curriculum developers. Usually, temporary committee form as per demand. The member of such committee can be school or college or University physics teachers.

(2) **Higher Secondary level physics content:** The Higher Secondary Education Board (HSEB) has responsibility to take care curriculum development and revision as well as evaluation. Recently HSEB have formed physics subject committee.

(3) **College (B.Sc.) and University (M.Sc.) level physics content:** The Physics Subject Committee of Tribhuvan University is responsible for the curriculum development, revision and evaluation. In a few occasion, foreign experts are invited to work on curriculum with the subject committee.

School Level Physics Content

During April 2016, I was invited by the Ministry of Education in a discussion program with government school physics teachers. Teacher raised many questions regarding the physics content of class 9 and 10. After going into the details of the content, I found that there many mis-conceptions in the books. As an example, the 'weightlessness' described in the school text book was incomplete and the interpretation was wrong. We noticed many such cases in the curriculum.

At the secondary school level (class 8 to 10), a strong motivation is needed in the curriculum. In addition, such motivation should be connected with the national needs. The physics content should contain (1) historical developments of physics in various theoretical as well as experimental areas (2) the formulation (laws, principles, verification of laws and principals and their relevant numerical) (3) experimental and/or demonstration part. The experimental section is badly lacking in the curriculum. As per European 2001 Standard, the experimental section should take 50% credit hour (see Figure 1).

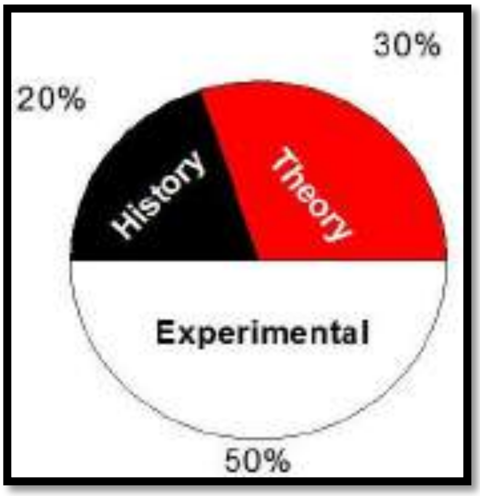

Figure 1: *School level physics content (Euro 2001)*

The theory content should be added in such a way that students can make personal understandings as well as they connect it to the real life.

Higher Secondary Level Physics Content

The existing physics curriculum at this level is relatively better in the sense that the students perform sufficient numerical as well as conceptual questions. It has covered a wide range: from mechanics, thermodynamics to optics & electricity, magnetism to modern physics. These are extremely important content at this level. The theoretical content is overloaded whereas the experimental section is limited. Since physics is an experimental science. Whatever human have achieved through physics, it is because of the experimental and finally technological success. So, HSEB should give more waitage on experiments.

In the very near future, grading system is going to be implemented at this level. The GPA system helps students to place them at their position withing suppressing their innovative skill. I hope experimental section will be benefit from this system. The traditional evaluation scheme needs a revision as well as improvement. Final examination question should be correct. This year, one question, in which interaction between quark and lepton was asked in a worong sense. Standard book should be used while making questions. There are many cut-copy-paste books in the market in which the concepts, formulation as well as interpretation of many sections are misguiding. I think Nepal Physical Society should take lead to upgrade the standard of +2 level physics books written by physics faculties of the nation.

There is a significant overlap between the secondary and higher secondary physics curriculum. This should be studied by a group of experts of HSEB board. As a whole higher secondary level physics content is satisfactory.

B.Sc. Level Physics Content

Institute of Science & Technology (IoST), Tribhuvan University has implemented four year B.Sc. program from the year 2012. This program is running under the annual system and has percentage evaluation system. The first batch of four year B.Sc. students has recently given fourth year final examination.

The structure of four year B.Sc. program of Tribhuvan University is given in the table 1. This structure is three-tire to one-tire system, best described by the figure 2. In each discipline students are required to study 45% core course and rest 55% additional courses. Out of 55% additional courses 12.5% courses are compulsory. These are scientific communication (first year), applied statistics (second year), research methodology (third year) and computational course (fourth year). The practical content is 25%. The major disadvantage is the research content, which is only 5% and optional. Therefore, students can complete four year B.Sc. level without carrying out research work. In a few discipline (e.g., Microbiology, Geology, etc) about 100% students perform research work, whereas in physics, chemistry and mathematics, only a very few (less than 10%) students carry out research work at this level. IoST should provide research infrastructure in these disciplines.

Table 1: Four Year B.Sc. Course Structure of Tribhuvan University[1]

Year	Description	Nature	
First Year	**a) Core Course:** Any three subjects either from physical or biological group.	Theory Practical **(450)**	(100 x 3) (50 x 3)
	b) Scientific Communication	Theory **(50)**	(50 x1)
Second Year	**a) Core Course:** continuation from first year	Theory Practical **(450)**	(100 x 3) (50 x 3)
	b) Applied Statistics	Theory **(50)**	(50 x1 1)
Third Year	a) **Core Course:** Any two subjects from first/second year.	Theory Practical **(300)**	(100 x 2) (50 x 2)
	b) **Research Methodology**	Theory **(100)**	
	c) **Elective Course**: Any two subjects from the respective subject pool.	Theory **(100)**	(50 x 2)
Fourth Year	a) **Core Course:** any one subject from third year (one-major)	Theory Practical **(300)**	(100 x 2) (50 x 2)
	b) **Project Work/Field Work** OR **Applied Science** (leading to core subject)	Research work & Presentation Theory **(100)**	
	c) **Computational Course**	Theory/Lab **(50)**	
	d) **Interdisciplinary Course**: one	Theory **(50)**	
Marks			**2000**

Figure 2 gives an outlook of an educational pyramid of B.Sc. (Four Year System).

Figure 2: *Three-tire educational system of B.Sc. (four year system), Tribhuvan University*

One-major system with a few elective courses and a multidisciplinary course is the major highlight of TU B.Sc. program. This program is the extension of previous one-major three years B.Sc. program. Still the program is traditional, lack of self-employment and career oriented courses.

About 17,000 students are enrolled in the B.Sc. (Four Year) program in 24 TU constituent colleges and a few TU affiliated colleges throughout the nation (TU Controller of Examination, 2016)[2].

Table 2: Physics content of B.Sc. (Four Year System)

Year	Code	Course Name	Nature	F.M.
I	PHY101	Mechanics, Thermodynamic, Statistical Physics, Electricity and Magnetism	Theory/ Core	100
I	PHY102	Physics Laboratory	Practical/ Core	50
II	PHY201	Optics, Modern Physics, Electronics	Theory/ Core	100
II	PHY202	Physics Laboratory	Practical/ Core	50
III	PHY301	Math Physics & Classical Mechanics	Theory/ Core	100
III	PHY302	Physics Laboratory	Practical/ Core	50
III	PHY303	Applied Mathematics	Theory/ Elective	50
III	PHY304	Space Science	Theory/ Elective	50
IV	PHY401	Quantum Mechanics	Theory/ Core	100
IV	PHY402	Physics Lab (General)	Practical/ Core	50
IV	PHY403	Nuclear Physics & Solid State Physics	Theory/ Core	100
IV	PHY404	Physics Lab (Electronics)	Practical/ Core	50
IV IV	PHY405 PHY406	Material Science OR Project	Theory OR Research	100 100
IV	PHY407	Econophysics	Theory / Interdisciplinary	50
TOTAL (Core+Elective+Optional+Interdisciplinary)				950

Table 2 shows the physics content of the B.Sc. (Four year system). The details of these courses are prepared by Physics Subject Committee. The first two year's course and curriculum is exactly same as the previous B.Sc. (three year system) program. It needs extensive revision. There is a significant overlap between the higher secondary physics content and the B.Sc physics content, which are as follows:

content	B.Sc.	suggestion
	(overlap with +2 Level in %)	
Mechanics	15%	Need minor revision
Thermodynamics	10%	required
Electricity & Magnetism	25%	Need thorough revision
Statistical Physics	00%	-
Optics	10%	required
Modern Physics	20%	Need thorough revision
Electronics	15%	Need minor revision

The third and fourth year's physics content is revised in the last year. Two elective courses (space science & applied mathematics) have been introduced in the curriculum of third year (see Table 2). In addition, material science (as an elective course) and econophysics (as interdispilinary) are added for the fourth year.

Physics Subject Committee has recently asked physics department of all 23 TU constituent colleges to send comments on the curriculum of all four years. A revision in the content will be done in the near future. IoST has organized faculty orientation program for all four years. Microsyllabus has been made and circulated to all colleges. Final examination question model has been revised.

M.Sc. Level Physics Content

The M.Sc. (Physics) courses are designed with the following objectives:

1. To give students up to date knowledge of recent trends in physics.
2. To impart skills to the students in the areas of theoretical, experimental and applied physics.
3. To develop manpower in teaching physics at the tertiary level and to conduct research in physics.
4. To produce high level research manpower in physics.

The semester-wise course content is listed in Table 3.

Table 3: Physics content of M.Sc. (semester system)[3]

Semester	PHY	Course title	CH	Nature
FIRST	501	Mathematical Phys. I	3	Compulsory
FIRST	502	Classical Mechanics	3	Compulsory
FIRST	503	Quantum Mechanics I	3	Compulsory
FIRST	504	Electronics	3	Compulsory
FIRST	505	Physics Practical I	3	Compulsory
SECOND	551	Mathematical Phys. II	3	Compulsory
SECOND	552	Statistical Mechanics	3	Compulsory
SECOND	553	Solid State Physics	3	Compulsory
SECOND	554	Electrodynamics I	3	Compulsory
SECOND	555	Physics Practical II	3	Compulsory
THIRD	601	Electrodynamics II	3	Compulsory
THIRD	602	Quantum Mech. II	3	Compulsory
THIRD	603	Physics Practical III	3	Compulsory
THIRD	611	Adv. Solid State Phy. I	3	Elective
THIRD	612	Micro & Optoelec. I	3	Elective
THIRD	613	Seismology I	3	Elective
THIRD	614	Atmospheric Phys. I	3	Elective
THIRD	615	Plasma Physics I	3	Elective
THIRD	616	Biomedical Physics I	3	Elective
THIRD	617	Gravita. & Cosmo. I	3	Elective
THIRD	618	Astrophysics I	3	Elective
FOURTH	651	Quantum Mech. III	3	Compulsory
FOURTH	652	Nuclear & Particle Ph.	3	Compulsory
FOURTH	653a	Electronics Practical	3	Elective
FOURTH	653b	Computational Phys.	3	Elective
FOURTH	653c	Project	3	Elective
FOURTH	661	Adv. Solid State Phy II	3	Elective
FOURTH	662	Micro and Optoelec. II	3	Elective
FOURTH	663	Seismology II	3	Elective
FOURTH	664	Atmospheric Phys. II	3	Elective
FOURTH	665	Plasma Physics II	3	Elective
FOURTH	666	Biomedical Physics II	3	Elective
FOURTH	667	Gravita. & Cosmo. II	3	Elective
FOURTH	668	Astrophysics II	3	Elective
FOURTH	699	Dissertation	6	Elective
Total (required)			60	

A student can choose any two courses from the electives including dissertation. 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 in order to enroll for the dissertation. The practical course in the third semester is compulsory however in the last semester, three optional courses namely electronics practical, project and computational physics will be offered. One can choose project work or perform electronics experiments or take computational physics course. However, one student cannot choose dissertation and project work both.

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 15% students of full quota are required to run an elective course. The physics subject committee may also develop new elective courses in the future.

There is a significant overlap between the B.Sc. physics content and the M.Sc. physics content, which are as follows:

content	**M.Sc.**	**suggestion**
	(overlap with B.Sc. Level in %)	
Mathematical Physics I	40%	Need major revision
Quantum Mechanics I	50%	It needs major revision
Classical Mechanics	25%	Need thorough revision
Electrodynamics I	25%	Need thorough revision
Electronics	25%	Need thorough revision
Solid State Physics	50%	Need major revision
Lab (first semester)	60%	Need major revision
Lab (second semester)	15%	Need major revision
New Courses		**Course Nature**
Quantum Field Theory		Compulsary
Computational Physics		Compulsary
Solid Earth Geophysics		Elective
Material Science		Elective

Because of the new and updated curriculum of B.Sc. third and fourth year, six courses of M.Sc. (first and second semester) needs thorough revision. Because of these changes the curriculum of compulsory courses of third and fourth semester need revision. There will be space for at least 6 credit hours. The possible future courses will be quantum field theory, computational physics as compulsory courses and Solid Earth Geophysics and Material Science as electives.

The fundamental differences between the structure and evaluation system of B.Sc. and M.Sc. levels are shown in Figure 3. One is annual system with percentage evaluation, another is the semester system with GPA evaluation system.

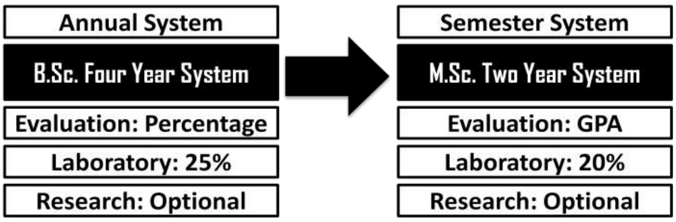

***Figure 3**: Fundamental difference between the B.Sc. (Four Year Annual System) and M.Sc. (Two Year Semester System).*

Recommendations

I conclude with the following recommendation regarding the course structure and content of B.Sc. and M.Sc. program of TU:

1. The four year annual B.Sc. system should be changed to the semester system. The evaluation system in both B.Sc. and M.Sc. level should be similar. The GPA system should be introduced at the B.Sc. level.
2. At the B.Sc. level, additional elective or optional courses e.g, Earth Geophysics, Siesmology, computational physics, etc should be added. The curriculum of first and second year B.Sc. (Physics) should be extensively revised.
3. The research content (project work for B.Sc. and Dissertation at M.Sc. level) should be made compulsory. For this minimum research infrastructure is needed at TU constituent colleges and the central department.
4. A new structure for M.Sc. (Physics) should be made. Fourth semester course should have elective papers and research works only. The credit hour for laboratory work should be increased from 3 to 6 at the masters' level. The present status of laboratory needs extensive reform, from Central Department to constituent colleges. A regular laboratory grant should be supplied for the improvement.
5. At the M.Sc. level, three courses are lacking to meet international standard: Quantum Field Theory or High Energy Particle Physics, Computational Physics as compulsory course and General Theory of Relativity (at least Einstein Field equation and its solutions).

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Computational Physics Course at Central Department of Physics Tribhuvan University

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

ABSTRACT

Computer has changed a lot in our life. It has brought changes also in the way we do physics. It has been used to solve physics problem right after its invention in 1940s first to study the nuclear bomb and ballistic simulation and to study the equation of state of water. Since then it has been widely used to solve different types of problems. Its applications range from simply displaying data to solve nonlinear equations to simulate a simple physical system to black holes. Some time the simulations carried out in the conditions where simple real experiments cannot be performed for example in very high pressure or high temperature. Because of its uses, almost all the physics departments of universities across the globe have introduced the course "computational physics". Here at central Department of Physics also computational physics was introduced long time back. However it was not in a formal course. To fulfill the demand, it has been introduced as a course in fourth semester as an optional. It is hoped that it will definitely be helpful to find answer of our young graduate student's curiosities.

Motivation

Generally, nuclear physics deals with physics of nucleus, atomic physics deals with physics of atoms and so on. However, computational physics does not study with computers. Computational physics is used to solve physics problems in any area of physics like classical physics, statistical physics, solid state physics, astrophysics, cosmology, math physics, quantum physics, electromagnetism, spectroscopy etc. Nowadays, computers are considered to be one of the most important tools available to physicists. Computational physics is actually a tool to advance physics education and research. Some time they are used just to calculate and present (display) the obtained results. Some time computers are used to simulate experiments. They are also used in solving complex systems of equations especially nonlinear equations to obtain new and intriguing physics. It can also be used to imitate an experiment which is not otherwise possible say for example in very high pressure [1], very high temperature or even at O K [2], which are not practically feasible. In 1990s American Institute of Physics performed a survey to Graduate students in physics asking them which aspect of their education is most valuable in their current employment. The results showed that for science graduates the most important skill is scientific problem solving [3]. I think this applies to everywhere in physics learning. The scientific problem solving technique is one of the most important skill, we must impart to our graduates in Tribhuvan University also. Obviously, problem solving using computers is one of the best ways to learn. In this context, computational physics provides a broader, more balanced, and more flexible education than a traditional physics teaching. Moreover, these skills are also highly important to graduates who find employment related to software, with this latter group having a high need for computer programming and software development.

The term computational physics means (i) process and analysis of data, (ii) numerical solution of equations or (iii) computer experiments. In process and analysis, a large amounts of data from measurements; are fitted to theoretical models; or they are displayed/animated graphically. Examples in this case include plot of wave functions of electrons in solid, search for "events" in particle physics, image analysis in astronomy etc. Numerical solution of equations means some equations (coupled, nonlinear equations) cannot be accomplished by analytical techniques and one has to solve such equations numerically. Examples are in fluid dynamics Navier Stokes equation, in numerical relativity (Einstein's field equations), in solid state physics electronic ground state wave functions of a solid, nonlinear growth equations etc. In computer experiments: we simulate physical phenomena, observe and extract quantities as in experiments. We explore simplified model systems for which no solution is known. A few typical examples are molecular simulations of materials (see for e.g. [4,5]), protein folding, planetary dynamics (N-body dynamics).

As mentioned above almost all the physics department of universities is having a course called "*computational physics*". It was high time that central department of physics also introduce the course. Two years back, when Central Department of Physics, Tribhuvan University introduced semester system, the department has opportunity to review all the courses. Many courses are changed to new and higher level and a new course "Computational Physics" also added as an optional.

Is it really New Course?

Even though as a formal course "Computational physics" is new one in research work it has been carrying out by huge number of students and faculties [6] since long time. More than 100 M.Sc. graduates and a few Ph.D. graduates from Central Department of Physics, Tribhuvan University had already used computational tools in their dissertation works. It is because almost all the faculties of Central Department of Physics, Tribhuvan University work in the computational physics whether it is condensed matter physics or cosmology or astro-particle physics or plasma or atmospheric or biomedical physics. As discussed above, it is an indispensable tool now. Every physics student of Tribhuvan University must know computer literacy, idea about different Operating Systems especially Linux and Windows which are used by many physicists. Some programming knowledge is essential as it is demanding for even experimentalists to interpret their findings with numerical modeling or so. The aim is not to make expert in computer languages like Fortran/C but basic knowledge is required for each of our graduates in physics. Each student was encouraged to plot the experimental data by using computers from long time.

Computational Physics Course at CDP, TU

According to fourth semester syllabus the objectives of the computational physics course are following: to train the students in the methods of computations in physics and apply them to solve the real problems, at the completion of the course, the student should be able to solve different physical problems using recent computational techniques. The objectives can be met in three distinct levels. First the course provides computer literacy to all the students. It is highly demanding that a physics graduate must be familiar with different Operating Systems of computers, different editors to write their documents (thesis or any other documents), plotting programs to display the outcome of any simple experiments they carry out in laboratory or for their research work to be published. Further, (s)he must know modern computer languages like Fortran/C. Secondly, the students opting this course have to be familiar with how to apply those computer languages to solve simple physics problems. The course contains numerical methods to fulfill this aim. In this section, students get opportunity to learn not only simple codes to understand deeply quantum mechanics or statistical mechanics or problems in any other branch of physics but also to broaden the physics knowledge. This chapter provides opportunity to learn already solved problems in different, new and more depth way. For example, see another article in this issue of Symmetry by Y Kandel (Fourth Semester student). Also there are a few topics like Monte Carlo Integration which provides idea about latest techniques which may be useful in molecular simulation to understand the static properties. The Monte Carlo techniques are applied in physical sciences, engineering, finance, searches and rescues, artificial intelligence etc. Moreover, there are different ways to solve partial differential equations used to solve physics problems in many cases. Thirdly, it contains some models used in different areas of physics like condensed matter, astroparticle and plasma physics. It can be extended to teach other models also if time permits. There are some models whose analytical solution does not exist in closed form like the most studied model - Ising model in 3 dimensions. However one can use computational physics tools to get numerical solutions of such models.

Conclusions

Computational physics has been developed as an indispensable tool and grown as a separate branch of physics apart from theoretical and experimental physics. It is essential to have basics of computational physics by each of physics (under)graduates. It is good that Central Department of Physics has introduced the course of computational physics. By the time, this article appears in symmetry first batch opting for the course will finish the course. The author thinks that it has provided broader idea about solving physics problems. Obviously, there is enough room to improve. In future, I hope that it will be a compulsory course so that each of the graduates gets opportunity to learn about its techniques, to apply them, to realize physics in different way than the traditional way. Further it provides each student to show their creativity by writing computer codes to solve different physics problems. It is said that beginnings are always challenging. Although only time will judge the viability of programs such as computational physics at Central Department of Physics Tribhuvan University, they do appear to attract new students and to provide them with broad preparation for future career choices. I am sure most of them will opt computational physics as their career.

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I think nature's imagination Is so much greater than man's, she's never going to let us relax. Richard Feynman

Ionosphere and its Influence in Communication Systems

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ABSTRACT

Ionosphere is the region of the upper atmosphere with the sufficient amount of charged particles also referred to as plasma.Even though ionosphere is a small part of the atmosphere, it has a profound effect on the properties and behaviour of the medium. The model result of vertical profile of electron density shows the different layers of the ionosphere, which depend on the day or night-time period as well as solar conditions. When the radio wavespropagate through the ionosphere, they are affected by the phenomena of reflection, refraction, diffraction, absorption, polarization and scattering. So the ionosphere has practical importance as it influences radio wave propagation to distant places on the earth, which directly impacts on radio wave communication systems.

What is ionosphere?

Ionosphere is the region of the Earth's upper atmosphere extending from altitudes of approximately 60 km from the surface of Earth to the altitudes beyond 1000 km, where the sufficient amount of charged particles exists. In other words, this is the region of a shell of electrons and electrically charged particles (atoms and molecules), also known as plasma that surrounds the Earth.In plasma, the electrostatic force attracts the negative free electrons and the positive ions to each other, but they are too energetic to stay fixed together in an electrically neutral molecule. The plasma concentration may amount to only about 1% of the neutral concentration and the total ionosphere represents only less than 0.1% of the total mass of the Earth's atmosphere (*Kelley*, 1989). Even though it is such a small part, it is tremendously important and it has a profound effect on the properties and behaviour of the medium.

Scientifically, the ionosphere is not another atmospheric layer. During the daytime, the ionosphere separates into several layers or regions depending upon the local time of day. The main layers are D-region, E-region, F1-region, and F2-region as shown in Figure 1. The layers are generally characterized by a density maximum at a certain altitude and a densitydecreases with altitude on both sides of the maximum.The D-region ranges from about 60 km to 90 km and is controlled by ionization of neutrals by solar X-Rays and Lyman alpha radiation, which cause two- and three-body recombination and electron attachment. The dynamics of the D-region are mostly dominated by the neutral atmosphere. In this region, the plasma density range is 10^2-10^4 cm^{-3}. The E-region extends from ~90 km to 150 km altitude with a plasma density ~10^5 cm^{-3}. This region is chemically dominated and contains molecular ions such as N_2^+, O_2^+, NO^+ as primary constituents (*Shunk and Nagy*, 2000). The F_1-region ranges from ~150 km to 200 km altitude with plasma density range of ~10^5-10^6 cm^{-3}. The F_2-region extends from an altitude of ~200 km to 500 km and the plasma density maximum varies around 300 km up to 10^6 cm^{-3}. This is the region of peak electron density of the ionosphere, which is usually over an order of magnitude greater than the E-region peak density. These F_1- and F_2-regions are dominated by monoatomic oxygen and the ions transported through diffusion.

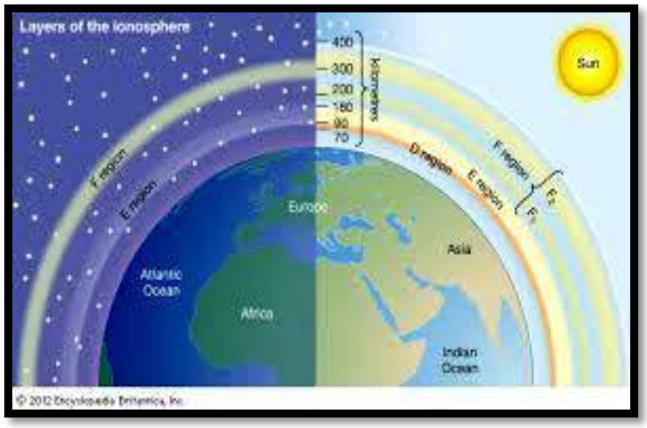

Figure 1: *Earth's Ionospheric layers are shown [source: https://www. google.com.np/search ?q=ionospheric+layer]*

The D- and F_1-regions vanish during the night and the E-region become much weaker. The daytime plasma densities are greater than that of the night-time and also larger during the solar maximum than in solar minimum. At solar maximum, the electron densities are greater by a factor of two to four than at solar minimum, especially in the F-region. The E-region and lower part of the F-region undergo relatively greater variations in electron density between day and nighttime than does the upper F-region. The F_2-layer is the principle-reflecting layer for HF communications and is responsible for most sky wave propagation of radio waves. Thus, this region is of the greatest interest for radio wave propagation. Unfortunately, this layer is also the most anomalous, the most variable and the most difficult to predict.

How is ionosphere formed?

The solar radiation of all wavelengths travels towards the Earth, first reaching the outer regions of the atmosphere. When radiation of sufficient intensity strikes an atom or a molecule, the photon transfers its energy to the electron as excess kinetic energy. When this excess energy under some circumstances exceed the binding energy in the atom or molecule, the electron splits the influence of the positive charge of the nucleus. This leaves a positively charged nucleus or ions and a negatively charged electron, although as there are the same number of positive ions and negative electrons, while the whole gas still remains with an overall neutral charge.For example, Figure 2 shows helium atom is incident by the solar radiation; electron is ejected from the atom and get ionised giving the positively charged ion and free electrons. Similar phenomena happens to other gases to form ionisation and hence to form ionosphere.

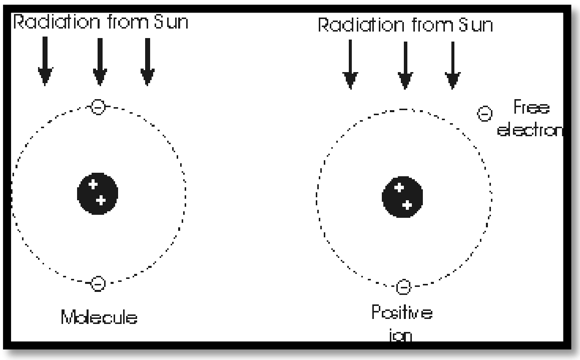

Figure 2: *Ionisation of molecules by solar radiation.*

Most of the ionisation in the ionosphere results from ultraviolet (UV) radiation. At each time of the ionisation, an atom or a certain amount of energy is used thereby reducing theintensity of radiation. Because of this reason that the UV radiation causes most of the ionisation in the upper regions of the ionosphere, but at lower altitudes the radiation that is able to penetrate further cause more of the ionisation. Accordingly, extreme UV (ultraviolet)radiation and X-Rays give rise to most of the ionisation at the lower altitudes.

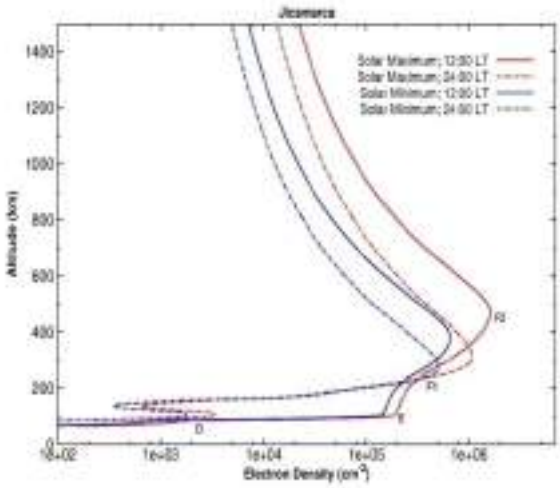

Figure 3: *Model calculation of electron density (or plasma density) profile of the equatorial ionosphere at noon (solid lines) and midnight (dashed lines) for solar minimum (blue lines) and solar maximum conditions (red lines).*

The level of ionisation varies over the extent of the ionosphere with respect to altitudes as the level of radiation reduces with decreasing altitude. So the density of the gases also varies with altitudes. In addition, there is a variation in the proportions of monatomic and molecular forms of the gases that is the monatomic forms of gases being far greater at higher altitudes. Accordingly, the ionization constituent's also vary with altitudes with dominant of monoatomic charge in higher altitudes.

The level of ionisation in the ionosphere also varies with time of day, seasons and many other external influences including the solar activities. While the radiation from the Sun causes the atoms and molecules to split into free electrons and positive ions, on the other hand, when a negative electron meets a positive ion, they may combine. Consequently, two opposite effects of splitting and recombination of charges are taking place. This is known as a state of dynamic equilibrium. Accordingly, the level of ionisation is dependent upon the ionisation and recombination rate. This has a significant effect on radio wave propagations and hence in communication systems.

We have calculated the model results of the vertical structure of the electron density (or plasma density) of the ionosphere at the local noon (solid lines) and local midnight (dashed lines) for solar minimum (blue lines) and solar maximum (red lines) conditions as shown in Figure 3. The data were obtained by running the International Reference Ionosphere (IRI) model developed by *Bilitza*,(2008) for solar minimum (September 22, 2006) and maximum conditions (on September 22, 2001) at Jicamarca, Peru, which lies close to the dip latitude. The dip latitude is the imaginary horizontal line running east-west normal to the magnetic field lines and is an angular measurement in degrees ranging from 0° at the magnetic equator to 90° at the magnetic poles (*Chapagain*, 2011). The Figure clearly shows the plasma density is maximum with around from 250 km to 400 km altitudes depending on the day- or night-time period, or with solar conditions. Daytime electron density is high during solar maxima compared to night-time period in solar minima conditions.

Radio wave communication system

Radio waves are affected by the phenomena of reflection, refraction, diffraction, absorption, polarization and scattering when traveling through the ionosphere as similar to the form of electromagnetic radiation, like lighting waves (Booker and Wells, 1938). Radio propagation is the behaviour of radio waves when they are transmitted, or propagated from one point on theearth to another, or into various parts of the atmosphere.When the radio waves are transmitted from the surface of the Earth, they are reflected back from the ionosphere and able to reach the transmitter (as shown in Figure 4). So the ionosphere has practical importance because, among other functions, it influences radio propagation to distant places on the earth. Radio wave was being used on a daily basis for broadcasting as well as for two-way radio communication systems. Radio waves, microwaves, infrared and visible light can be used for communication system. For instance, radio waves are used to transmit television and radio programs, while the microwaves are used to transmit satellite television and for mobile phones. Additionally, infrared wave can be used to transmit information from remote controls.

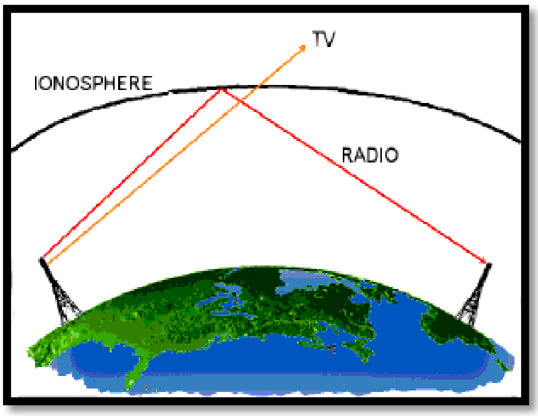

***Figure 4**: Radio wave propagation from Ionosphere [source: https://www.google.com.np/search?espv=2]*

The radio wave propagation is affected by many factors such as by the daily changes of water vapour in the troposphere and ionization in the upper atmosphere, due to the Sun. Understanding the effects of varying conditions on radio propagation has many practical applications, from choosing frequencies for international shortwave broadcasters, to designing reliable mobile telephones systems, or radio navigation, to operation of radar systems. Moreover, radio wave propagation is also affected by several other factors determined by its path from point to point. This path can be direct line of sight path or an over-the-horizon path added by refraction in the ionosphere, which is a region between approximately 50 and 600 km. In addition, factors influencing ionospheric radio signal propagation can include inonospheric variability such as sporadic-E, Spread-F andionospheric layer tilts, and solar activities such as solar flares, geomagnetic storms, and solar proton events and so on.

Radio waves of different frequencies propagate in different modes. At extra low frequencies (ELF) and very low frequencies havevery much larger wavelengththan the separation between the earth's surface and the D-layer of the ionosphere. Consequently, electromagnetic waves can propagate in this region as a waveguide. Actually, for frequencies below 20 kHz, the wave propagates as a single waveguide mode with a horizontal magnetic field and vertical electric field. The interaction of radio waves with the ionize regions of the atmosphere makes radio propagation more complex to predict and analyse than in free space.

Radio wave propagation through the ionosphere, especially during the disturbed ionospheric conditions also referred to as ionospheric irregularities (Chapagain et al., 2009), ismore complex to predict and analyse than in free space. Ionospheric radio wave propagation has a strong association to space weather. A sudden ionospheric disturbance or shortwave fadeout is observed when the X-ray associated with a solar flare ionizes the D-region ionosphere. Consequently, enhanced ionization in that region increases the absorption of radio signals passing through it. During the active solar period, such as strongest solar X-ray flares complete absorption of virtually all ions spherically propagated radio signals in the sunlit hemisphere can occur. These solar flares can disrupt HF radio propagation, whichdisturb GPS (Global Position System) accuracy. Since radio wave propagation is not fully predictable, such services as emergency locator transmitter in flight communication for long distant such as with ocean crossing aircraft, and television broadcasting have been moved to communications satellites. A satellite link, through expensive, can offer highly predictable and stable line of sight coverage of a given area.

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"I remember discussions with Bohr which went through many hours till very late at night and ended almost in despair; and when at the end of the discussion I went alone for a walk in the neighboring park I repeated to myself again and again the question:

Can nature possibly be so absurd as it seemed to us in these atomic experiments?"

Werner Heisenberg

Hydrogen as an Alternative to Fossil Fuel

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ABSTRACT

In this article, a brief description regarding the importance of Hydrogen as an alternative fossil fuel will be presented.

Introduction

We are facing many problems in 21st century. These problems are environmental problems, political problems, supply of sustainable and sufficient energy problems, etc. Out of these problems, problem of energy would be the most serious.

A question may arise. Why would problem of energy be the most serious? The recent energy problem in our country is one of the examples, which showshow serious the problem of energy would be. Further, let us discuss present global energy scenario. According to BP (formerly British Petroleum) statistical review of world energy of 2015 the global primary energy consumption is estimatedwith 12928.4 million tons of oil equivalent (MTOE) for 2014 [1]. This value is equivalent to 0.541 ZJ. If we inspect the data given by this report (Figure 1), the consumption of primary energy is rising by some factors in each year. Furthermore, the data presented in this report (Figure 1) show that the total energy consumption for 2004was 10556.6 MTOE (0.442 ZJ).The rise of consumption of energy for 10 years is thus 0.099 ZJ. Let us compare the same from the energy consumption by US persons. The present energy consumption in the US is 322 GJ per person [2].The world population in 2050 would be 9.6 billion [3]. In 2050 the amount of energy consumption by the world population would be 3.091ZJ, if the whole world populations use the same amount of energy as the US persons and the energy consumption would rise to 2.55 ZJ. Thus, both data show that we have to increase the production of energyin coming year for better quality of life.

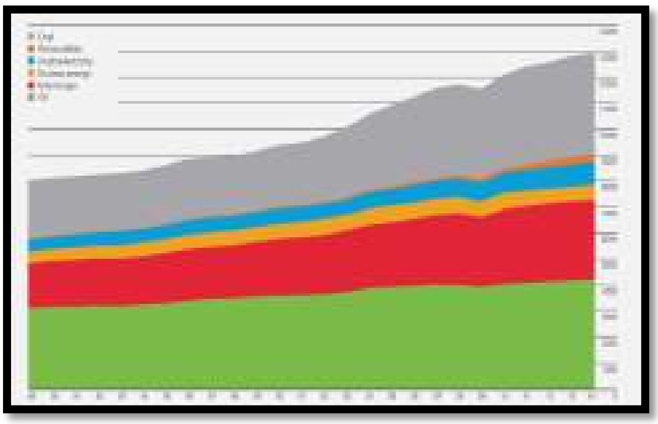

Figure 1: *World Primary Energy Consumption in Million Tonnes of Oil Equivalent from 1989 to 2014 [Courtesy: BP Statistical Review of World Energy].*

At present our energy system are mainly dependent on fossil fuels. Fossil fuels are not only limited but also harmful to the environment if consumed intensely. According to the IPCC (Intergovernmental Panel on Climate Change) report [4] there was a considerable and sudden increase in global temperature when compared to the last thousand years. These increases in temperature may be attributed due to carbon dioxide emissions. Although it is much more difficult to replace fossil fuels in transport applications, we have to reduce its burningfor electricity generation. If no measures are taken to reduce its burning in the 21st century, a further substantial increase in atmospheric carbon dioxide can be expected.

It is now clear that burning fossil fuels is creating negative environmental impacts. Thus, human beings are looking toward a new means of obtaining energy. For this, renewable energy technologies such as hydro, solar, wind, biomass, geothermal energy havealready been used in many countries. However, neither these options alone can meet the increase in global energy demand nor it may reduce the dependence on fossil fuels.

One of the alternative energy sources could be nuclear power technology. In nuclear power technology, nuclear fission currently provides 7% of the global primary energy and 17% of electricity. In Western Europe only 35% of electricity is produced by nuclear power plants [5]. . However, like our fossil-fuel based power technologies, nuclear power technologies are based on finite uranium resource.Nuclear fusion technology could be alternative to nuclear fission. Compared to nuclear fission it is safety and is good for environment as it does not produce any nuclear wastes.Moreover, the fusion fuels (lithium and deuterium) are readily available and supplies would last for millennia.However, nuclear fusion technologyis still in the research phaseand it may need another three/four decades to develop itfor a viable energy source.

For a reasonable life quality of all human beings, production of energy should be increased in one hand and we have to reduce using fossil fuels to prevent further contamination of carbon dioxide in another hand. We now know that fossil fuels are not only rare, it is creating lot of environmental problems so it is in urgent need of a finding zero-emission energy cycle based on renewable energies within the first half of the 21stcentury to simultaneously solve the energy problem as well as environmental problem.However, the development of energy needs from alternative energy sources is a challenge nowadays. One of the alternatives would be the hydrogen which would reduce our dependence of fossil fyuels.

Hydrogen has may advantages in comparison to other energy sources. Hydrogen with oxygen exhausts clean H2O. Hydrogen gas is not toxic and highly volatile in atmospheric conditions. Hydrogen is combustive in nature so it can be used directly in an internal combustion engine by replacing automotive gasoline. Another advantage of using hydrogen is that it can be stored in fuel cells for creating electricity which can provide another power source for a vehicle. Further, natural gas can be replacedby using hydrogen in heating and cooling homes.The most important of its application is that it could also be used to turn the turbines that bring electricity to homes.

It is not so easy to find a material that can store hydrogen under moderate temperature and pressure. It is now necessary to developsuitable small and large scale hydrogen storage containers. Lot of works regarding this is going on.

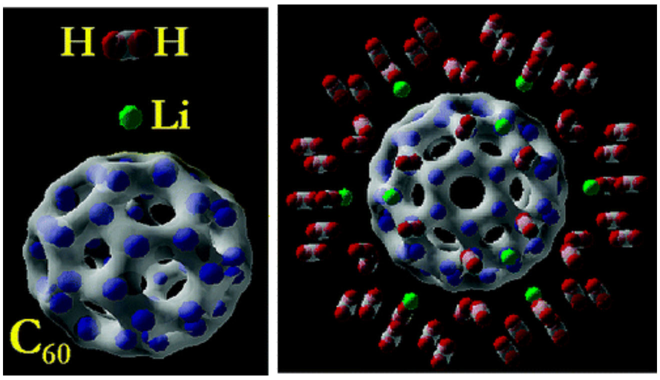

Figure 2: *Li metal coated with C60 for hydrogen storage [Figure Courtesy: J. Am. Chem. Soc. 128, 9741 (2006)].*

There are two ways of interaction of hydrogen molecules with materials. It interacts with other materials either in molecular form or in atomic form. The first one is called physisorbed and in this form there is no transfer of charge takes place between the surface and the hydrogen,this resulting weak binding. The latter case is called chemisorbed and has strong binding. For ideal system of hydrogen storage hydrogen binds molecularly but with abinding energy that should be intermediate between the physisorbed and chemisorbed state.

Recent research shows that carbon materials could be usedfor one of the hydrogen storage systems. Among the carbon materials graphite nanofibres is one of the examples [6]. Another carbon materialwould be coating of C60 fullerenes with suitable metal atoms. Li metal coated with C60 [7], electron-doped C60 monolayer on Cu [8] are some examples of hydrogen storage systems. It has been also known that multi-wall carbon nanotubes (MWNT) are otherpromising candidates for hydrogenstorage if doped with alkali metals such as lithium or potassium[9]. Recently discovered graphene could also be the hydrogen storage material [10]. Besides carbon materials,research on searching of other materials for hydrogen storage system is underway. It is found that metal hydrides (PdH, MgH2 , H4AlNa, FeTiH2 H2NLi, LaNi5H6 etc.)are another candidates that can be used as a hydrogen storage system [10, 11].

There are other materials that can store hydrogen. These includenanoscale titanium benzene complex [12], carbon nitride nanotubes [13], Li-coated zigzag boron nanotubes [14], etc.Extensive research on it has been going on.

In conclusion, hydrogen has the potential to meet the energy need of human beings in coming years as it is the simplest and most abundant element in the universe. For this, we have to develop a technolgy for its production and storage.

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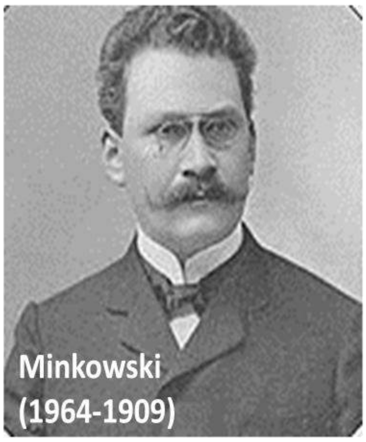

Hermann Minkowski **was a Lithuanian-German mathematician, professor at Königsberg, Zürich and Göttingen. He created and developed the geometry of numbers and used geometrical methods to solve problems in number theory, mathematical physics, and the theory of relativity. Minkowski is perhaps best known for his work in relativity, in which he showed in 1907 that his former student Albert Einstein's special theory of relativity (1905), could be understood geometrically as a theory of four-dimensional space–time, since known as the "*Minkowski spacetime*".**

Experimental Setup for a Two-bit Flash A/D

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ABSTRACT

An experimental set up for a two-bit flash A/D is designed using a reference voltage network, operational amplifiers, diodes and gates. This setup is capable of converting an analog signal in the range from millivolts to volts into 2-bit digital number.

Introduction:

Physics is the science of measurement. A transducer is used to produce an electrical signal corresponding to a physical quantity. For example, a microphone converts sound signal into an electrical signal [1]. An electrical signal produced by transducer is of analog current or voltage signal. The magnetude of the signal depends on the type of signal generator. For example, Electrocardiogram (ECG) monitoring system produces electrical signals in milivolt range [2] whereas the hydropower system produces electrical signals in the kV range. The problem of size dependance of the electrical signal can be removed using an appropriate reference signal during analog to digital conversion. Thus, for precise measurement of physical quantities, nowadays, digitization of analog signals become mandatory. In this regards, analog to digital conversion technique with suitable reference voltage is required and flash analog-to-digital technology is the fastest one [3]. Two bit flash A/D could be the best example to explain the basic concept of analog to digital conversion for physics students.

Theory:

A two-bit flash analog to digital converter (A / D) converts the input voltage into one of four digital numbers 00, 01, 10 and 11 depending on the reference voltage. The reference voltage is choosen such that it is the maximum value of the signal voltage that has to be digitized in an experiment. For example in the measurement of temperature using a thermocouple, the thermo e.m.f. will be in the milivolt range. The reference voltage required to convert the thermo e.m.f. into the digital numbers should be greater or equal to the maximum thermo e.m.f. Thus the reference voltage for thermo e.m.f. should also be in milivolt region. Equation 1 shows the relation between an analog (V_a) number and two-bit digital number (AB).

$$V_a = 2^1 A + 2^0 B \quad \text{-------------} \ (1)$$

Circuit Design:

A complete circuit diagram of a two-bit flash A/D circuit is shown in Fig. 1 & 2. Figure 1 consists i) reference voltage generator, ii) comparator and iii) interface sections. Figure 2 is the priority encoder.

First Part: Production of Reference Voltage

This is the most important and crucial part of the design. The reference voltage (V_{ref}) can be obtained from the analog voltage (V_a) as

$$V_{ref} \geq (V_a)_{max} \quad \text{-----------------} \ (2)$$

Also, from the circuit Fig. 1 the V_{ref} will be

$$V_{ref} = \frac{4R}{4R+R_1} V_{dc} \quad \text{--------------------} \ (3)$$

By choosing R, R_1 can be calculated as

$$R_1 = \left(\frac{V_{dc}}{V_{ref}} - 1\right) \times 4R \quad \text{-------------} \ (4)$$

Second Part: Comparator

For n-bit Flash A/D, 2^n-1 number of comparators will be needed. So for 2-bit Flash A/D the number of comparator will be 3. Operational amplifiers (by using IC 741) are used as comparator. As the operational amplifier is biased by ± 12 V, the output of comparator will be low (-12 V) if its input voltage difference between non-inverting and inverting terminals of Op-Amp is negative and high (+12 V) if it is positive.

Third Part: Interface

The interface circuit is designed by using diodes (1N4007) and resistors. This circuit bypasses negative voltage and produces ≈0 V. It also reduces +12 V to +5 V. This part helps to communicate between comparators and priority encoder.

Fourth Part: Priority Encoder

The priority encoder (Fig. 2) is designed on the basis that it produces output correspond to the currently active input which has the highest priority [3, 4]. Thus, when an input with a higher priority is present, all other inputs with a lower priority will be ignored. Here, priority of the comparator increases from lower to upper one. Truth table of a priority encoder is shown in Table 1.

Table 1: Truth Table for priority encoder

Inputs			Outputs	
X	**Y**	**Z**	**A**	**B**
0	0	0	0	0
0	0	1	0	1
0	1	1	1	0
1	1	1	1	1

From Truth Table, Booleans equations for outputs A and B can be written as

$$A = Y$$
$$B = X + \overline{Y}\,Z$$

The priority encoder is designed by using NAND gates (IC 7400) as shown in Fig. 2.

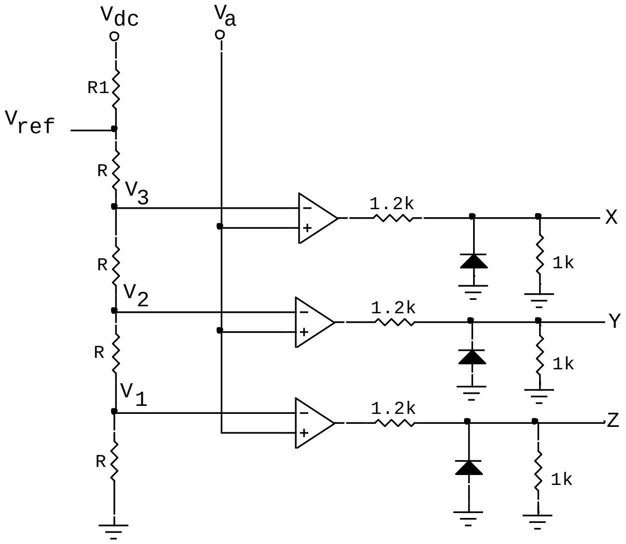

Figure 1: *Comparator with reference voltage and interface*

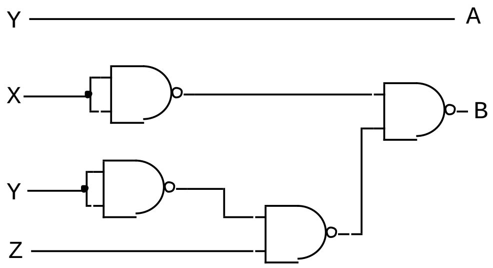

Figure 2*: Priority Encoder*

Task to the Students:

Students are asked to design an A/D to convert a range of analog voltage to digital equivalents. They should find the maximum analog voltage and setup the reference voltage by using appropriate DC voltage source (V_{dc}) and R_1/4R resistors combination. They should also construct complete circuit shown in Figures 1 and 2. Finally, the students should note down the values of the digital equivalent number (AB) and verify the result.

Acknowledgement:

Thanks to Mr. Hari Shankar Mallik for valuable suggestions and help.

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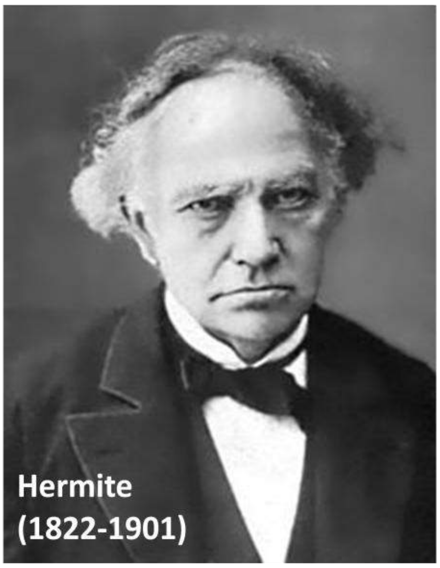

Charles Hermite was a French mathematician who did research on number theory, quadratic forms, invariant theory, orthogonal polynomials, elliptic functions, and algebra. Hermite polynomials, Hermite interpolation, Hermite normal form, Hermitian operators, and cubic Hermite splines are named in his honor. One of his Ph.D. students was Henri Poincaré. He was the first to prove that e, the base of natural logarithms, is a transcendental number. His methods were later used by Ferdinand von Lindemann to prove that π is transcendental. He is best known for Hermitian adjoint, Hermitian form, Hermitian function, Hermitian matrix, Hermitian metric, Hermitian operator, Hermite polynomial, Hermitian transpose, Hermitian wavelet

What is Polytropes? Why it is important for the White Dwarf, Neutron Stars and Pulsars?

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ABSTRACT

Polytropes are useful as they provide simple solutions for the internal structure of a star that can be tabulated and used for estimates of various quantities. They are much simpler to manipulate than the full rigorous solutions of all the equations of stellar structure. But the price of this simplicity is assuming a power law relationship between pressure and density which must hold (including a fixed constant) throughout the star.

Polytrope

Many astrophysicists feel that the study of polytropes is of historical interest only. While it is true that the study of polytropes did develop early in the history of stellar structure, this is so because polytropes provide significant insight into the structure and evolution of stars. The motivation comes from the observation that ideal gases behave in a certain way when they change in an adiabatic manner. It is the generalization of their behaviour which is characterized by the polytropic equation of state. When convection is established in the interior of a star, it is so efficient that the resultant temperature gradient is that of an adiabatic gas responding to hydrostatic equilibrium. Such a configuration is polytrope. The degenerate gas equations of state have the same form as the polytropic equation of state, so we might properly expect that degenerate configurations will be well represented by polytropes. In addition, we shall find that in massive stars where the pressure of radiation, the equation of state is essentially that of a photon gas in statistical equilibrium and that equation of state is also polytropic. The simple nature of polytropic structure and its correspondence to many physical stars provides a basis for incorporating additional effects (such as rotation) in a semi-analytical manner and thereby offers insight into the nature of the effects in real stars. Thus, for providing insight into the structure and behaviour of real stars, an understanding of polytropes is essential. However, even beyond the domain of stellar astrophysics, polytropes find many applications. Certain problems in stellar dynamics and galactic structure can be described by polytropes, and the polytropic equation of state has even been used to represent the density distribution of dark matter surrounding galaxies. But with the applications to in mind, let us consider the motivation for the polytropic equation of state. [1]

Lane-Emden Differential Equation

Lane-Emden equation describes polytropes in hydrostatic equilibrium. This equation is useful for a system of gas in which the pressure is given as a power-law in density,

$$P = K\rho^{\gamma} \qquad (1)$$

Here K and γ are constants. We know that

$\gamma = 5/3$ for non-relativistic electron degenerate gas
$= 4/3$ for relativistic electron degenerate gas
$= 1$ for non-degenerate gas

The Lane-Emden equation combines the above equation of state for polytropes and the equation of hydrostatic equilibrium,

$$\frac{dP}{dr} = -G\frac{m(r)\rho(r)}{r^2} \qquad (2)$$

$$m(r) = -\frac{r^2}{G\rho(r)}\frac{dP}{dr}$$

Differentiating,

$$\frac{dm(r)}{dr} = -\frac{1}{G}\frac{d}{dr}\left\{\frac{r^2}{\rho(r)}\frac{dP}{dr}\right\} \qquad (3)$$

The mass-continuity relation is,

$$\frac{dm(r)}{dr} = 4\pi r^2\rho(r) = -\frac{1}{G}\frac{d}{dr}\left\{\frac{r^2}{\rho(r)}\frac{dP}{dr}\right\}$$

$$-4\pi G\rho(r) = \frac{1}{r^2}\frac{d}{dr}\left\{\frac{r^2}{\rho(r)}\frac{dP}{dr}\right\}$$

Using equation (1), we have

$$-4\pi G\rho(r) = \frac{1}{r^2}\frac{d}{dr}\left[\frac{r^2}{\rho(r)}K\gamma\rho^{\gamma-1}\frac{d\rho}{dr}\right] \qquad (4)$$

Let us introduce,

$$\rho = \lambda\theta^n$$

$$\gamma = \frac{n+1}{n}$$

Equation (4) takes the form:

$$-4\pi G(\lambda\theta^n) = \frac{1}{r^2}\frac{d}{dr}\left[\frac{r^2}{\lambda\theta^n}K\left(\frac{n+1}{n}\right)\left(\lambda\theta^n\right)^{\frac{n+1}{n}-1}\frac{d}{dr}\left(\lambda\theta^n\right)\right]$$

On solving we get,

$$-\theta^n = \left[\frac{n+1}{4\pi G}K\lambda^{\frac{1-n}{n}}\right]\frac{1}{r^2}\frac{d}{dr}\left[r^2\frac{d\theta}{dr}\right] \qquad (5)$$

We make this equation dimensionless by introducing,

$$\xi = r/\alpha$$

$$\alpha = \sqrt{\frac{n+1}{4\pi G} K\lambda^{\frac{1-n}{n}}}$$

Then equation (5) reduces to,

$$\frac{1}{\xi^2}\frac{d}{d\xi}\left[\xi^2 \frac{d\theta}{d\xi}\right] + \theta^n = 0 \qquad (6)$$

This is the Lane-Emden differential equation for polytropes in hydrostatic equilibrium.
In order to solve this equation, we need to choose polytropic index (n=0, 1, 2, 3, ...).
This equation can be solved analytically only for n=0, 1&5. For other values, numerical method is required.
For any polytropes, boundary conditions are:

1. At the centre of star (r=0) where ξ = 0, θ(0) must be 1. (normalized central density)
2. Since dp/dr approaches to zero as r→0, we need dθ/dr = 0; or dθ/dξ=0 at ξ=0. (central density is constant)

For n=0, equation (6) reduces to,

$$\frac{1}{\xi^2}\frac{d}{d\xi}\left[\xi^2 \frac{d\theta}{d\xi}\right] = -1$$

Integrating we get,

$$\frac{d\theta}{d\xi} = -\frac{1}{3}\xi + \frac{c_1}{\xi^2} \qquad (7)$$

Applying boundary conditions,

$$\frac{d\theta}{d\xi}\Big|_{\xi=0} = 0, \text{ we get } c_1 = 0$$

Substituting this in equation (7) and then integrating we get,

$$\theta = -\frac{1}{6}\xi^2 + c_2 \qquad (8)$$

Applying another boundary condition, θ (0) = 1, we get $c_2 = 1$, thus equation (8) becomes

$$\theta_0 = 1 - \frac{1}{6}\xi^2$$

This is analytical solution of equation (6) for *n* = 0. This solution is applicable for a constant density incompressible sphere. Because, for n = 0, ρ=constant and γ is infinite.

Table 1: The values of θ and ξ for polytropic index n = 0, 1 & 5.

n	θ	Ξ	Remarks
0	$1-\frac{\xi^2}{6}$	$\sqrt{6}$	Constant density incompressible sphere
1	$\frac{\sin\xi}{\xi}$	π	Neutron star : compact system
5	$\left(1-\frac{\xi^2}{3}\right)^{\frac{1}{2}}$	∝	Sphere of infinite radius
>5			No sphere (binding energy positive)

The polytropic index *n* determines the order of that solution. In particular, the solution only depends on n, and can be scaled by varying P_c and ρ_c to give solutions for stars over a range of total mass and radius.
For n=0, the density of the solution as a function of radius is constant. This is the solution for a constant density incompressible sphere. The values of n=1 to 1.5 approximates a fully convective star, i.e. a very cool late-type star such as a M, L, or T dwarf. The index n=3 is the Eddington Approximation, there is no analytical solution for this value of n, but it is useful as it corresponds to a fully radiative star, which is a useful approximation for the Sun. [3]

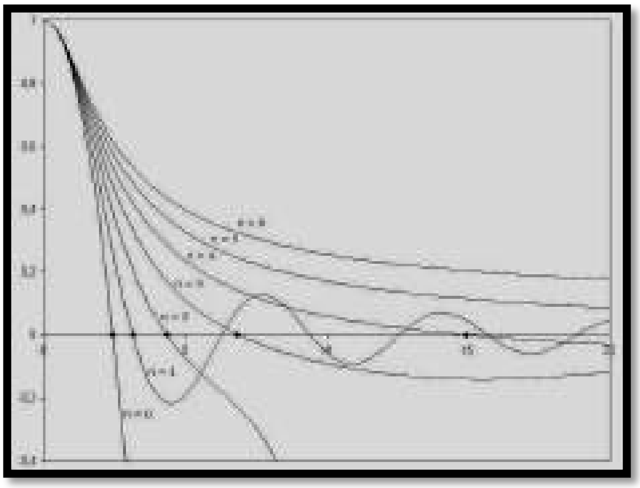

Figure 1: *Solutions to the Lane-Emden equation for various values of n. The black dot along the horizontal line marks the value of for each solution displayed [4].*

The Lane-Emden constants are listed in the table below:

Table 2: Values of Lane-Emden constants for different values of polytropic indices (*n*).

n	$\gamma = \frac{n+1}{n}$	ξ_1	$\xi_1^2\lvert\theta^1(\xi_1)\rvert$
0	∝	2.44940	4.89880
0.5	3	2.75280	3.78710
1.0	2	3.14159	3.14159
1.5	5/3	3.65375	2.71406
2.0	3/2	4.35287	2.41105
5.0	1.2	∝	1.73205

Using these values of constants we can get solutions of Lane-Emden equation for different polytropic indices. [2]

We use polytrope to model degenerate core of the star (red giant, white dwarf, etc) to study their mass, density, pressure and temperature profile. Using polytropic index *n*=1.5 the expressions for mass, density, pressure and temperature profile for white dwarfs are respectively obtained as:

$$m(r) = \left(\frac{3}{4\pi}\right)^2 \left(\frac{5K}{2G}\right)^3 \frac{1}{r^3} \qquad (9)$$

$$\rho(r) = \left(\frac{15K}{8\pi G}\right)^3 \frac{1}{r^6} \qquad (10)$$

$$\mathrm{P(r)} = K\left(\frac{15K}{8\pi G}\right)^5 \frac{1}{r^{10}} \qquad (11)$$

$$\mathrm{T(r)} = \left(\frac{3}{a}\right)^{\frac{1}{4}} \left(\frac{15K}{8\pi G}\right)^{\frac{5}{4}} \frac{1}{r^{\frac{5}{2}}} \qquad (12)$$

Where $a = \frac{4\sigma}{c}$, called as radiation constant.

Table 3: mass ($m(r)$), density ($\rho(r)$) and pressure ($P(r)$) profile of neutron stars for polytropic index 0.5 and 1.

n	***m(r)***	$\rho(r)$	***P(r)***
0.5	$\left(\frac{4\pi}{5}\right)^2 \left(\frac{2G}{3K}\right) r^5$	$\frac{8\pi G}{15K} r^2$	$K\left(\frac{8\pi G}{15K}\right)^3 r^6$
1.0	$e^{\frac{\pi G r^2}{K}}$	$\left(\frac{G}{2Kr}\right) e^{\frac{\pi G r^2}{K}}$	$\frac{G^2}{4Kr^2} e^{\frac{2\pi G r^2}{K}}$

The angular mpmentum of neutron star is steadily decreased by the emission of electromagnetic radiation, neutrinos, cosmic ray particles and possibly gravitational radiation. Thus the angular velocity decreases. Because of this reason, neutron star is modelled using polytropic index n less than 1.0 upto n=0.5.

Conclusion

From equations (9) to (12), it is concluded that the mass profile of the White Dwarf decreases as the radius increases. Thus the amount of mass is higher in the central part of the degenerate core. The density varies inversely with the sixth power of the radius which indicates the central region is extremely densed so that electrons are relativistic. The pressure decreases very sharply with increasing radius which signifies that electrons are confined in the central reason of the core. But the temperature profile is found to decrease with radius with the power index less than 3. Which suggest that temperature do not decrease sharply as density and pressure with increasing radius. For neutron stars, from table 2, it can be concluded that, the mass, density and pressure profile increases with integral powers of r with increases radius for n = 0.5 but they increase exponentially for n = 1.0.

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AUGUSTA ADA LOVELACE was an English mathematician and writer, chiefly known for her work on Charles Babbage's early mechanical general-purpose computer, the Analytical Engine. Her notes on the engine include what is recognised as the first algorithm intended to be carried out by a machine. She is often regarded as the first computer programmer. Ada married William Lord King in 1835. As a teenager, her mathematical talents led her to an ongoing working relationship and friendship with fellow British mathematician Charles Babbage, also known as 'the father of computers', Lovelace's notes are important in the early history of computers. She also developed a vision of the capability of computers to go beyond mere calculating or number-crunching, while many others, including Babbage himself, focused only on those capabilities. Her mind-set of "poetical science" led her to ask questions about the Analytical Engine (as shown in her notes) examining how individuals and society relate to technology as a collaborative tool.

Mathematical Formulation of Stress Tensor

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ABSTRACT

Tensor calculus being the most important part of mathematics used to understand the laws of physics, a physicist should know the basic rules of tensor operations and their utilities. In this article, I tried to present the rules of tensor analysisis to formulate Cauchy stress tensor in more simpler and analytical way as a reference example of understanding the tensor fields. The stress tensor itself is a physical quantity and as such, its components depend on the coordinate system chosen to represent it at a point of application of tension in a material body. Out of nine components of the stress tensor, three components are invariant under coordinate transformations and these are called normal or principal stresses, and the rest six components change under coordinate transformations and these are called shear stresses. The stress tensor transforms obeying the laws of tensor transformation so that it is a contravariant tensor of rank two.

Background

Tensors are very important physical quantities used in different fields of physics ranging from the theory of relativity and electrodynamics to the characteristic study of bulk matter such as stress and strain, moment of inertia, etc. The laws of physics remain invariant under the transformation of coordinate system in defining the tensors as the generalization of scalars and vectors. A scalar is a single valued real number which remains invariant under the rotation of coordinate axes so that it is also known as a tensor of rank zero. A vector which is also said to be a tensor of rank one has a number of real components equal to the dimension of the coordinate system. The components of the vector transform like the coordinates of a fixed point when the coordinate system is rotated [1]. In the similar way the ordinary multiplication of two vectors form a *dyad* (tensors of rank 2) and that of three vectors form a *tryad* (tensor of rank 3) so that the tensors can be regarded as generalised extended form of vectors.

The concept of stress in mechanics was originally led to the invention of tensors (*tenseur*, that which exerts tension, *stress*).The name Cauchy stress tensor comes after Augustin-Louis Cauchy. In continuum mechanics, the stress tensor completely defines the state of stress at a point inside a material body in the deformed state, placement, or configuration in accordance with the central concept in the linear theory of elasticity. The tensor relates the stress vector $\vec{F}$ to a unit normal vector $\hat{n}$ on an imaginary surface drawn inside the body [2].

If the continuum body is in static equilibrium, the components of the stress tensor at every point inside the body satisfy the Cauchy's equations of motion according to the law of conservation of linear momentum. Also, according to the law of conservation of angular momentum the equilibrium state leads to the conclusion that the stress tensor is symmetric having only six components instead of nine. The three components along the diagonal of the stress tensor matrix are invariants under the coordinate transformation. Such three eigenvalues are also called principal stresses. The Cauchy stress tensor satisfies the transformation law of tensors under a change in the system of coordinates. The graphical representation of this transformation law is called *Mohr's circle* of stress [3].

The new or transformed coordinate system is the function of old coordinate system so that

$$\bar{x}_i = \bar{x}_i(x_1, x_2, \dots \dots, x_n)$$

The differential elements are $d\bar{x}_i = \frac{\partial \bar{x}_i}{\partial x_j} dx_j$ as the components of a contravariant vector or a tensor of rank one because it satisfies the laws of transformation of the contravariant vector [4]: $\bar{A}^i = \frac{\partial \bar{x}_i}{\partial x_j} A^j$

Also, under the transformation: $x_i = x_i(\bar{x}_1, \bar{x}_2, \dots \dots, \bar{x}_n)$, the scalar or invariant (the tensor of rank zero) is $\emptyset(x_i) = \bar{\emptyset}(\bar{x}_i)$ which under the partial differentiation, we get $$\frac{\partial \bar{\emptyset}}{\partial \bar{x}_j} = \frac{\partial x_i}{\partial \bar{x}_j} \frac{\partial \emptyset}{\partial x_i}$$

Here, $\frac{\partial \emptyset}{\partial x_i}$ is a gradient of function $\emptyset$ and it is a covariant vector or tensor of rank one because it satisfies the laws of transformation of the covariant vector [4]:

$$\bar{A}_j = \frac{\partial x_i}{\partial \bar{x}_j} A_i$$

By the similar way, the transformation laws for the components $A^{\alpha\beta}$ of a contravariant tensor of rank two are: $$\bar{A}^{ij} = \frac{\partial \bar{x}_i}{\partial x_\alpha} \frac{\partial \bar{x}_j}{\partial x_\beta} A^{\alpha\beta}$$

Also, the transformation laws for the components $A_{\alpha\beta}$ of a covariant tensor of rank two are:

$$\bar{A}_{ij} = \frac{\partial x_\alpha}{\partial \bar{x}_i} \frac{\partial x_\beta}{\partial \bar{x}_j} A_{\alpha\beta}$$

To be a tensor, any physical quantity should satisfy these transformation laws.

Mathematical Formulation

We suppose that a unit cube is in equilibrium under the three forces: $\vec{F}^1$, $\vec{F}^2$ and $\vec{F}^3$ applied to three faces of the cube. Since each face has the unit area, each force vector represents the force per unit area or stress on that face. These forces can be represented in the component form as in the Figure 1. Using the standard basis vectors $\hat{e}_1, \hat{e}_2$ *and* $\hat{e}_3$, we write

$Stress\ on\ face\ 1,\qquad \vec{F}^1 = S^{1j}\hat{e}_j = S^{11}\hat{e}_1 + S^{12}\hat{e}_2 + S^{13}\hat{e}_3$

$Stress\ on\ face\ 2,\qquad \vec{F}^2 = S^{2j}\hat{e}_j = S^{21}\hat{e}_1 + S^{22}\hat{e}_2 + S^{23}\hat{e}_3$

$Stress\ on\ face\ 3,\qquad \vec{F}^3 = S^{3j}\hat{e}_j = S^{31}\hat{e}_1 + S^{32}\hat{e}_2 + S^{33}\hat{e}_3$

In general notation, we write

$$\vec{F}^i = S^{ij}\hat{e}_j \text{ .... } (1)$$

where $S^{ij} = \begin{bmatrix} S^{11} & S^{12} & S^{13} \\ S^{21} & S^{22} & S^{23} \\ S^{31} & S^{32} & S^{33} \end{bmatrix}$ is stress tensor [5].

The matrix elements S^{ij} are the components of a second-order cartesian tensor called Cauchy stress tensor, which completely defines the state of stress at a point where S^{11}, S^{22}, and S^{33} are normal stresses, and S^{12}, S^{13}, S^{21}, S^{23}, S^{31}, and S^{32} are shear stresses. The first index i indicates that the stress acts on a plane normal to the x_i-axis, and the second index j denotes the direction in which the stress acts [3]. A stress component is positive if it acts in the positive direction of the coordinate axes and if the plane where it acts has an outward normal vector pointing in the positive coordinate direction, otherwise the component is negative as in the Figure 2.

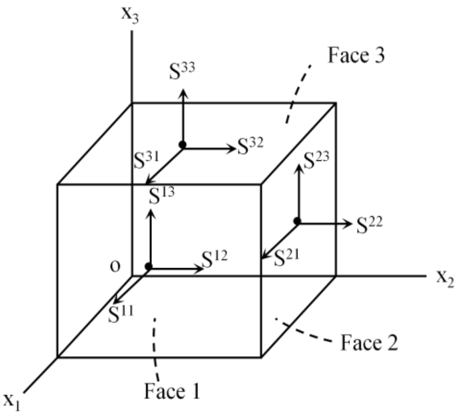

Figure 1: *Components of stress tensor on three faces of a unit cube where the forces are applied [5].*

A tetrahedron can be formed by the edge cross section of the cube along with three coordinate planes x_1x_2, x_1x_3 and x_2x_3 as in the Figure 2. The cube being in equilibrium, the stresses on x_1x_2-, x_1x_3- and x_2x_3- bases of the tetrahedron are: $-\vec{F}^3$, $-\vec{F}^2$ and $-\vec{F}^1$ respectively as shown component wise in Figure 2. Hence, the forces on the same bases are: $dA_1(-\vec{F}^3)$, $dA_2(-\vec{F}^2)$ and $dA_3(-\vec{F}^1)$ respectively. For the tetrahedron to be in equilibrium, the resultant force on it must be vanished, i.e. $\sum \vec{F} = 0$. In general, we have

$$dA\vec{F} + dA_1(-\vec{F}^3) + dA_2(-\vec{F}^2) + dA_3(-\vec{F}^1) = 0$$

$$\therefore \vec{F} = \left(\frac{dA_3}{dA}\right)\vec{F}^1 + \left(\frac{dA_2}{dA}\right)\vec{F}^2 + \left(\frac{dA_1}{dA}\right)\vec{F}^3 \text{ .... } (2)$$

where dA_1 is the projection of dA on x_1x_2-plane and so on [5]. So, we write

$$dA_1 = (dA\hat{n})\hat{e}_3, dA_2 = (dA\hat{n})\hat{e}_2 \text{ and } dA_3 = (dA\hat{n})\hat{e}_1 \text{ .... } (3)$$

The resultant force, from (2) and (3), is given by

$$\vec{F} = (\hat{n}\hat{e}_1)\vec{F}^1 + (\hat{n}\hat{e}_2)\vec{F}^2 + (\hat{n}\hat{e}_3)\vec{F}^3 = \vec{F}^r(\hat{n}\hat{e}_r) = S^{rs}(\hat{n}\hat{e}_r)\hat{e}_s \text{ .... } (4)$$

We can change the basis of R^3 by means of a transformation of the form [5, 6]:

$$\hat{e}_i = M_i^j\hat{f}_j \text{ .... } (5)$$

where $\left|M_i^j\right| = \left|\frac{\partial\bar{x}_j}{\partial x_i}\right| \neq 0$. So, equation (4) is

$$\vec{F} = S^{rs}(\hat{n}M_r^i\hat{f}_i)M_s^j\hat{f}_j = S^{rs}M_r^iM_s^j(\hat{n}\hat{f}_i\hat{f}_j) = \bar{S}^{ij}(\hat{n}\hat{f}_i\hat{f}_j) \text{ .... } (6)$$

where $\bar{S}^{ij} = S^{rs}M_r^iM_s^j = S^{rs}\frac{\partial\bar{x}_i}{\partial x_r}\frac{\partial\bar{x}_j}{\partial x_s} \text{ ...... } (7)$

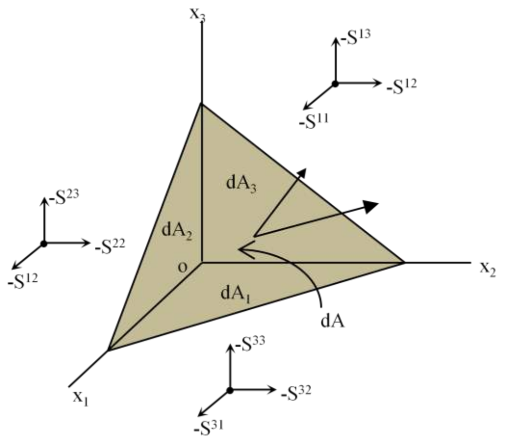

Figure2: *Stresses on a cube section-tetrahedron [5]*

Equation (6) represents the balancing force acting on an imaginary surface of tetrahedron in the unit cube of a material body in terms of components of stress tensor in new and old coordinate systems. Equation (7) shows that the stress components S^{rs} satisfy the transformation laws of second rank contravariant tensor.

Conclusion

The stress tensor has nine components and each of them transforms like the components of a contravariant tensor of rank two under the transformation of a coordinate system related to the every point of a material body with the application of a deforming force or stress at that point resulting either deformations on or equilibrium of the body.

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How Physics works in Biology

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ABSTRACT

Life is a little current of electricity, driven by sunlight. The study of light and electricity are the parts of Physics and life is a part of study of biology. Hence,the relation between biology and Physics are very close in many aspects. Most of the biological phenomena are explained from the formulation of Physics. Cell is the basic unit of living organism. The cell is made up of molecules and atoms, so the complete explanation of molecular level of living organisms is possible only fromthe proper understanding of atomic physics. Similarly, laws of thermodynamics, quantum mechanics, electromagnetism and statistical mechanics are applicable to understand the metabolism of living body. Moreover, the functioning of our internal and external organs conveys the information to the brain via electrical signals. This article attempts to convey some convincing aspects of linkage of biology and physics, in aggregated form, the Biophysics.

Introduction

The science and technology has compressed the world in a single computer. The human beings stepped on the surface of the moon and now they have been incessantly exploring other heavenly bodies of the universe. Many physical laws have been discovered to explain the activities of the nature. The profound understanding about the natural laws has made the life style highly sophisticated. People know many secretes of the stars, planets and other heavenly bodies of the universe; however they are still unable to disclose the many secrets our life process.Before 1840, the study of organic compounds were considered different field of study than that of inorganic compounds and it was assumed that the study of life processes is different than the study physical laws. But Now-a-days, the concept has been changed. Contemporary researches on biology are relied on basic laws of physics.

Debate on organic & inorganic compounds

In the explanation of organic and inorganic compounds, two views are highly influential. Actually they contradict to each other. In the early stages in the development of natural science, a non-scientific point of view became popular in the religious society and even also in the scientific society. According to this concept, life is somehow separated from the inanimate matter, which became known as "Vitalism". On the other hand, life is considered as the physical activities of complex molecular system which interact with surroundings by exchanging matter and energy, which is known as "Materialistic view".

Vitalistic view:

Vitalism is a scientific hypothesis which believes that the living organisms are fundamentally different from non-living compounds. This hypothesis assumes that the activities of living matters are governed by different principles than that of inanimate things. From the beginning of chemistry until about 1840, it was firmly believed that organic compounds had their sole origin in connection to process of life. This concept of chemistry had also supported the principle of vitalism, that life creates life, not by any other inorganic compounds. Although many societies believe this principle till date, it became weaker after the production of urea, an organic compound synthesized from inorganic components, discovered by German scientist Friedrich Wohler.

Materialistic view:

Materialistic view considers that the nature is made with materials, even our soul, though it has not been understood what really it is. This concept is closely related to physicalism, the things in nature are merely physical matters and their properties are studied by physical laws. Materialistic view assumes that the nature exists those things what we see, feel and measure. Modern scientific discoveries are based on the concept of materialism.The philosophies of Hinduism, Buddhism, Jainism and Sikhism have the somewhat similar concept in the composition of our body. Our body is composed with matter and space which are called PANCHA BHAUTIK TATTWA. They are PRITHVI (LAND), JALA (WATER), TEJ (ENERGY), BAYU (AIR), AAKASH (SPACE). After death, these all things ultimately go to mix with the correlated matter and space.

Connection of physics and biology:

Thermodynamics approach: A cell is enveloped by a membrane, called cell membrane. The membrane separates a cell with the surroundings forming a thermodynamic system. The cell exchange both matter and energy to the surroundings. So it can be considered as the open thermodynamic system. The chemical reactions occur into the cell which provides energy both for internal molecular processes and external physical works. The exchange of energy with the surroundings enables us to find the entropy and enthalpy change in biomolecules.Furthermore, the groupsof similar cells form tissues and the tissues form the organs. Although the number of cells in tissues and organs are statistically very large, their features and properties are understandable in terms of features and properties of single cell.

Electromagnetic approach: Electromagnetic view assumes that a cell contains large number of molecules.

Most part of the cell is composed of water (H_2O) molecules and organic compounds, which contain carbon atoms. Atomic nuclei such as H-1, C-13, etc have nuclear spin which show the magnetic properties. When they are subjected to an external magnetic field, they behave like bar magnets and therefore precessing around the axis of the magnetic field, and transition occurs in the radio-wave region. This is the basic principle of nuclear magnetic resonance (NMR). The NMR techniques are very useful in clinical monitoring of metabolic processes in the molecular level, which help to diagnose the clinical abnormalities of body parts. Similar principle is applied in Electron Spin Resonance (ESR).

Quantum mechanics approach: Biological processes occur into molecular level of a cell. For the complete description of mechanism of biological processes in the molecular level, quantum mechanics is essential. Quantum mechanics provides the successful description of the movement of electrons and their interactions with other electrons and nuclei. Furthermore, the weak and strong interactions among the biomolecules are determined only from quantum mechanical techniques.

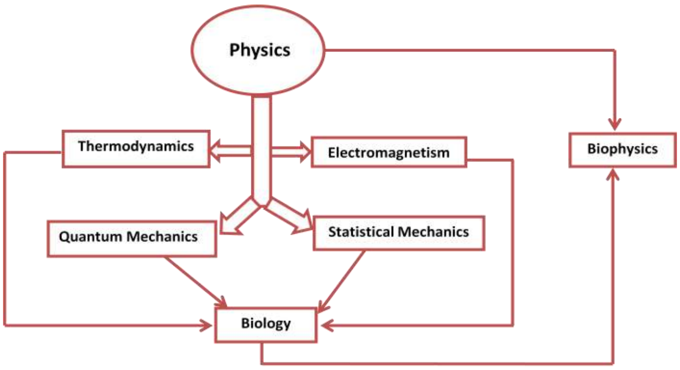

Figure 1: *Connection of Physics and Biology*

Statistical Mechanics approach: The study of life is the study of complex molecular system. We can easily understand this view by taking a unicellular bacterium, Escherichia Coli (E. Coli). E. Coli is a single cellular cylindrical microorganism about 3 μm long, 1 μm radius and about 10^{-12} to 10^{-13} gm mass. Surprisingly, it contains about 5000 organic compounds,among them about 1000 different types of nucleic acids and about 3000 different proteins and so on. In human body, there are about 5 x 10^6 different types of proteins. Even more interesting fact is that none of the protein found in E coli is similar to the protein in human body. So, we can easily guess that the composition of even a cell is how complex a molecular system. Therefore, there is no alternative way of statistical mechanics to hold such large molecular system to develop in convincing result.

The connection of biology and physics are shown in figure 1 in terms of block diagram.

Structural analysis of body parts using physical laws

Many laws associated with physics are applicable to determine the molecular structure of body parts. Electron Microscopy, X- ray Diffraction, Ultrasonography (USG), and Nuclear Magnetic Resonance (NMR) and Electrocardiography (ECG) are some basic techniques to study the structure of bio-molecules. Electron Microscope is employed in the study of biological systems at cellular level. The X ray diffraction is a very powerful tool to observe the three dimensional structure of tissues at atomic resolution. It provides the high resolution of macromolecular structure and structural dynamics, even the molecular structure of protein chains, nucleotide units, and lipid molecules can be visualized by using x ray diffraction technique. In Ultrasonography (USG), the structures of delicate organs are visualized by analyzing the echo of ultrasound wave that allows passing into the body. It is the safe and effective way of detecting foreign body like kidney stone, gall bladder stone, and cist grown into the body. Nuclear Magnetic Resonance (NMR) technique is employed to study the structural and functional dynamics of macromolecules. It is a non-invasive technique. NMR methods allow non-destructive imaging of static sections like skull, vertebral column as well as dynamic features like blood flow and heart-beat. Electrocardiography (ECG) is a very useful of testing the abnormality of action of heart.

Electrical Activity of some Organs:

The electrical activities of many organs are explained by using physical laws. Neurotransmission, Vision, hearing and heart actions are some very important activity of human body.

The neuron is a unit of nerve cell. When a small stimulus is given to a part of skin, the sodium and potassium ions exchange process begins across the inner and outer surface of the wall of neuron, which ultimately generates an electric pulse. This produces the certain potential difference across layers of the nerve cell, which we say the action potential. The neurotransmission occurs when action potential is generated across the layers. Hodgkin and Huxley formulated the phenomenon of nerve impulse physically.

Human eye is an optical device in which eye lens forms the image on retina. From mechanical view, the visualization process is the process of energy transform. The incident light photon transforms into the photochemical energy in the light sensitive receptor cells. This chemical energy is transformed to an electrical signal which is ultimately transferred to the brain where the signals are processed and translated.

While hearing, the mechanical energy in the form of pressure variations in atmosphere transforms to the electrical signals that are processed in the auditory field of the brain. In the beginning, the pressure variation in the atmosphere oscillates the tympanic membrane in the ear drum. Motion of this membrane causes the deflection of a set of small bones in the middle ear. The mechanical linkage of cochlear fluid with atmosphere transfers the vibration. On basilar membrane, the displacement of it triggers the nerve signal and transfers to the brain where the acoustic signals are processed and translated.

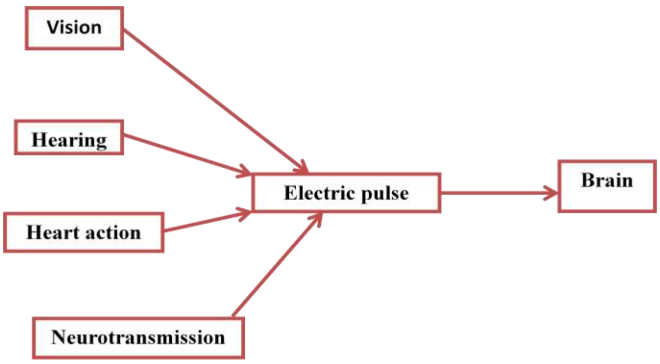

Figure 2: *Electric pulse transmission in human body parts*

The heart activity is processed by the repeated activity of electrical events. The potential difference is developed between two points of skin (especially between right arm and left leg) in each cardiac cycle (pumping and releasing blood from heart chambers). Hence, the action of heart can be explained in terms of physical phenomena.

Conclusion:

The activities of biomolecules are governed by the laws of physics. Many functions in the body like blood flow, nerve impulse and information transfer by sense organs are all works transmitting the electric pulses. Moreover, Laws of Thermodynamics, Electrodynamics, Quantum Mechanics and Statistical Mechanics are highly applicable to study the dynamics of biomolecules. The application of laws of physics to deal the biological molecules is an interdisciplinary subject, called Biophysics. Biophysics incorporates not only biology and Physics; it also includes chemistry, statistics, engineering and mathematics. The application of physical laws to study the biomolecules is an emerging field for the students in Physics.

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Friedrich Wilhelm Bessel was a German astronomer, mathematician, physicist and geodesist. He was the first astronomer who determined reliable values for the distance from the sun to another star by the method of parallax. A special type of mathematical functions were named Bessel functions after Bessel's death, though they had originally been discovered by Daniel Bernoulli. In January 1810, at the age of 25, Bessel was appointed director of the newly founded Königsberg Observatory by King Frederick William III of Prussia. On the recommendation of fellow mathematician and physicist Carl Friedrich Gauss he was awarded an honorary doctor degree from the University of Göttingen in March 1811.

He is best known for Bessel functions, Stellar parallax and Bessel ellipsoid. In the second decade of the 19th century while studying the dynamics of 'many-body' gravitational systems, Bessel developed what are now known as Bessel functions. Critical for the solution of certain differential equations, these functions are used throughout both classical and quantum physics.

Experimental Setup for Seeded-Arc Plasma at Central Department of Physics

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ABSTRACT

Plasma production and its diagnostics is one of the oldest but still an active and interesting research problem in the field of plasma physics. Arc discharge is a thermal discharge of very high temperature and can be generated using a suitable power supply. An addition of a foreign material to the arc, hence called Seeded-Arc, and its study is an interesting field because of its emerging new applications. But a detailed study and characterization of the seeded-arc is lacking. We aim to produce seeded-arc plasma in the Central Department of Physics and characterize it to seek for its possible applications. A brief introduction to the discharge methods for plasma production will be presented and the recently establishedexperimental setup for the seeded-arc plasma in the Department will be described.

Introduction

The existence of plasma as "the fourth state of matter" was first identified by Sir William Crookes in 1879, however the term "plasma" was introduced by Langmuir in 1928 [1]. If we increase the temperature of a gas beyond a certain limit it does not remain a gas 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 to electrically neutral atoms, we now have a mixed population of charged and neutral particles. This is plasma, and it is neither solid nor liquid nor gas. Plasma is thus defined as the collection of charged and neutral particles exhibiting collective behavior. Collective behavior implies that the motions of plasma particles depend not only on local conditions but on the state of the plasma in remote regions as well [2].

Plasma can be produced with the help of an electric arc in laboratory using simple instrumentation and the discharge methods are categorized as follows.

1. Arc discharge: this is a high power thermal discharge of very high temperature (~ 10^4 K). It can be generated using various power supplies. It is commonly used in metallurgical processes.
2. Corona discharge: this is a non-thermal discharge generated by the application of high voltage to sharp electrode tips. It is commonly used in ozone generator and particle precipitators.
3. Capacitive discharge: this is non-thermal plasma generated by the application of RF power (e.g. 13.56 MHz) to one powered electrode, with a ground electrode held at a small separation distance on the order of 1cm. Such discharges are commonly stabilized using a Nobel gas such as Helium or Argon [3].
4. Dielectric barrier discharge: this is a non-thermal discharge generated by the application of high voltage across small gaps .Where in a non-conducting coating prevents the transitions of the plasma discharge into an arc. It is widely used in the web treatment of fabrics [4, 5].

Seeded-arc means a little amount of a foreign material added to the arc thereby enhancing the discharge properties as required for various applications of the resulting plasma. Plasma production and diagnosis is one of the oldest but still an active and interesting research problem in plasma physics. Some important applications of plasma discharges are: Polymer surface modification, Treatment of water by direct discharge, Ozone generation for water treatment, Welding arcs, mercury rectifiers, Spark gaps, Lightning discharges, Metallurgy, etc. An experimental setup for the production of seeded-arc plasma has been recently developed in our Department which is currently being characterized and we aim to study the possible applications of the produced plasma. Variation of the plasma parameters (electron temperature, ion temperature, plasma potential etc.) for different types of materials used as the electrodes will be studied in detail. A brief introduction about the experimental setup is presented here.

Experimental setup

The experimental setup for the production and characterization of the seeded-arc plasma using Langmuir probe are shown schematically in Figure 1 and 2. The beauty of the proposed research work lies in the fact that simple instrumentation can give us information on plasma parameters of the seeded-arc plasma. We planto apply the Langmuir electrical probe for studying the seeded-arc plasma[1, 6]. As the arc temperature is quite high (10^4K) the probe is kept moving through the body of the arc because if it stays in the arc even for a fraction of a second is enough for its melt down. The moving probe is given a fixed DC potential to collect electric charge, which is analyzed and worked out to obtain the values of plasma parameters. To initiate arcing a high DC voltage (400V) is applied across the electrodes. In the beginning the single probe method is applied for the determination of parameters .We will also use double probe method to determine the parameters with higher accuracy. For the use of single and double Langmuir probes in our case we will follow the method adopted by Narayan et al. [7].The experimental setup in our Department and the resulting 'first' arc plasma are shown in Figure 3 and 4 respectively. The theoretical background of the discharge and the Langmuir probe are avoided in this introductory article which can be found in the references cited earlier.

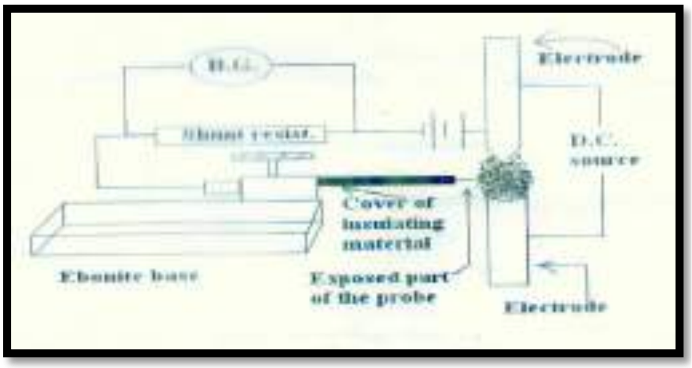

***Figure 1**: Seeded-Arc plasma with single-probe arrangement*

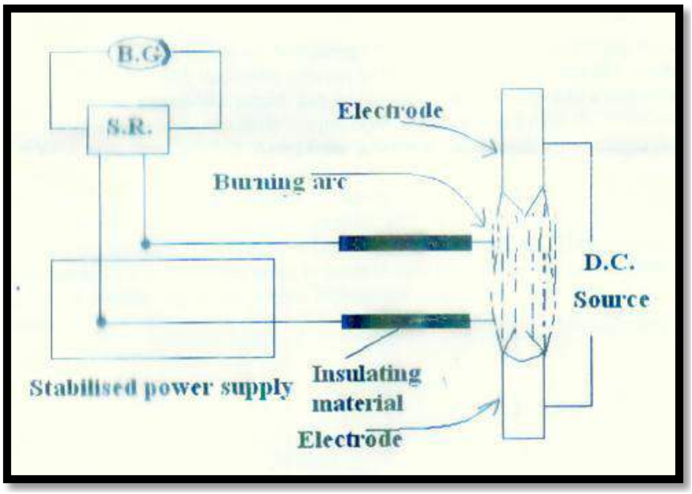

***Figure 2:** Seeded-Arc plasma with double-probe arrangement*

***Figure 3:** The experimental arrangement at the Central Department of Physics, TU, Kirtipur (with first author)*

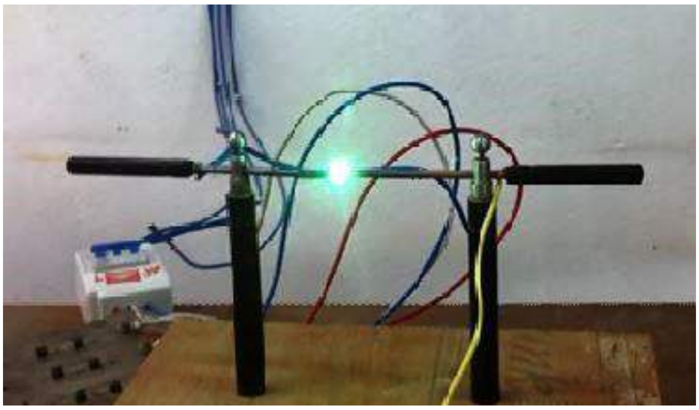

***Figure 4:** The 'first' arc plasma produced in the Department*

Importance and expected outcome

The plasma arc technology is the most sought-after thing these days. The seeded-arc plasma has been of interest for a long time and is still an interesting field of interest as new applications are emerging. However, the detail characterization and study of seeded-arc produced by DC source is lacking and thus we are interested in producing and investigating the properties of seeded-arc for different materials used as the electrodes for producing the discharge with the following objectives.

- design and fabricate an experimental set-up for the production of seeded- arc plasma
- characterize the plasma produced: the parameters to be analyzed are the electron and ion density and their temperatures at different conditions
- study the variation of plasma parameters with the change of materials of the arc producing electrodes: the discharge is to be produced using Copper, Iron and Aluminum electrodes in air, nitrogen and argon
- explore for its possible applications

Our study is expected to surface new properties that can be further harnessed for developing better plasma technology cracking even new areas of applications.

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I accept no principles of physics which are not also accepted in mathematics.
René Descartes (1596 -1650)

Use of Interactive Sky Atlas Aladin-v2.5 to Study the Dust Driven Region around White Dwarf

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ABSTRACT

We present a result of systematic survey around 200 white dwarfs using IRAS photometric data.These data were critically studied to find active region in which the process of cavity formation is expected. The interaction between wind and its surroundings in the interstellar medium (ISM) provides a laboratory to study the behaviour of dust particles. The information obtained from the dust colour temperature and dust mass of WD0038+730 will be presented. In addition, the variation of flux density along major diameter, temperature along major diameter and its non-Gaussian nature will be presented and discussed.

Introduction

Aladin v2.5 is an interactive sky atlas developed and maintained by the Center de Donne's astronomiques de Strasbourg (CDS) for the identification of astronomical sources through visual analysis of reference sky images. This software allows the user to visualize digitized images of any part of the sky, to superimpose entries from the CDS astronomical catalogues and tables, and to interactively access related data and information from SIMBAD, NED or other archives of all known objects in the field.

Counter Map

To separate the region of maximum flux density, I adopt the method of drawing contours and study the flux density within the region at 60 and 100 μm because I concern my focus on temperature profile and the mass distribution within the structures. We intend to study the cavity structure at 60 μm and 100 μm. We adopt the method of drawing contours at different levels so that we can separate the region of maximum and minimum flux density. The number of the contours is according to the requirements so as to include the maximum features of the region. The number of the contour in 100 μm and 60 μm FITS image are chosen independently to make the best contour level. We are interested in these minima to study the mass distribution of the dust driven region within the cavity structure includingWhite dwarf. We are interested to study the temperature and mass profile of isolated symmetric spherical cavity structure.

Density Variations

We have studied the flux density of each pixel inside the contour using the software Aladin v2.5. We studied the flux density of all pixel lying inside outermost contour of the 100 μm interested region and find the flux of corresponding pixels in 60 μm FITS using the software Aladin v2.5, which was used to calculate the temperature and mass of the each pixel due to the contribution of dust. Here we found the region of the maximum and minimum flux and study the variation of density in each image. We studied the flux density variation along the major and minor diameters of the counters. Also we have studied the flux density variations along the line joining the maximum temperature & minimum flux and minimum temperature & minimum flux within the contour.

Background Corrections

Flux density obtained is subtracted with the background flux density. Background flux is the flux emitted by other sources lying nearby the region of interest (not from the region of interest). The average value of the background flux is obtained by noting and summing up of the minimum flux densities around the region of interest and dividing the sum by total number of pixel with this minimum flux density. When this background flux is subtracted from the obtained flux density of each pixels in the region of interest, it is said to be background flux density. If there is no background flux outside the region of interest by taking minimum flux inside the isocontour we have taken a difference between second minimum say (a) and minimum flux say (b) and divided by 2 which is a background flux density. i.e., Mathematically, background flux = $\frac{a-b}{2}$. At last when we substarct it from relative flux density we get correct flux density.

Dust color temperature estimation

We use data base from the IRAS 60 μm and 100 μm flux densities is similar to that of Schnee et al. (2005). By knowing the flux densities at 60μm and 100 μm, the temperature contribution due to dust color can be calculated. The dust temperature T_d in each pixel of a FITS image can be obtained by assuming that the dust in a single beam is isothermal and that the observed ratio of 60 μm to 100 μm emission is due to black body radiation from dust grains at T_d, modified by a power law of spectral emissivity index. The flux density of emission at a wavelength λ_i is given by

$$F_i = \left[\frac{2hc}{\lambda_i^3 \left(e^{\frac{hc}{\lambda_i k T_d}} - 1 \right)} \right] N_d \alpha \lambda_i^{-\beta} \Omega_i \qquad \text{...... (1)}$$

where, N_d is the column density of dust grains, is a constant which relates the flux with the optical depth of the dust, β is the spectral emissivity index, and Ω_i is the solid angle subtended at λ_i by the detector. Following Dupac et al (2003) we use the equation

$$\beta = \frac{1}{\delta + \omega T_d} \quad \dots\dots\dots\dots (2)$$

to describe the observed inverse relationship between temperature and emissivity spectral index. Here, δ and ω are free parameters found that the temperature dependence of the emissivity index fits very well with the hyperbolic approximating function. Considering temperature as an independent variable, the best fit gives δ = 0.40 $\pm$ 0.02 and ω= 0.0079 $\pm$ 0.0005 K^{-1}, with the χ^2 /degree of freedom = 120/120. With the assumptions that the dust emission is optically thin at 60 μm and 100 μm and that $\Omega_\omega \cong \Omega_{100}$ (true for IRAS image), we can write the ratio "R" of the flux densities at 60 μm and 100 μm as

$$R = 0.6^{-(3+\beta)} \frac{e^{\frac{144}{T_d}} - 1}{e^{\frac{240}{T_d}} - 1} \quad \dots\dots(3)$$

The value of β depends on dust grain properties as composition, size, and compactness. For reference, a pure blackbody would have β = 0, the amorphous layer-lattice matter has β ~1, and the metals and crystalline dielectrics have β ~ 2. For a smaller value of T_d, 1 can be dropped from both numerator and denominator of equation and it takes the form

$$R = 0.6^{-(3+\beta)} \frac{e^{\frac{144}{T_d}}}{e^{\frac{240}{T_d}}} \quad \dots\dots (4)$$

Taking natural logarithm on both sides of equation (4) we find the expression for the temperature as

$$T_d = -96 \frac{1}{ln\{R\times 0.6^{(3+\beta)}\}} \quad \dots\dots(5)$$

where R is given by

$$R = \frac{F(60\,\mu m)}{F(100\,\mu m)} \quad \dots\dots.(6)$$

$F(60\,\mu\text{m})$ and $F(100\,\mu\text{m})$ are the flux densities at 60 μm and 100 μm, respectively. In this way we can use equation (5) for the determination of the dust grain temperature.

Mass Estimation

Since the longer wavelength measurements give us more precise dust masses due to the characteristics of the Planck curve, the far infrared emission which is used for the derivation of the dust mass is measured from the 100 μm IRAS images. The dust masses are estimated from the IR flux densities. In order to estimate the dust masses from the infrared flux densities at 100 μm, following the calculation of Young et al. we need the background correction of flux and convert the relative flux into absolute flux. The background correction is done by subtracting the average flux emitted by the external sources other than the object of interest. The blackbody intensity can be calculated using the basic expression as given in equation (2). The resulting dust mass depends on the physical and chemical properties of the dust grains, the adopted dust temperature T_d and the distance D to the object.

$$M_{dust} = \frac{4}{3}\frac{a\rho}{Q_\nu}\left[\frac{S_\nu D^2}{B(\nu,T)}\right] \quad \dots\dots\dots.(7)$$

Where ,

a = Weighted grain size

ρ = Grain density

Q_ν= grain emissivity

S_ν= total flux density of the region whose mass is to be determined = $f \times 5.288 \times 10^{-9}$ MJy/Sr

D = distance of the structure

$B(\nu,T)$ = Planck's function

$$B(\nu,T) = \frac{2h\nu^3}{c^2}\left[\frac{1}{e^{\frac{h\nu}{kT}} - 1}\right] \quad \dots\dots(8)$$

Where,

h = Planck's constant

c = velocity of light

ν = frequency at which the emission is observed

T = the average temperatures of the region value of different parameters we use in the calculation of the dust mass in our interest are as follows:

a = 0.1μm (Young et al 1993)

ρ = 3000 Kg m^{-3}

Q_ν= 0.0010 for 100μm and 0.0046 for 60μm respectively (Young et al. (1993)

Using these values the expression (i) takes the form:

$$M_{dust} = 0.4\left[\frac{S_\nu D^2}{B(\nu,T)}\right] \quad \dots\dots\dots.(9)$$

We use the equation (9) for the calculation of the dust mass.

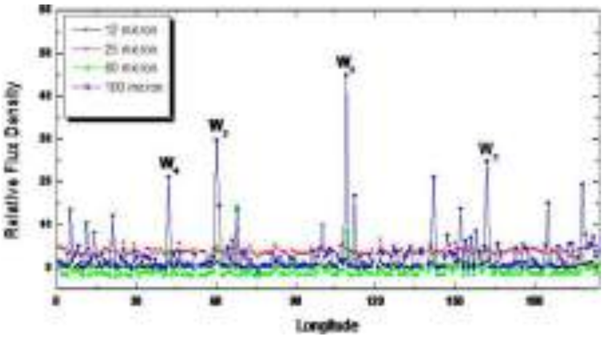

Figure 1 : Representation of scatter plot between longitude versus relative flux density of 201 white dwarfs W_1 , W_2 W_3 and W_4 refer WD0102+610 (01^h 05^m 58^s +61^o 20' 14"), WD0038+555 (00^{h}41^{m}20^s+55^{o}50'09"), WD0127+581 (01^{h}30^{m}39^s,58^{o}21"57'), WD0029+571 (00^{h}31^{m}53^s+57^{o}22'33") respectively which are assigned as 12 micron, 25 micron, 60 micron and 100 micron emitter.

It is clear from the expression (3.8) that the value of Planck function $B(\nu,T)$ for longer wavelength is higher than that of the shorter wavelength. Consequently, the range of $B(\nu,T)$ for fixed temperature (say ΔT) goes narrower if wavelength of the images increases.

Result and Discussion:

We have obtained following scattered diagram by using origin 5.0 of different data. Description about the figure and images are given in their caption.

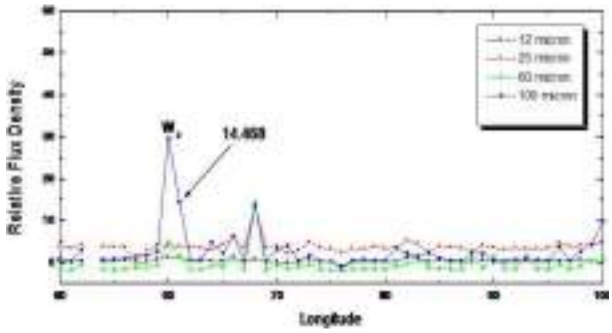

Figure 2: *Representation of scatter plot between longitude versus relative flux density of 50 white dwarfs W_2 refer WD0038+555 ($00^h41^m20^s+55^o50'09''$) arrow with flux value 14.468 represent best candidate i.e. WD0038+730 ($00^h41^m43^s+73^o21'14''$) .*

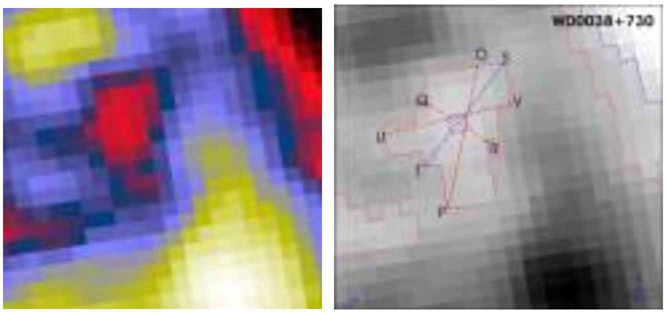

Figure 3: *Representation of 100 micron image of WD0038+730 (left). Aladin result of 100 micron FITS image of WD0038+730 in which OP line represents Major diameter, QR line represents minor diameter , ST line represent s distance passes through minimum temperature region and UV line represents the distance passes through maximum temperature region.*

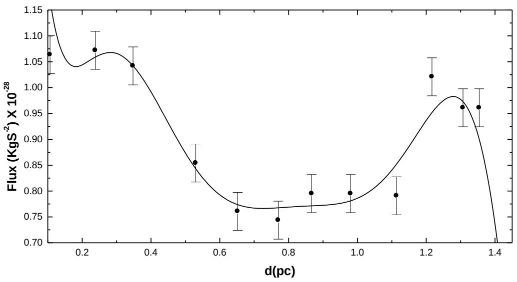

Figure 4: *Showing the variation of flux density along major diameter of isocontour level 68 The distribution of flux density along major diameter of the white dwarf WD0038+730. The solid circle with $\pm\frac{\sigma}{\sqrt{n}}$ error bars represent the standard error of the distribution. The soild curves represent the best fit polynomial (8^{th} order polynomial).*

$$S_v = 2.35-26.78d + 203.02d^2 - 751.05d^3 + 1518.73d^4 - 1773.70d^5 + 1192.92d^6 - 427.87d^7 + 63.16\, d^8 \quad \text{..........(10)}$$

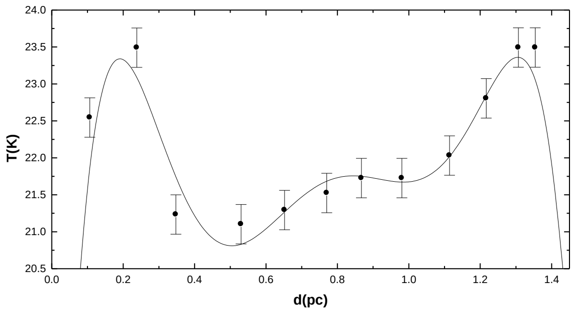

Figure 5: *Showing the variation of temperature along major diameter of isocontour level 68. The distribution of temperature along major diameter of the white dwarf WD0038+730. The solid circle with $\pm\frac{\sigma}{\sqrt{n}}$ error bars represent the standard error of the distribution. The solid curves represent the best fit polynomial (6^{th} order) WD0038+730. The solid circle with $\pm\frac{\sigma}{\sqrt{n}}$ error bars represents the standard error of the distribution. The solid curves represent the best fit polynomial (6^{th} order polynomial).*

$$T = 13.49 + 153.12d - 812.50\, d^2 + 1880.27d^3 - 2157.57d^4 + 1207.60d^5 - 262.77d^6 \quad \text{................(11)}$$

In both equations (10) and (11) deviation from Gaussian distribution can be seen.

Conclusion:

The minimum and maximum dust colour temperature near to White dwarf region WD0038+730 (00^h $41^m43^s73^0 21' 14''$) is found to be 19.45K and 23.79K.The total dust mass near the white Dwarf WD 0038+730 is found to be 6.23×10^{25} kg ie 3.12×10^{-5} M_{sun}.

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"Yesterday I received a very interesting paper on invariants from Miss Noether. I'm impressed that these things can be seen in such a general way. It would do the old guard at Göttingen no harm to be sent back to school under Miss Noether. She knows her stuff."

Albert Einstein (1918)

2-Bit Magnitude Digital Comparator

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ABSTRACT

Data comparison is one of the most essential tools in the arithmetic operation of numbers.A digital number system can be 1-bit or more according to the need and availability. Among them a 2-bit digital comparator will be a demonstrative experiment in the laboratory. It compares the most significant digit first and then the least significant digit.

Introduction

It is often necessary, in digital system, to know whether a binary number is equal to, greater than or less than another number. A magnitude digital comparator is a combinational circuit of logic gates that compares two numbers A and B and determines their relative magnitudes [1]. The outcome of the comparison is specified by three binary variables that indicate whether A = B, A > B or A < B. The circuit for comparing two n-bit numbers has 2^{2n} entries in truth-table and becomes tedious to solve K-map, even with n = 3. Alternatively, number of gates can be reduced by applying priority comparison technique. In the priority comparison process the most significant digits of number are compared first.

THEORY

Two numbers, A and B, are

$$A = A_n \ldots\ldots\ldots A_3A_2A_1A_0$$
$$B = B_n \ldots\ldots\ldots B_3B_2B_1B_0$$

Where "0" subscripted letter represents least significant bit (LSB) number and that of "n" represents most significant bit (MSB) number.

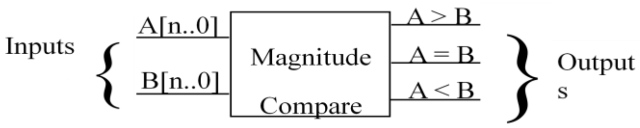

***Figure 1**: Block diagram of magnitude digital comparator*

To determine whether A is greater or less than B, inspect the relative magnitudes of pairs of significant digits, starting from the MSB. If the two digits of a pair are equal, compare the next lower significant pair of digits. This comparison process continues until a pair of unequal digits is reached. If the corresponding digit of A is 1 and that of B is 0, which concludes that A > B. Similarly, If the corresponding digit of A is 0 and that of B is 1, which concludes that A < B. At last, if all pairs of significant digits are equal then the two numbers are equal and equality of each pair of bits can be expressed logically with an exclusive-NOR function [2].

CIRCUIT DESIGN

Consider two bit numbersA and B as

$A = A_1A_0$
$B = B_1B_0$

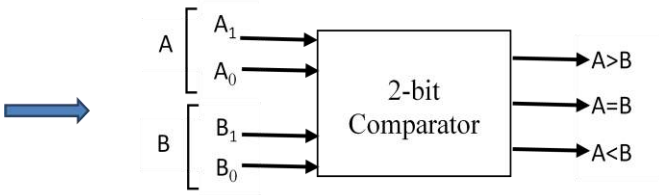

***Figure 2**: Block diagram of 2-bit magnitude digital comparator*

For comparing the MSB A_1& B_1, let us designate

$$A_1\bar{B}_1 = 1 \Rightarrow Y_{11}$$
$$also \qquad \bar{A}_1B_1 = 1 \Rightarrow Y_{12}$$
$$and \qquad E_1 = \bar{A}_1\bar{B}_1 + A_1B_1[XNOR]$$
$$= \bar{Y}_{11}\cdot\bar{Y}_{12}$$

Then for comparing the LSBA_0 & B_0

$$E_1A_0\bar{B}_0 = 1 \Rightarrow Y_{01}$$
$$also \qquad E_1\bar{A}_0B_0 = 1 \Rightarrow Y_{02}$$
$$and \qquad E_0 = \bar{Y}_{01}\cdot\bar{Y}_{02}$$

Finally

$$Y_1 = Y_{11} + Y_{01} \qquad (A > B)$$
$$Y_2 = Y_{12} + Y_{02} \qquad (A < B)$$
$$E = E_1 \cdot E_0 \qquad (A = B)$$

The circuit diagram of two bit magnitude digital comparator is shown in Fig. 3.

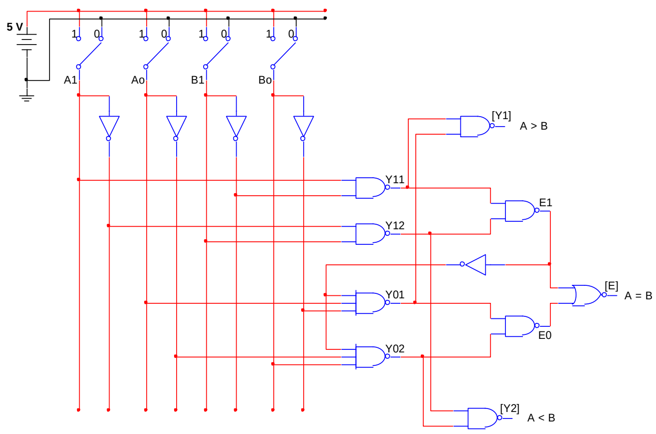

***Figure 3**: Two bit magnitude digital comparator*

Examples:

(i) A = 11 and B = 01

In this example, MSB of both numbers are not equal. So MSB of A is A_1 = 1 and that of B is B_1 = 0 should be compare first and gets A_1> B_1. So one concludes that A > B without comparing lower significant bits.

(ii) A = 10 and B = 11

In this example, MSB of both numbers are equal. So one should compare lower significant bit i.e LSB of the numbers (in this case). The LSB of A is $A_0 = 0$ and that of B is $B_0 = 1$ should be compare and gets $B_0 > A_0$. So one concludes that A < B.

(iii) A = 01 and B = 01

Here, MSB of both numbers are equal. So one should compare lower significant bit i.e LSB of the numbers (in this case) that is also equal. Hence all bits are equal so one concludes that A = B.

And so on

At last, to compare the two numbers, first compare the MSB. If the MSBs are not equal, then it would be clear that either A is greater than or less than B and the process of comparison completes. But if these MSBs are equal, then only need to compare the next lower significant bits and the process continues until LSB.

Acknowlwdgement

I would like to express my special thanks of gratitude to my teacher Dr. Hari Prasad Lamichhane for his encouragementandcontinuous support.

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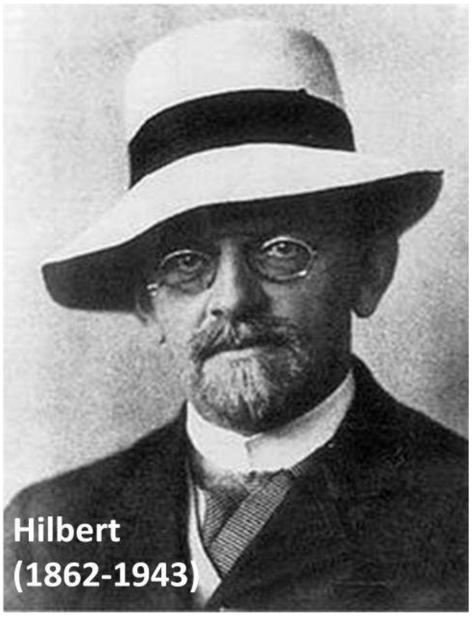

David Hilbert was a German mathematician. He is recognized as one of the most influential and universal mathematicians of the 19th and early 20th centuries. Hilbert discovered and developed a broad range of fundamental ideas in many areas, including invariant theory and the axiomatization of geometry. He also formulated the theory of Hilbert spaces, one of the foundations of functional analysis. Hilbert adopted and warmly defended Georg Cantor's set theory and transfinite numbers. Hilbert and his students contributed significantly to establishing rigor and developed important tools used in modern mathematical physics. Hilbert is known as one of the founders of proof theory and mathematical logic, as well as for being among the first to distinguish between mathematics and meta-mathematics.

Among Hilbert's students were Hermann Weyl, chess champion Emanuel Lasker, Ernst Zermelo, and Carl Gustav Hempel. John von Neumann was his assistant. At the University of Göttingen, Hilbert was surrounded by a social circle of some of the most important mathematicians of the 20th century, such as Emmy Noether and Alonzo Church. Among his 69 Ph.D. students in Göttingen were many who later became famous mathematicians, including (with date of thesis): Otto Blumenthal (1898), Felix Bernstein (1901), Hermann Weyl (1908), Richard Courant (1910), Erich Hecke (1910), Hugo Steinhaus (1911), and Wilhelm Ackermann (1925).[10] Between 1902 and 1939 Hilbert was editor of the Mathematische Annalen, the leading mathematical journal of the time.

"After receiving Miss Noether's new paper, I once again feel that depriving her of a teaching job is a great injustice. I would like vigorous steps to be taken with the Ministry. If you do not think this is possible, then I will go the trouble of doing it myself."

Albert Einstein (1918)

OPINION PAGE

Higher Studies in Physics

Dr. Leela Pradhan Joshi
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ABSTRACT

In this brief article, I will share my experience as well as opinion regarding the importance of higher studies in Physics.

From the discovery of the Higgs boson particle in 2012 to the more recent detection of gravitational waves in space, there have been many breakthrough developments in the field of Physics that are important enough to be front page news. From this, we may understand that the public opinion of Physics as a field of study has shifted to the point where physicists now receive the respect and support for their work they should have years ago. Students studying Physics will no longer be questioned why they want to specialize in something so obscure and irrelevant. It is a matter of great pride that society has come to recognize Physics as an important part of life. It is the study of the universe as a whole and hence very pertinent to our daily life.

I feel that there is nothing without Physics. Our entire lives are governed by the principles, laws and theories of Physics. Thus, it stands to reason that without first furthering our knowledge of Physics, we will never be able to further our understanding of the universe. But it is not merely for comprehending the cosmos that we require Physics. We require it to improve our quality of life as well. Smart phones, laptops, televisions, and so much more are the products of Physics. Studying Physics enables a student to understand how the world—and everything in it—works. Not only that, it provides a student the opportunity and the skill set required to innovate something so revolutionary that they might even be able to change the whole globe as we know it.
There is no shortage of examples of students—especially Nepali students—that have taken on the arduous challenge of pursuing education in Physics and reached great heights. Our fellow Nepali physicists have reached summits as high as NASA and the very team of specialists that detected the gravitational waves I mentioned earlier. However, many prospective students are deterred from pursuing their higher studies in Physics purely because of how difficult others say it is. Yes, Physics is an intimidating subject. But, that is only because of how invaluable it is to our existence. It includes so much that no one could ever fully comprehend every part of it, even after a lifetime of study. Students must first accept that there are some things that will always confuse them in their studies. Then, they must learn to fully appreciate how much is possible with a degree in Physics. Everything is related to Physics these days. Medicine, technology, engineering are all fields that would have been impossible to develop without the prior establishment of a good Physics background.

One of the main things holding students in our country back from pursuing higher studies in Physics may be the lack of proper research opportunities and facilities in Nepal. But that is not entirely the case. While it is true that there is no abundance of well-equipped science labs and no excess of cutting edge machinery in Nepal, it does not mean that we are confined to reading about theories in books here. Despite all that obstacles that arise while attempting to conduct research in Nepal, the Physics community is still continuously striving to push its boundaries and grow as much as possible. We have undertaken research such as fabrication of dye-sensitized solar cells, thin film preparation and many more. Now all we need to expand and develop even further is more students passionate enough about understanding the world and improving it to devote themselves to the study of Physics.

As one of my own professors at Kent State University, OH, USA used to say, "*If you can do Physics, you can do anything*". That does not mean that Physics is difficult and everything else is easy. It simply means that Physics is a thread that connects all other fields of study like nothing else. It is difficult to grasp, but, if you can grasp it, it will prepare you tremendously to take on anything else in life. That is why I strongly recommend students to consider pursing higher studies in Physics.

COVER STORY - 1

Emmy Amalie Noether: A Brief Story

Apsara Sharma Dhakal
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Introduction

There have been many women in the history of science

but among them Emmy Noether is special. Emmy Noether was the first lady Mathematician who contributed her life in the abstraction of algebra and theoretical physics. She was born on March 23, 1882 in Germany. Her father was also a mathematician, Max Noether who initiated her interest for math in her life. She graduated from Hohere Tochter schule in Erlangen and passed the examination of the state of Bavaria in 1990 that allowed her to teach English and French at schools for women. Because of being woman, it was difficult for her to take classes. Then she decided to continue her study on mathematics which was a challenging path for a woman. She passed a test to become a doctoral student in Mathematics without attending class and took five more years of classes and hence became the first woman to get doctorate degree in mathematics after running through many obstacles. Then she desired to be professor which was difficult for her being a woman. Her father allowed her to take his class whenever he was sick or out for the day. During her helping period, she did research and wrote paper on what she found. Then, Felix Klien and David Hilber invited her to join the mathematics department of university of Gottingen in 1915 to help them understand theory of relativity. Though her hard working, she was not given the status of professor as that period was woman dominating society. Later, in 1922 she was granted the position of extra ordinary professor, still not got paid. After the death of her father she got paid a small stipend for teaching in 1923.

In 1933, she shifted to U.S as she was unable to continue her profession because of Nazis who took over the Germany. There she taught at Bryn Mawr College in Dennsylvanian as a guest professor. Later on, at the age of 53 she died because of the tumor. Her sudden death surprised everyone as she had told only to her closest ones about her illness. She was the first one to introduce high order generalized symmetry. Albert Einstein described her as the most important and significant woman in the history of Mathematics. Being mathematician she is known for her theorems like Noether theorems, Noetherian rings, Noether groups, Noether equations, Noether modulus and many more. It's hard to estimate the importance of Noether's work in modern physics. Noether helps us to solve physical problems like, how planet move around the sun, or finding the gravitational solution such as a black hole. Therefore she gave a structure behind how we view physics and how we relate symmetry and conservation laws. She did a fabulous job in non-commutative algebra, group theory, hyper complex numbers. She provided mathematical backbone to the general theory of relativity determining the relationship between momentum and position, energy and time.

Brilliant mathematicians often make their greatest contributions early in their careers; Noether was one of the notable exceptions to that rule. She began producing her most powerful and creative work about the age of 40. Her change in style started with a 1920 paper on non-commutative fields (systems in which an operation such as multiplication yields a different answer foraxb than for b x a). During the years that followed, she developed a very abstract and generalized approach to the axiomatic development of algebra. As Weyl attested, "*she originated above all a new and epoch-making style of thinking in algebra.*"

Noether with her students

Noether's 1921 paper on the theory of ideals in rings is considered to contain her most important results. It extended the work of Dedekind on solutions of polynomials— algebraic expressions consisting of a constant multiplied by variables raised to a positive power—and laid the foundations for modern abstract algebra. Rather than working with specific operations on sets of numbers, this branch of mathematics looks at general properties of operations. Because of its generality, abstract algebra represents a unifying thread connecting such theoretical fields as logic and number theory with applied mathematics useful in chemistry and physics.

Noether with her younger relatives

During the summer of 1934, Noether visited Göttingen to arrange shipment of her possessions to the United States. When she returned to Bryn Mawr in the early fall, she had received a two-year renewal on her teaching grant. In the spring of 1935, Noether underwent surgery to remove a uterine tumor. The operation was a success, but four days later, she suddenly developed a very high fever and lost consciousness. She died on April 14th, apparently from a post-operative infection. Her ashes were buried near the library on the Bryn Mawr campus.

Over the course of her career, Noether supervised a dozen graduate students, wrote forty-five technical publications, and inspired countless other research results through her habit of suggesting topics of investigation to students and colleagues. After World War II, the University of Erlangen attempted to show her the honor she had deserved during her lifetime. A conference in 1958 commemorated the fiftieth anniversary of her doctorate; in 1982 the university dedicated a memorial plaque to her in its Mathematics Institute. During the same year, the 100th anniversary year of Noether's birth, the Emmy Noether Gymnasium, a coeducational school emphasizing mathematics, the natural sciences, and modern languages, opened in Erlangen.

Therefore, her contribution to the globe is priceless and uncountable. The world gave her nothing only obstacles but she gave us one of the most powerful theorems in physics. She was passionate about mathematics and never allowed social convention to limit her. She was not profound of recognition; she just did what she wanted to do and what she loved to. She changed the world she lived in and she changed it for better and for all of us.

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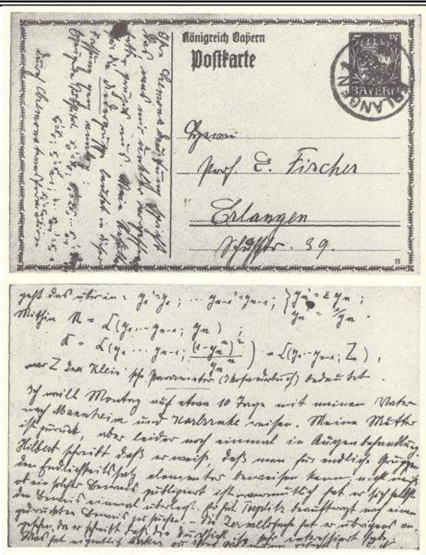
Paul Gordan supervised Noether's doctoral dissertation on invariants of bi-quadratic forms.



Noether sometimes used postcards to discuss abstract algebra with her colleague, Ernst Fischer. this card is postmarked 10 April 1915. During her first years teaching at Göttingen she did not have an official position and was not paid; her family paid for her room and board and supported her academic work. Her lectures often were advertised under Hilbert's name, and Noether would provide "assistance".

COVER STORY - 2

Noether's Theorem

Editorial Board

Noether was brought to Göttingen in 1915 by David Hilbert and Felix Klein, who wanted her expertise in invariant theory to help them in understanding general relativity, a geometrical theory of gravitation developed mainly by Albert Einstein. Hilbert had observed that the conservation of energy seemed to be violated in general relativity, because gravitational energy could itself gravitate. Noether provided the resolution of this paradox, and a fundamental tool of modern theoretical physics, with Noether's first theorem, which she proved in 1915, but did not publish until 1918. She not only solved the problem for general relativity, but also determined the conserved quantities for every system of physical laws that possesses some continuous symmetry.

As an illustration, if a physical system behaves the same regardless of how it is oriented in space, its Lagrangian is rotationally symmetric: from this symmetry, Noether's theorem dictates that the angular momentum of the system be conserved, as a consequence of its laws of motion. The physical system itself need not be symmetric; a jagged asteroid tumbling in space conserves angular momentum despite its asymmetry. It is the laws of its motion that are symmetric.

As another example, if a physical process exhibits the same outcomes regardless of place or time, then its Lagrangian is symmetric under continuous translations in space and time: by Noether's theorem, these symmetries account for the conservation laws of linear momentum and energy within this system, respectively.

Noether's theorem is important, both because of the insight it gives into conservation laws, and also as a practical calculational tool. It allows investigators to determine the conserved quantities (invariants) from the observed symmetries of a physical system. Conversely, it allows researchers to consider whole classes of hypothetical Lagrangians with given invariants, to describe a physical system. As an illustration, suppose that a physical theory is proposed which conserves a quantity X. A researcher can calculate the types of Lagrangians that conserve X through a continuous symmetry. Due to Noether's theorem, the properties of these Lagrangians provide further criteria to understand the implications and judge the fitness of the new theory.

The behavior of a physical system can often be expressed very elegantly in terms of a specific function, called the Lagrangian, of the system variables. The system follows a path through phase space such that the integral of the Lagrangian is stationary. For a simple system with Lagrangian L of the variables q and $\dot{q}$ = dq/dt the equation of motion is

$$\frac{d}{dt}\left(\frac{\partial L}{\partial \dot{q}}\right) = \frac{\partial L}{\partial q}$$

This equation signifies that if the quantity on the right hand side is zero (meaning L is symmetrical over q), then the rate of change of the quantity in parentheses on the left side is also zero, so it is a conserved quantity. The same applies to more complicated systems; in general any symmetry of the Lagrangian corresponds to a conserved quantity, and vice versa. Despite the fact that the *Euler-Lagrange equation* is essentially an explicit statement of this proposition, it seems not to have been discussed and formalized as a theorem until 1915, by Emmy Noether (1882-1935), so it is now called Noether's Theorem. As an example, the classical Lagrangian of a free particle of mass m is simply L = (1/2) m $\dot{x}^2$, which depends only on $\dot{x}$, not on x, so we have dL/dx = 0, and it follows that $dL/d\dot{x} = m\dot{x}$ is constant, i.e., momentum is conserved. More generally, consider a system with n coordinates q_1, q_2, ..., q_n. The Lagrangian L is a function of all n variables and their first derivatives with respect to time. The equations of motion are the n Euler equations, one for each of the variables. The total differential of L with respect to the coordinates q_i is

$$dL = \sum_{i=1}^{n} \frac{\partial L}{\partial q_i} dq_i$$

Multiplying each of the n Euler equations by the respective differential dq_i and adding them together, we get

$$\frac{d}{dt}\left[\sum_{i=1}^{n}\left(\frac{\partial L}{\partial \dot{q}_i} dq_i\right)\right] = dL$$

Thus for any combination of differentials dq_i such that dL = 0, the summation on the left hand side is a constant, i.e., a conserved quantity. Of course, only the proportions between the differentials are significant, not their individual absolute values. Each set of coordinate differential proportions represents a direction in the coordinate space. Letting s denote a path parameter along a given curve $q_i(s)$ in coordinate space, we can divide through the above expression by ds to give in terms of derivatives instead of differentials the formulation

$$\frac{d}{dt}\left[\sum_{i=1}^{n}\left(\frac{\partial L}{\partial \dot{q}_i}\frac{dq_i}{d\sigma}\right)\right] = \frac{dL}{d\sigma}$$

To illustrate, consider a set of N particles with masses m_j

and positions x_i, y_i, z_i for $i = 1$ to N, with a potential energy that depends only on the pair-wise distances between the particles. Clearly that the Lagrangian is unaffected by any fixed displacement of the system, i.e., it is constant along any curve (in phase space) of the form $x_i(s) = k_x s$, $y_i(s) = k_y s$, $z_i(s) = k_z s$ for any constants k_x, k_y, k_z. Thus Noether's Theorem implies

$$k_x \sum_{i=1}^{N} m_i \dot{x}_i + k_y \sum_{i=1}^{N} m_i \dot{y}_i + k_z \sum_{i=1}^{N} m_i \dot{z}_i = \text{constant}$$

Since the constants k_x, k_y, k_z are arbitrary, it follows that each summation is individually a constant, meaning that momentum is conserved in each of the three coordinate directions, and therefore in every spatial direction. For the same set of particles we could also consider the invariance of the Lagrangian under a fixed rotation (i.e., a re-orientation) of the system about the origin. For each mass with coordinates x,y,z a fixed rotation about the z axis preserves the quantity $x^2 + y^2$ for each point, from which we get $xdx + ydy = 0$. Thus we can represent the differentials for this symmetry by $dx_i = ds\, y_i$, $dy_i = -ds\, x_i$, and $dz_i = 0$, so by Noether's Theorem we have the conserved quantity

$$\sum_{i=1}^{N} m_i \left(\dot{x}_i y_i - x_i \dot{y}_i \right) = \text{constant}$$

This expresses the general conservation of angular momentum about the z axis, and in the same way we can show that the physical symmetry under re-orientations about the x or y axes implies conservation of angular momentum about those axes as well.

In addition to symmetry with respect to spatial displacement and orientation, another important symmetry of all known physical laws is with displacements in time. In this case too the Euler equations identify a conserved quantity. Assuming the Lagrangian L is not an explicit function of time (although the system variables may be), we have the total derivative

$$\frac{dL}{dt} = \sum_{i=1}^{n} \left(\frac{\partial L}{\partial q_i} \frac{dq_i}{dt} + \frac{\partial L}{\partial \dot{q}_i} \frac{d\dot{q}_i}{dt} \right)$$

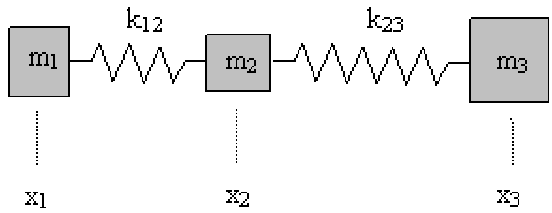
The Euler equations for the system enable us to subsitute for the partials of L with respect to q_i on the right hand side, and we can express dq_i/dt in dot notation, so we have

$$\frac{dL}{dt} - \sum_{i=1}^{n} \left(\dot{q}_i \frac{d}{dt} \left(\frac{\partial L}{\partial \dot{q}_i} \right) + \frac{\partial L}{\partial \dot{q}_i} \frac{d\dot{q}_i}{dt} \right) = 0$$

Noting that the summand is the derivative with respect to time of a single product, this can also be written as

$$\frac{d}{dt} \left[L - \sum_{i=1}^{n} \left(\dot{q}_i \frac{\partial L}{\partial \dot{q}_i} \right) \right] = 0$$

Thus the quantity in square brackets is constant. As an illustration, consider the mass-spring system shown below.



This system has the usual Lagrangian given by kinetic energy T minus potential energy V

$$L(x_1, x_2, x_3, \dot{x}_1, \dot{x}_2, \dot{x}_3) = T - V$$
$$= \frac{1}{2} m_1 \dot{x}_1^2 + \frac{1}{2} m_2 \dot{x}_2^2 + \frac{1}{2} m_3 \dot{x}_3^2 - \left[\frac{k_{12}}{2} (x_2 - x_1)^2 + \frac{k_{23}}{2} (x_3 - x_2)^2 \right]$$

We have

$$\sum_{i=1}^{3} \dot{x}_i \frac{\partial L}{\partial \dot{x}_i} = m_1 \dot{x}_1^2 + m_2 \dot{x}_2^2 + m_3 \dot{x}_3^2 = 2T$$

Since L = T – V the conserved quantity corresponding to time symmetry is

$$L - 2T = T - V - 2T = -(T + V)$$

is the total energy of the system.

For as more formal proof of Noether's Theorem, and to show how naturally it appears in the derivation of the Euler-Lagrange equation itself, suppose $x_1, x_2, \ldots, x_n$ are the dynamical variables describing the physical state of a system, and each of them is a function of the time t, and suppose the Lagrangian of the system is $L(x_1, x_2, \ldots, x_n)$. The usual way of deriving the equations of motion is to consider a set of perturbed variables

$$X_i(t, \varepsilon) = x_i(t) + \varepsilon \delta_i(t)$$

where the functions $d_i(t)$ are arbitrary variations, and then determine the conditions that must be satisfied in order for the integral of Ldt to be stationary, meaning that the integral is unaffected by an incremental value of the variational parameter e. To do this we differentiate the integral with respect to e as follows

$$\frac{d}{d\varepsilon} \left(\int_{t_1}^{t_2} L\, dt \right) = \int_{t_1}^{t_2} \left(\sum_{i=1}^{n} \left(\frac{\partial L}{\partial X_i} \frac{\partial X_i}{\partial \varepsilon} + \frac{\partial L}{\partial \dot{X}_i} \frac{\partial \dot{X}_i}{\partial \varepsilon} \right) \right) dt$$

Setting this to zero when e = 0 and therefore $X_i = x_i$, and substituting for the partials with respect to e, gives the condition

$$\int_{t_1}^{t_2} \left(\sum_{i=1}^{n} \left(\frac{\partial L}{\partial x_i} \delta_i + \frac{\partial L}{\partial \dot{x}_i} \dot{\delta}_i \right) \right) dt = 0$$

The second term in each summand can be integrated by parts as

$$\int_{t_1}^{t_2} \frac{\partial L}{\partial \dot{x}_i} \dot{\delta}_i \, dt = \frac{\partial L}{\partial \dot{x}_i} \delta_i \Big|_{t_1}^{t_2} - \int_{t_1}^{t_2} \frac{d}{dt}\left(\frac{\partial L}{\partial \dot{x}_i}\right) \delta_i \, dt$$

so the preceding equation can be written in the form

$$\sum_{i=1}^{n} \left(\frac{\partial L}{\partial \dot{x}_i} \delta_i \right) \Bigg|_{t_1}^{t_2} + \int_{t_1}^{t_2} \left(\sum_{i=1}^{n} \left(\frac{\partial L}{\partial x_i} - \frac{d}{dt} \frac{\partial L}{\partial \dot{x}_i} \right) \delta_i \right) dt = 0 \qquad (1)$$

At this point we usually focus on disturbing functions that equal zero at the endpoints of the interval from t_1 to t_2, in which case the first term in the above expression is identically zero, and we just need to ensure that the integral vanishes. Since the d_i functions are independent and arbitrary (between the end points), this requires that each of the summands individually must vanish, so we arrive at the Euler-Lagrange equations of motion

$$\frac{\partial L}{\partial x_i} - \frac{d}{dt} \frac{\partial L}{\partial \dot{x}_i} = 0 \qquad i = 1, 2, \ldots n$$

However, Noether made the interesting observation that equation (1) applies to arbitrary disturbing functions, not just those that vanish at the endpoints, provided the function L is unaffected by the disturbances. Furthermore, if the system is evolving in accord with the equations of motion, the integral in (1) vanishes, and the remaining equation implies that the value of the summation is unchanged from t_1 to t_2, so we have the conserved quantity

$$\sum_{i=1}^{n} \frac{\partial L}{\partial \dot{x}_i} \delta_i = \text{constant}$$

Noether was primarily an algebraicist (as was her father, Max Noether), but in 1915 she was asked by David Hilbert for help in trying to understand the status of energy conservation in general relativity. As we've seen, the conservation of energy in classical physics is closely related to the time-invariance of physical laws, but in general relativity there is not necessarily a global time coordinate, so the classical invariance cannot be invoked to establish the conservation of energy. Nevertheless, if spacetime in the region of interest is regarded as asymptotically flat, it is possible to define a conserved energy. This important aspect of general relativity was greatly clarified by Noether's Theorem. Subsequently the theorem has found important applications in many branches of physics. For example, in quantum mechanics the phase of the wave function can be incremented without affecting any observables, and this "*gauge symmetry*" corresponds to the conservation of electric charge. Moreover, Noether's approach of identifying symmetries with conserved quantities forms the basis of the Standard Model of particle physics.

Noetherian Rings

From 1920 to 1926, Noether opened up new frontiers in algebra by her studies of idealsand by her effectiveness as a teacher of a "*somewhat noisy and stormy*" group of highlytalented graduate students known as "*the Noether boys*". The theory of ideals had been introduced a generation earlier by Richard Dedekind forthe purpose of formulating the fundamental theorem of arithmetic (that every positiveinteger is a unique product of primes) for other numbers than just the integers. Thegenius of Dedekind's ideals is suggested by an example: Let (2) denote the set of evenintegers and (6) the set of all integer multiples of 6. Then the fact that 6 is divisible by 2 is equivalent to the containment (6) (2). More generally, n is divisible by m if andonly if It follows that everything about divisibility can be formulated in termsof set containment! The sets (n) are examples of ideals in the ring of integers.

The theory of ideals had been developed considerably before 1920. But many proofs, such as that of Lasker's theorem (named for Emanuel Lasker, algebraist and world chesschampion) could be replaced by much simpler proofs only after Noether showed theimportance of a particular condition for rings. It is called the ascending chain condition (ACC). To define the ACC, we first define a set of ideals in a ring R to bean ascending chain if Now, if every ascending chain in R comes toan end (meaning that there is some k such that, then R has the ACC. In 1921, Noether published a paper showing the naturalness and usefulness of the ACC, and it is largely as a result of that paper that rings satisfying the ACC are calledNoetherian rings. The integers, with the ordinary and for example, are a Noetherian ring.

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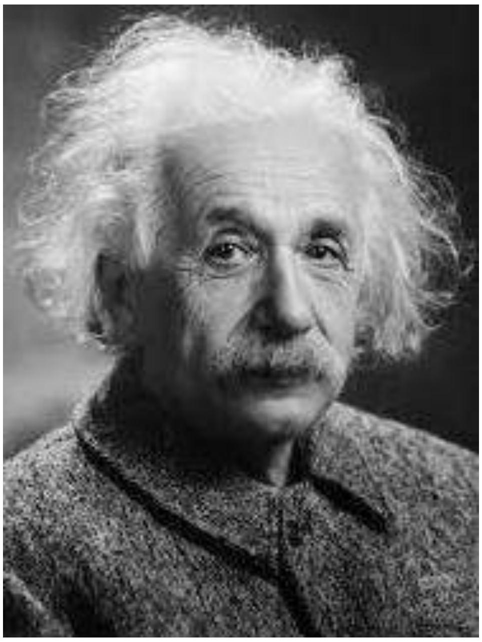
Emmy's mother was a skilled pianist, but Emmy did not enjoy piano lessons. Her main passion was dancing.

COVER STORY - 3

Einstein Writes about Emmy……

To the Editor of ***The New York Times***



The efforts of most human-beings are consumed in the struggle for their daily bread, but most of those who are, either through fortune or some special gift, relieved of this struggle are largely absorbed in further improving their worldly lot. Beneath the effort directed toward the accumulation of worldly goods lies all too frequently the illusion that this is the most substantial and desirable end to be achieved; but there is, fortunately, a minority composed of those who recognize early in their lives that the most beautiful and satisfying experiences open to humankind are not derived from the outside, but are bound up with the development of the individual's own feeling, thinking and acting. The genuine artists, investigators and thinkers have always been persons of this kind. However inconspicuously the life of these individuals runs its course, none the less the fruits of their endeavors are the most valuable contributions which one generation can make to its successors.

Within the past few days a distinguished mathematician, Professor Emmy Noether, formerly connected with the University of Göttingen and for the past two years at Bryn Mawr College, died in her fifty-third year. In the judgment of the most competent living mathematicians, Fräulein Noether was the most significant creative mathematical genius thus far produced since the higher education of women began. In the realm of algebra, in which the most gifted mathematicians have been busy for centuries, she discovered methods which have proved of enormous importance in the development of the present-day younger generation of mathematicians. Pure mathematics is, in its way, the poetry of logical ideas. One seeks the most general ideas of operation which will bring together in simple, logical and unified form the largest possible circle of formal relationships. In this effort toward logical beauty spiritual formulas are discovered necessary for the deeper penetration into the laws of nature.

Born in a Jewish family distinguished for the love of learning, Emmy Noether, who, in spite of the efforts of the great Göttingen mathematician, Hilbert, never reached the academic standing due her in her own country, none the less surrounded herself with a group of students and investigators at Göttingen, who have already become distinguished as teachers and investigators. Her unselfish, significant work over a period of many years was rewarded by the new rulers of Germany with a dismissal, which cost her the means of maintaining her simple life and the opportunity to carry on her mathematical studies. Farsighted friends of science in this country were fortunately able to make such arrangements at Bryn Mawr College and at Princeton that she found in America up to the day of her death not only colleagues who esteemed her friendship but grateful pupils whose enthusiasm made her last years the happiest and perhaps the most fruitful of her entire career.

ALBERT EINSTEIN.
Princeton University, May 1, 1935.
[New York Times May 5, 1935]

COVER STORY - 4

Hermann Weyl's speech at Emmy Noether's funeral

Who is Herman?

Hermann Klaus Hugo Weyl (9 November 1885 – 8 December 1955) was a German mathematician, theoretical physicist and philosopher. Although much of his working life was spent in Zürich, Switzerland and then Princeton, he is associated with the University of Göttingen tradition of mathematics, represented by David Hilbert and Hermann Minkowski. His research has had major significance for theoretical physics as well as purely mathematical disciplines including number theory. He was one of the most influential mathematicians of the twentieth century, and an important member of the Institute for Advanced Study during its early years.

The hour has come, Emmy Noether, in which we must forever take our leave of you. Many will be deeply moved by your passing, none more so than your beloved brother Fritz, who, separated from you by half the globe, was unable to be here, and who must speak his last farewell to you through my mouth. His are the flowers I lay on your coffin. We bow our heads in acknowledgement of his pain, which it is not ours to put into words.

But I consider it a duty at this hour to articulate the feelings of your German colleagues - those who are here, and those in your homeland who have held true to our goals and to you as a person. I find it apt, too, that our native tongue be heard at your graveside - the language of your innermost sentiments and in which you thought your thoughts - and which we hold dear whatever power may reign on German soil. Your final rest will be in foreign soil, in the soil of this great hospitable country that offered you a place to carry on your work after your own country closed its doors on you. We feel the urge at this time to thank America for what it has done in the last two years of hardship for German science, and to thank especially Bryn Mawr, where they were both happy and proud to include you amongst their teachers.
Justifiably proud, for you were a great woman mathematician - I have no reservations in calling you the greatest that history has known. Your work has changed the way we look at algebra, and with your many gothic letters you have left your name written indelibly across its pages. No-one, perhaps, contributed as much as you towards remoulding the axiomatic approach into a powerful research instrument, instead of a mere aid in the logical elucidation of the foundations of mathematics, as it had previously been. Amongst your predecessors in algebra and number theory it was probably Dedekind who came closest.

When, at this hour, I think of what made you what you were, two things immediately come to mind . The first is the original, productive force of your mathematical thinking. Like a too ripe fruit, it seemed to burst through the shell of your humanness. You were at once instrument of and receptacle for the intellectual force that surged forth from within you. You were not of clay, harmoniously shaped by God's artistic hand, but a piece of primordial human rock into which he breathed creative genius.

The force of your genius seemed to transcend the bounds of your sex - and in Göttingen we jokingly, but reverentially, spoke of you in the masculine, as "den Noether". But you were a woman, maternal, and with a childlike warmheartedness. Not only did you give to your students intellectually - fully and without reserve - they gathered round you like chicks under the wings of a mother hen; you loved them, cared for them and lived with them in close community.

The second thing that springs to mind is that your heart knew no malice; you did not believe in evil, indeed it never occurred to you that it could play a role in the affairs of man. This was never brought home to me more clearly than in the last summer we spent together in Göttingen, the stormy summer of 1933. In the midst of the terrible struggle, destruction and upheaval that was going on around us in all factions, in a sea of hate and violence, of fear and desperation and dejection - you went your own way, pondering the challenges of mathematics with the same industriousness as before. When you were not allowed to use the institute's lecture halls you gathered your students in your own home. Even those in their brown shirts were welcome; never for a second did you doubt their integrity. Without regard for your own fate, openhearted and without fear, always conciliatory, you went your own way. Many of us believed that an enmity had been unleashed in which there could be no pardon; but you remained untouched by it all. You were happy to go back to Göttingen last summer, where, as if nothing had happened, you lived and worked with German mathematicians striving for the same goals. You planned on doing the same this summer.

You truly deserve the wreath that the mathematicians in Göttingen have asked me to lay on your grave.

We do not know what death is. But is it not comforting to think that souls will meet again after this life on Earth, and how your father's soul will greet you? Has any father found in his daughter a worthier successor, great in her own right?

You were torn from us in your creative prime; your sudden departure, like the echo of a thunderclap, is still written on our faces. But your work and your disposition will long keep your memory alive, in science and amongst your students, friends and colleagues. Farewell then, Emmy Noether, great mathematician and great woman. Though decay take your mortal remains, we will always cherish the legacy you left us.

Hermann Weyl

Expulsion from Göttingen

When Adolf Hitler became the German Reichskanzler in January 1933, Nazi activity around the country increased dramatically. At the University of Göttingen the German Student Association led the attack on the "un-German spirit" attributed to Jews and was aided by a privatdozent named Werner Weber, a former student of Noether. Antisemitic attitudes created a climate hostile to Jewish professors. One young protester reportedly demanded: "*Aryan students want Aryan mathematics and not Jewish mathematics.*" One of the first actions of Hitler's administration was the Law for the Restoration of the Professional Civil Service which removed Jews and politically suspect government employees (including university professors) from their jobs unless they had "*demonstrated their loyalty to Germany*" by serving in World War I. In April 1933 Noether received a notice from the Prussian Ministry for Sciences, Art, and Public Education which read: "On the basis of paragraph 3 of the Civil Service Code of 7 April 1933, I hereby withdraw from you the right to teach at the University of Göttingen. Several of Noether's colleagues, including Max Born and Richard Courant, also had their positions revoked. Noether accepted the decision calmly, providing support for others during this difficult time. Hermann Weyl later wrote that "*Emmy Noether—her courage, her frankness, her unconcern about her own fate, her conciliatory spirit—was in the midst of all the hatred and meanness, despair and sorrow surrounding us, a moral solace.*" Typically, Noether remained focused on mathematics, gathering students in her apartment to discuss class field theory. When one of her students appeared in the uniform of the Nazi paramilitary organization Sturmabteilung (SA), she showed no sign of agitation and, reportedly, even laughed about it later.

"If Emmy Noether could have been at the 1950 Congress, she would have felt very proud. Her concept of algebra had become central in contemporary mathematics. And it has continued to inspire algebraists ever since."

Garrett Birkhoff

Noether's work in abstract algebra and topology was influential in mathematics, while in physics, Noether's theorem has far-ranging consequences for theoretical physics and dynamic systems. She showed an acute propensity for abstract thought, which allowed her to approach problems of mathematics in fresh and original ways.

Cryptography: Classical Versus Quantum

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ABSTRACT

This article presents basic introduction to cryptography and an overview of security-based queries like- how vulnerable our information sharing process would be- with the introduction of quantum computers and how basic principles of quantum mechanics could be exploited in order to avoid these threats.

Introduction

In quantum realm, things would start behaving strangely from our common intuition. For an instance, we cannot measure position and velocity of quantum particle simultaneously. Before and after measurement, the system would be in different states. This ignites the fact that our measurement won't be able to give the exact state of the system. A fundamental principle of quantum mechanics such as superposition principle can baffle even a good quantum physicist. Even Feynman was convinced to the school of thought "No one understands quantum mechanics". Such seemingly weird properties of quantum mechanics are exploited in the construction of quantum computers. Technologies build up on principle of quantum mechanics are hoped to help us uplift our understanding of it in the days to come.

Quantum Computers

Analogous to the bits in classical computation, Quantum computer uses qubits. Classical bits can be either in 0 state or in 1 state, but quantum bits (qubits) can be in 0 state as well as in 1 state at the same time, which gives it superior computational power. For instance, linear combination of 0 and 1; $\alpha\, |0\rangle + \beta\, |1\rangle$ (Here, α and β are complex numbers and $\alpha^2 + \beta^2 = 1$) and is also possible state. There are number of physical objects that can be used as qubits such as a single photon, a nucleus or an electron. For an instance, if we have two bits of information then four set of information (11, 10, 01, and 00) is possible and we need only two information to determine the state of the system. However, if we have two qubits, say spin of electron, then we may consider 1 as 'spin up' and 0 as 'spin down' and Quantum mechanically they can be in the state : $(\alpha\, |00\rangle + \beta\, |11\rangle + \gamma\, |01+10\rangle + \delta\, |01-10\rangle)$. Further, having values of these four coefficients, we will be able to exactly figure out the state of the system. This is how two qubits can contain information of four classical bits and in this way; N qubits contain 2^N classical bits information. Imagine the power of exponential! How much information can 100 qubits store? [1].The problems, which classical computers take years to solve, quantum computer is assumed to solve in minutes.

Cryptography

Cryptography is the study of technique of secure communication in the presence of adversaries. The main goal of cryptography is for a sender and intended recipient to be able to communicate in a form which is unintelligible to third parties. Applications of cryptography include ATM Cards, Computer passwords and electronic commerce [2]. Field of cryptography is divided into several parts:

Secret-key cryptography

This refers to the encryption method in which both sender and the receiver shares the same key. The shortcoming of secret-key cryptography is number of key required increases with the increase of network members which requires complex key management system to keep them all secret and consistent.

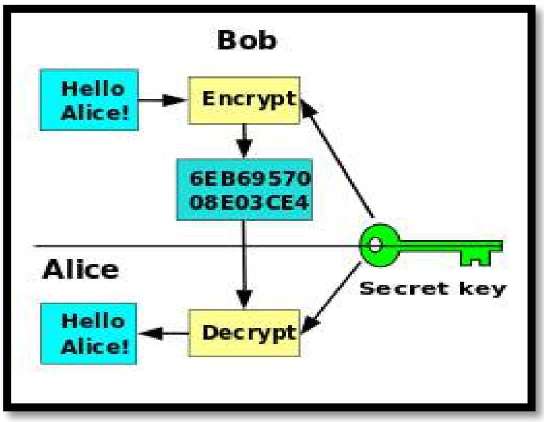

Figure 1: *Encryption and Decryption in Secret-key Cryptography [adapted from https://en.wikipedia.org/ wiki/Cryptography]*

Public-key cryptography

In this system, two different but mathematically related keys are used. One is called public key and another is private key. The public key may be freely distributed but its paired private key must remain secret. Here public key is used for encryption and private key is used for decryption [3]. It is often compared to mailbox that uses two keys. The public key of a user is allowed to others (public) to deposit mail for him and the private key of the user is used to decode the mail he received.

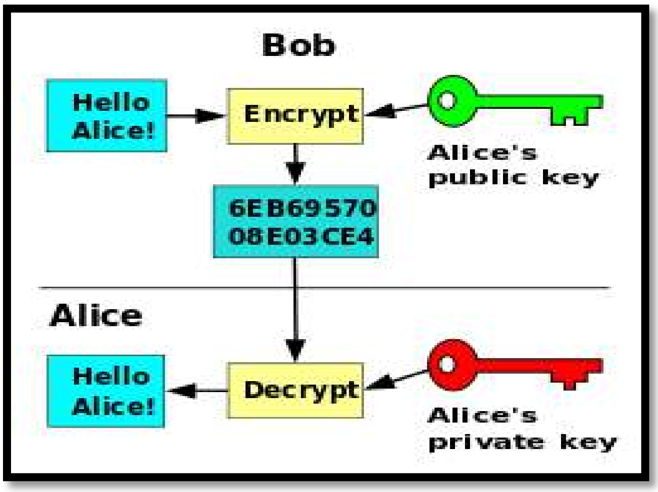

Figure 2: *Encryption and Decryption fashion in Public-key Cryptography [Source: https://en.wikipedia.org/wiki/Cryptography]*

Quantum cryptography

> "NSA seeks to build quantum computer that could crack most types of encryption"

Along with tremendous speed of quantum computers, it has brought a breakthrough in cryptography. Keys used in modern cryptography is so large that millions of computer in conjunction with each processor, processing a billion calculation per second still takes millions of days to definitely crack a key. Though it seems utterly difficult to crack a private key for now, with the advent of quantum computer and it's unfathomable computational speed, cracking a key would take much less effort and time[4]. This suggests that secret-key cryptography would be preferred method in the future. The chief downside of secret-key cryptography put forth a question, how two users may agree on what private key should be used for both sending and receiving information. If the information you want to share is with person you live next door it's not problem, you can meet him and agree on the key but it might not be always the case what if person you want to share information with lives in another country.

Quantum key distribution

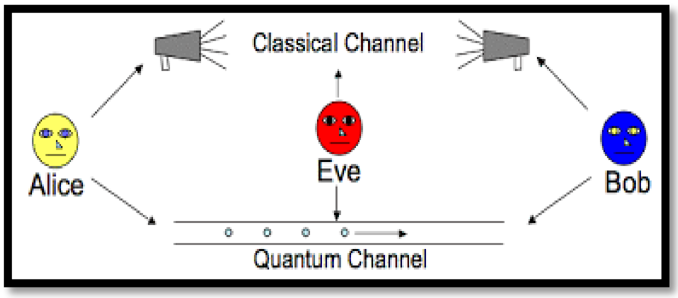

Figure 3: *Communication through Classical and Quantum channel [Adapted from www.cse.wustl.edu]*

This is the most known and developed application of quantum cryptography.

If Bob wants to share some information with Alice and he doesn't want Eve to know it. He has to send key for Alice to decode his message. If Eve tries to get the key sent from Bob she must do some sort of observation. Quantum mechanics deals this case by putting forward a restriction that: if you observe the system you disturb the system. So, when Eve tries to steal their shared key, they will find some kind of disturbance in their system if they are communicating through quantum channel whereas they won't be aware if they are communicating through classical channel.

Conclusion

Almost every part of science is approaching towards the development of quantum computers with the hope of adding new dimension in their corresponding field. But in parallel such developments make the classical key distribution system more vulnerable because the tremendously speedy quantum computers will have the power of easy access to millions of keys at a time. Since our classical approach of using mathematical technique in key distribution is going to be outdated with the arrival of quantum computers, the world where we exist is essentially in need of a safe security system regarding information sharing process. Thus, quantum key distribution seems to be a must at this era of Information Technology.

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Geometry of Gauge Theories and Symmetry Breaking

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ABSTRACT

Symmetry breaking mechanism, in which the Higgs potential is replaced by a constraint restricting the Higgs field to an orbit, is discussed in the framework of the standard model. On the classical level, this approach gives the same physical predictions as the standard model, except that it does not require the existence of a Higgs boson. As a final year student of M.Sc. (Physics) I will to explain my understanding of geometry of gauge theories and symmetry breaking.

Fields are the continuum of infinite harmonic oscillator. So, they have infinite degrees of freedom in general. In fact, we need different abstract algebraic theories to discribe them. Writing Lagragian, checking symmetries and conserved currents, imposing second quantization to create annihilate quanta of energy or particles as well and all of their interpretation to produce a visible effect in a whole humanity is really challenging and interesting for every phenomenon. So, we take the assistance of abstract algebra that provides us a good roadmap where to go and what to doto obtain the intended results. These algebraic theories have many complicatoins within themselves to go through and so are again difficult to handle and visualize. So, to visualize these abstract guys, we need to stick them to different independent dimension parameters and make a pictorial form for their representation, which is geometry of those fields. The most convenient way, then, to understand the nature of those fields is their geometrization. So, we seek geometry of algebra to understand and work with the field theories.

We know, group theories are are the major transitions in between algebra and geometry. Therefore, they are the most important mathematical tools used to describe the fields. Once the fields are described by group theories, they seek some symmetry of certain operations and the symmetry is broken, there exists new phenomenon yet to be described. It can be understood just like phase transition process. So, symmetry is the beauty of nature which consists almost all of the information of nature, but what symmetry demands is the geometry of nature.Here, nature means the fields used to describe the existing phenomena. And, symmetry is the heart of group theory. That's why we use group theory to describe the geometry of the fields.

In this article, I have attempted to clearify the role of geometry in symmetry properties by taking some gauge fields as an example and the geometrical mechanism of breaking gauge symmetry in gauge fields.

Electromagnetic Field:

Electromagnetic field is the abelian gauge field which is best explained by Maxwell's equations. These Maxwell's equations are invariant under the gauge transformation of potential,

$$A_\mu \rightarrow A_\mu - \partial_\mu \Lambda$$

where, Λ is any scalar function. This comes under the symmetry group U(1). The geometry of U(1) is such that it contains every possible phase values of the wavefunction as angular coordinates and it looks like a ring internally.

The gauge transformation group U(1) for electromagnetism is written as

$$U = \exp\{-iq\Lambda(x)\}$$

where, 'q' is the coupling constant or charge and Λ is the scalar parameter which is constant for global scale, but locally can be continually deformed and so is the function of spacetime locally. This transformation equation resembles to isotopic spin rotation (just in mathematical form), showing that gauge transformation sets the internal space coordinates into rotation. As U(1) is one dimensional,the rotation traces out a circle or ring as stated above. It's another consequence is that the covariant derivative becomes

$$D\mu\Psi = (\partial_\mu - iqA_\mu)\Psi,$$

showing that D_μ differs from ∂_μ from purely geometrical factor $iqA\mu$, where $A\mu$ is totally geometry dependent. As A_μ is also one dimensional, the geometrical factor is flat, with zero curvature which signifies that $[A_\mu , A_\nu] = 0$ i.e. vector potential doesn't change under external spacetime translation. The change of '∂_μ ' to 'D_μ' due to some external effects on field is called '*minimal coupling*'.

Gravitational Field

Gravitational force is now understood as a purely geometrical effect produced from the curvature of spacetime geometry due to the presence of matter. In a sense,it is doubtful whether to consider it as a force or not, due to it's geometrical realization that it is just the curvature of spacetime geometrically in the presence of matter, and affects the inertia of matter that produces it; and no any second quantization form of Einstein's equation, $G\mu\nu = k\, T\mu\nu$, in the quantum level.

The geometry of gravitational field is simple. Along Euclidean space, the basis vectors do not change and so, differentiation of a vector is very general i.e. $\partial A^\mu/\partial X^\nu$ or likewise. But in case of the Riemannian geometry (eg. curved geometry created by the presence of matter), the differential needs some extra term that represents curvature (geometry) eg. $\partial A^\mu/\partial X^\nu+\Gamma^\mu{}_{\nu\sigma}A^\sigma$. It is because, basis vectors are no longer constants of differentiation. This covariant differentiation is the heart to explain geometry of gravity. Due to some conceptual inconsistencies (eg. Self-interaction of gravity), we can't represent it into the gauge groups. But, we can have commutator $[\nabla_\mu, \nabla_\nu]V^\sigma = R^\sigma{}_{\tau\mu\nu}V^\tau$, where ∇_μ the covariant differentiation along x^μ-direction and $R^\sigma{}_{\tau\mu\nu}$is Riemann curvature tensor. If to the Lie group commutator algebra, $[X_a,X_b] = if^c{}_{ab}X^c$, we find that if $^c{}_{ab}X^c$ is very similar to $R^\sigma{}_{\tau\mu\nu}$ in a sense that $f^c{}_{ab}$ is a general structure constant which is purely determined by the geometry of Lie algebra. Also, just like in GTR, we can define matric in Lie algrbra to be

$$g_{ab} = -f^c{}_{ad}f^d{}_{bc} = tr(X_aX_b)$$

which is purely geometrical object. So, gravitational fields are purely geometrical that show somewhat similarity in mathematical structure with other gauge fields obeying Lie algebra. It has a major consequence that all gauge fields should contain some geometrical factor on them that explains their geometry and provides a microscopic view within them. It is imposed through the same thing: covariant differentiation and it's invariance properties.

Yang-Mill's Field

Yang-Mill's field is, simply to understand, the non-abelian mathematical generalization of electromagnetic field, though no claims over finding of non-abelian version of Faraday's or Ampere's law are available till date. It is because electromagnetic potentials are naturally abelian, but Yang-Mill's potentials are non abelian in nature.

The Maxwell's field strength tensor is,

$$F_{\mu\nu} = \partial_\mu A_\nu - \partial_\nu A_\mu \,.$$

The YM's field strength tensor is,

$$G_{\mu\nu} = \partial_\mu A_\nu - \partial_\nu A_\mu - ig[A_\mu, A_\nu]$$

where, 'g' is Yang-Mill's coupling constant.

First of all, let's see interaction of an electron with electromagnetic field. It's Lagrangian will be

$$L = i\bar{\psi}\gamma^\mu D_\mu\psi - (1/4)F_{\mu\nu}F^{\mu\nu} - m\bar{\psi}\psi\,,\ \bar{\psi} = \psi^\dagger\gamma^0$$

whose first term and third term in RHS are the Dirac lagrangian while the second is purely electromagnetic term. The interaction of Dirac field with the electromagnetic potential is assured by presence of covariant differentiation in the first term. The first two terms in the lagrangian are gauge invariant while the mass term is not. To make this lagrangian gauge invariant, the mass term should vanish. It predicts the Yang-Mill's gauge theory to be massless. It is because, Yang-Mill's field is the interacting field and firstly, they had attempted to make the gauge invariant field of interaction of electrons with electromagnetic field. Again, they tried to explain the field by replacing $F_{\mu\nu}$ by $G_{\mu\nu}$, which is actually Yang-Mill field known today, still the problem remained the same. So, the Yang-Mill lagrangian is,

$$L = i\bar{\psi}\gamma^\mu D_\mu\psi - (1/4)G_{\mu\nu}G^{\mu\nu} - m\bar{\psi}\psi$$

And, Yang-Mill equation is,

$$[D_\mu, G^{\mu\nu}] = 4\pi J^\nu\,.$$

The 'ψ' in Yang – Mill lagrangian is the isospin wavefunction with up- and down- states. But for any gauge group G, the 'ψ' can be interpreted as an n-component vector of internal isospin space and A_μ is the internal operator (in electomagnetism, it is just the electromagnetic potential) constructed by linear superposition of the gauge group generator of SU(2).

The origin of Newton or non- commutating term in the Yang-Mill Field strength tensor is that the internal operators are path dependent that do not commute at different space time points. It is the purely geometrical term that states that internal space of Yang-Mill gauge field is not flat unlike in the electromagnetism. If we try to solve the Yang –Mill's equation taking only one charge, it reduces to electromagnetic form, giving Coulomb –like solution. But if tried to solve taking two or more charges, they may be at rest in space time, but seems to precess with time in internal space due to non commutating potential operators at different space time points. So, geometry is the major aspect that determines the behaviour of field.

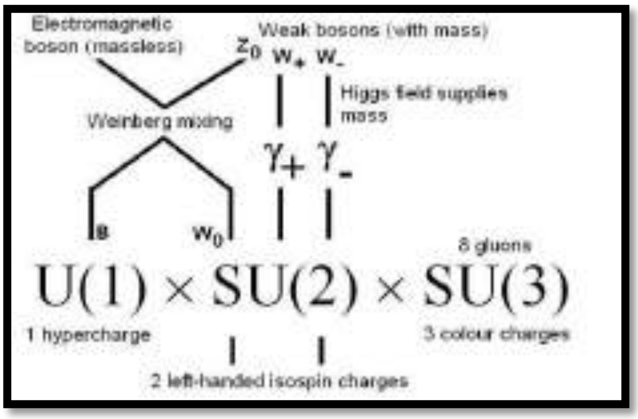

Figure 1: *Main-stream standard model*

The very difficulty of solving Yang-Mill wave equation led physicists to think of non-abelian gauge theory and behaviour of their quanta differently. Also, this theory predicted the non-abelian gauge fields do not have mass and so, range should be infinite. This problem was related to violation of gauge symmetry due to mass term. But experimentally, weak decays were found to be very short- ranged. Then one question arose: How to redefine geometry of Yang- Mill's fields? As an answer, symmetry was found to be broken to provide short range behaviour in weak decay.

Symmetry breaking and it's geometry

Gauge transformation says that a very small translation of a field in the space- time produced infinitesimal rotation in the internal space of the field Yang-Mill's field is gauge invariant only when the range of interaction is infinite or mass term vanishes. But the isotopic spin state is the generator of SU(2) that describes whole of the geometrical features of weak force. Experimentally, the mediator particles were found to be massive and the range was very short. The only possibility is, there must be some phenomena that breaks gauge symmetry and provides mass to the fields. Now, this phenomenon responsible for providing mass is termed as Higg's mechanism. Another wonder to state is, the isotopic spin is conserved during weak and strong interaction, indicating that the system is gauge- invariant, but not the lagrangian.

Symmetry cannot be broken just by putting some extra factors or terms in the lagrangian that cancels out the mass term. Also, we cannot put any constraint upon the particle interacting with the gauge field such that gauge internal space rotation could be independent of the space time translation. If further adds complication. The only thing we can do is, we can introduce some phase factor to the field operator that makes the translation of the particle 'self coherent', meaning that particles that particles internal space direction would be independent of external gauge field; the condition is particle should still preserve gauge symmetry by being minimally coupled. Then how is the phase of free particle adjusted to the self-coherent form of gauge fields? Geometrically, when the particle is displaced by "dx" in external space time, the field generates internal rotation of ' $\delta\theta$ ' given by ' $\delta\theta = q\, A_\mu dx^\mu$. where A_μ is the gauge field (YM) expressed as the linear superposition of components projected over field generators. i.e $A\mu = \Sigma A_\mu^{\ k}(x)\, F_k$ and $A_\mu^{\ k}(x) = \partial_\mu \theta^k(x)$.

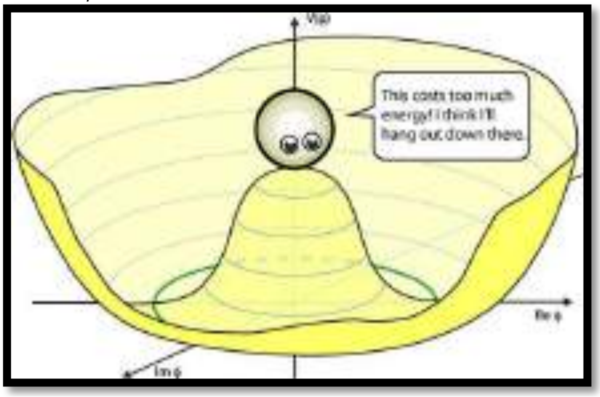

Figure 2: *Symmetry Breaking*

If we introduce a phase factor of $\delta\Phi = \partial_\mu \Phi\, dx^\mu$, the difference of phase will be $\delta\lambda = qW_\mu dx^\mu = \delta\,\theta - \delta\Phi$, implying that $W_\mu = A_\mu - \underline{(1/q)}\partial_\mu \Phi$ is new gauge field acting on the previous 'free particle' which bridges phase adjustment to the force acting on this phenomena. W_μ is now called broken gauge field (just like broken gauge super conductor) as it broke previous gauge symmetry and led to the new one.

Superconductivity, Higg's mechanism and evolution of mass term

In superconductivity, before the formation of cooper pair, the pair of electrons obeys Pauli exclusion principle, become non-degenerate, behave individually as spin ½ fermions and exhibit coulomb repulsion. But after phase transition, they lose their individual identity, do not exhibit Pauli Exclusion Principle, become degenerate and behave jointly as spin zero bosons of charge twice of an electron in superconducting state. Then attractive force tends to exist between them, particularly when there is very less energy. So the same gauge symmetry that exists in normal state doesn't exist in the superconducting state i.e. gauge symmetry is violated. This broken symmetry is actually responsible for electrons to undergo bosonization to form cooper pair. So, superconductivity is itself a broken gauge theory.

Taking the idea from Ginzberg-Landau theory of phase transition, Higg considered a scalar field 'Φ', just like cooper pair, named as Higg's field after him, which is chargeless spin-zero field. If we took a complex scalar field, it also gives the information of Goldstone-boson mode. For such fields, the self interacting potential is $V = \mu^2 |\Phi|^2 + \lambda/2\, |\Phi|^4$ and it is very similar to Ginzberg-Landau theory if Higg's field Φis replaced by or considered to be the order parameter of phase transition from normal state to super conducting state. Then at the ground state, V should be minimum implying that dV/dΦ=0 which gives $|\Phi|(2\mu^2 + 4/2\, |\Phi|^2 \lambda) = 0$ .Here $|\Phi| = 0$ is a very unstable mode and V is symmetric with $\Phi \rightarrow -\Phi$, so gives the Maxican hat potential mode. For stability, $|\Phi| \neq 0 \Rightarrow |\Phi| = \sqrt{(-\mu/\lambda)}\, e^{i\theta(x)}$, where $e^{i\theta(x)}$ is U(1) dependent phase form. So, the choice of stable configuration at one side is directly forbids the next, breaking symmetry and leading to new symmetry. Again, if Higg's field is a scalar field, in vaccum state at least i.e V-minimum state, it must satisfy the Klein-Gordan equation , $\Box^2 \Phi + m^2 \Phi = 0$ or in covalent form, very simply, the Lagrangian upto the quadratic form should be $L = |D_\mu \Phi|^2 - m^2 |\Phi|^2$ that involves miunimal coupling interaction between gauge field and degenerate vacua. In terms of broken gauge potential, the K.E can be wriiten as $|D_\mu \Phi_0|^2 = q^2 |W_\mu| |\Phi_0|^2$ that satisfies K.G eq^n. So,

$$|D_\mu \Phi_0|^2 = q^2 |W_\mu| |\Phi_0|^2 = m^2 |W_\mu| \text{implies,}$$
$$m = q \sqrt{|\Phi_0|^2} = q\, (-\mu^2/\lambda)^{1/2}$$

In this way, gauge fields are not massless, by above relation, but they generate mass from internal symmetry breaking in a natural way. That's why weak interaction vector bosons are massive with short range interaction.

So everything occurs naturally in a hidden way in gauge theories. The only need is to watch them properly with the help of some geometrical insights to truely understand what the basic laws of nature are and how beautiful the nature is.

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Optimization of a search for pair produced vector-like quark in pp collision at √S= 13TeV with the ATLAS at the LHC

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ABSTRACT

We present an optimization study of a search for vector-like top quark that decays into a W boson and a bquark. The analysis is performed using Monte Carlo simulation.

Introduction

Standard Model is the theory of fundamental particles and the interaction between them. The Standard Model (SM) includes electromagnetic, weak, and strong interactions. Thus far, all its predictions have been experimentally verified. Although it provides a good explanation of many experimental results and is self-consistent, it doesn't explain other many mysteries of the universe. So it is not quite regarded as the complete theory of nature. The SM has no mechanism to explain the matter-antimatter asymmetry. It cannot explain the generational structure of fundamental fermions and the mass hierarchy among those generations. Some additional phenomena that the SM doesn't explain are neutrino oscillation, dark matter, dark energy, and gravitation.

To resolve the inadequacies of the SM, many new theoretical models have been proposed.Some of thepopularextensions of the SM are super-symmetry (SUSY), Composite Higgs, Extra dimensions etc. A feature common to several of these models is the existence of 'vector-like' quarks. Vector like quarks are hypothetical spin ½ particles that transform as triplet under the color gauge group and whose left- and right-handed components have the same color and electroweak quantum numbers. which could possibly be pair produced at the Large Hadron Collider, and could then be detected as they decay into the SM gauge bosons and quarks.

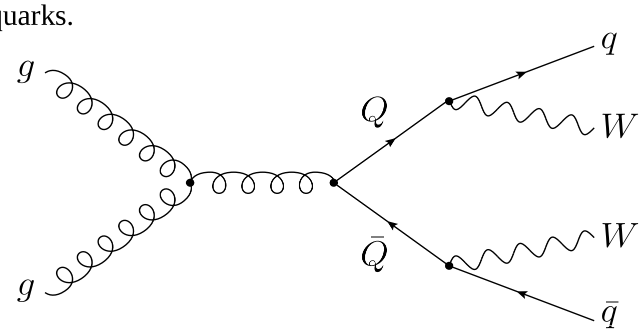

Figure 1: *Leading order Feynman diagram for VLQ pair production at the LHC.*

We present an optimization study of a search for pair production of vector-like top quark (T) that decays into aW and ab quark. The Feynman diagram for the signal process is as shown in Figure 1. We consider the channel in which one of the W bosons decays leptonically (to an electron or muon plus a neutrino) and the other W boson decays hadronically (into two light quarks). The study is performed using Monte Carlo simulation samples produced in the Data Challenge Campaign 2014 (DC14).

ATLAS detector

The ATLAS detector at the LHC covers nearly the entire solid angle around the interaction point. It consists of inner tracking detector surrounded by a thin superconducting solenoid, electromagnetic and hadronic calorimeters, andmuon spectrometer incorporating three large superconducting toroid magnets. The inner tracker is used to measure the momentum of the charged particles. The electromagnetic calorimeter measured the energy deposited by photons and electrons. The hadronic calorimeters measures the energy deposited byhadrons. The muon spectrometer measured the energy ofmuons. The final state particles of the signal of interest can all be detected by the ATLAS detector, except the neutrino which escapes the detector. However, its momentum in the direction transverse to the beam can be inferred from the missing momentum information. A schematic the ATLAS detector is shown in Fig. 2.

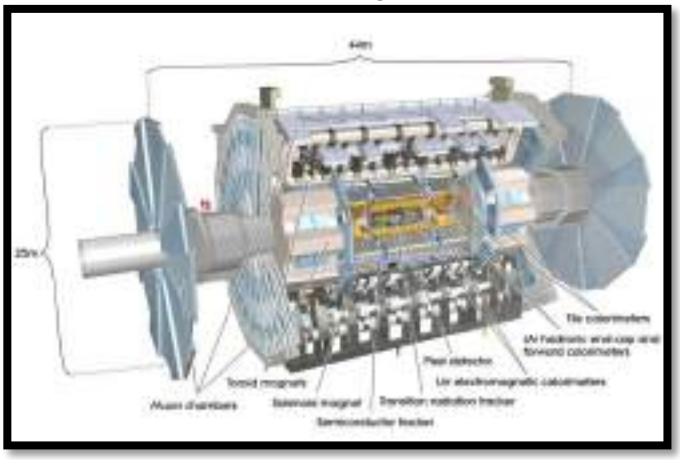

Figure 2. *The ATLAS detector and its components. Pre-selection and Analysis Strategy*

In a search for new physics signature, we have to understand the background processes that can mimic the signal. For the search of T quark pair production in the lepton+jets channel, the main background is tt because the decay products ofT quark and the standard model top quark (t) are similar, assuming that the T quark decays into a W boson and a b quark.

The physics objects used in this study are standard physics objects reconstructed by the Top Working Group in the ATLAS collaboration. The basic object selection, often simply called pre-selection,that we have adopted is exactly the same as recommended by the Top group. The pre-selection, in addition to requiring a lepton trigger, requires exactly one charged lepton, at least four jets, and large missing transverse momentum.

VLQ has been extensively studied by the ATLAS and CMS collaborations at the LHC. And these studies have set lower limit on the T quark mass, which falls in the range 715GeV to 950GeV, at 95% confidence level. Therefore, in our study, we have taken the signal to be a VLQ produced with the mass of 1100 GeV.

We use a boosted analysis strategy. Since the T quark is very heavy, its decay products are boosted (very high transverse momentum, pT). We can distinguish the signal from the background using HT (scalar sum of transverse momenta of the lepton, neutrino, hadronicW and two b-jet candidates) as HT of the signal is much greater than that of the background. Additionally, we also consider the reconstructed mass of vector-like topas one of the discriminants between the SM top and T quark.

1. Reconstructed Heavy Quark Mass

In our case, we considered the first two leading jets as two b-jet candidates and the third and fourth leading jets in the event as the jets coming from hadronicW. We construct the mass of hadronicW from the third and fourth leading jets and combine it with one of the b-jets to get the reconstructed mass of top on the hadronic side. This gives us two solutions for hadronic T mass. The z-component of the neutrino momentum, is solved for up to two-fold ambiguity using the Wmass constrain. Of the four permutations, the one that gives the smallest mass difference between the leptonic T and hadronic T, is kept as the best solution. Reconstructed mass of the T quark on the hadronic side, labeled mrecoHad, is considered as one of the discriminants.

Final Selection

By studying the various kinematic distributions of the signal and main background, we have chosen thefollowing selection requirements. In the first selection (cutc), we require events to have more than 3 jets because in our final state there are 4 quarks. In the second selection (cut2), we constrained the mass of Whadwithin 65 GeV to 105 GeV. Third and fourth selections (cut3 and cut4) require the leading jet to havepTgreater than 200GeV and the second leading jet to have pT greater than 80GeV.HT of tt system peaks around 500GeV while the signal has a peak at much higher value, so at cut5, we requireHT> 800GeV. Then we require ΔR between lepton and neutrino < 1.0, cut6. Since W is boosted the decay products of W must have small angular separation, therefore we require ΔR between third and fourth leading jet be smaller than 1.0 (cut7), and finally we require pT of Whad> 200GeV (cut8).

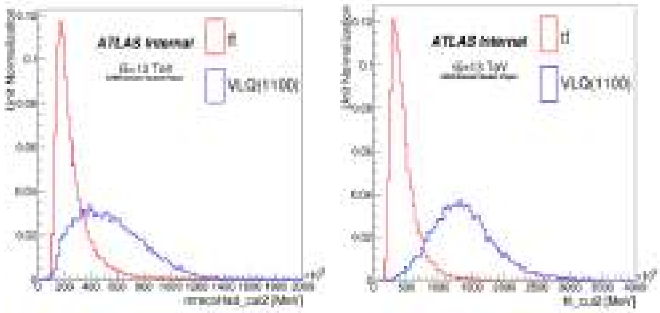

Figure 3: *mreco Had (left) and HT(right) distribution after cut2.*

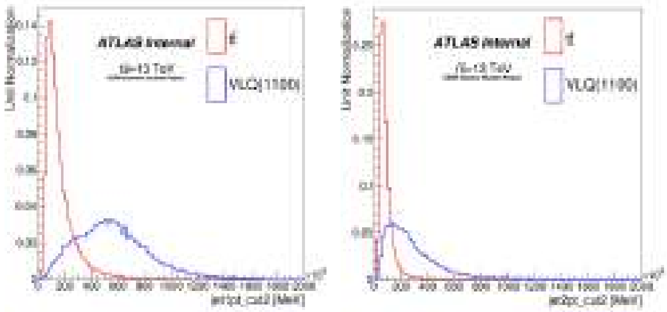

Figure 4: *pT distribution for first (left) and second (right) leading jets after cut2.*

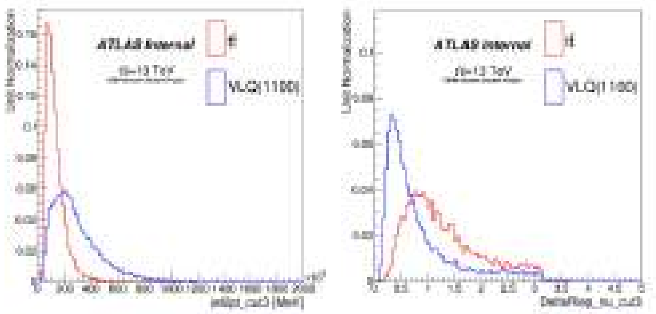

Figure 5: *pT of the second leading jet (left) and deltaR distribution between lepton and neutrino (right) after cut3.*

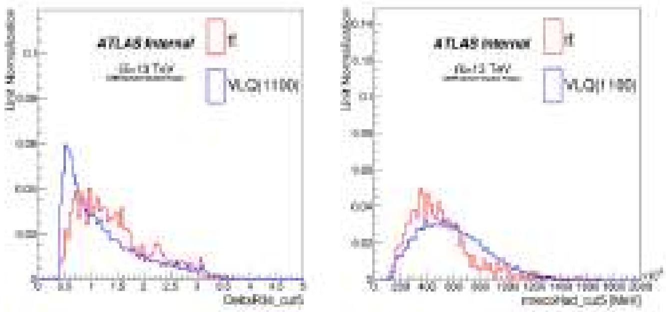

Figure 6: *DeltaR distribution between third and fourth leading jets and mrecoHad after cut5 (HT> 800GeV).*

Results & Outlook

We note that with each selection the significance, defined as signal/$\sqrt{\text{Background}}$, increases. Due to limited statistics in the available Monte Carlo samples, requiring very tight cuts gave highly unreliable mrecoHad and HTdistributions. However, from Figure 3 it can be seen that HT distribution can be a good discriminant against background.

We also show that with the given selection it is possible to reconstruct the mass of the VLQ. However, the reconstructed mass doesn't quite peak around 1100 GeV as one would expect for a VLQ of that mass. A potential problem we identified in the reconstructed mass may be due to the mixtureof decay modes.In the VLQ sample, the vector-like top can decay through different modes such as, T◊Wb, T◊Zt, and T◊Ht while we are only considering the Wb decay mode. An improvement for the future can be distinguishing the different decay modes and to optimize by picking only signals that decay to aW boson and a b quark.

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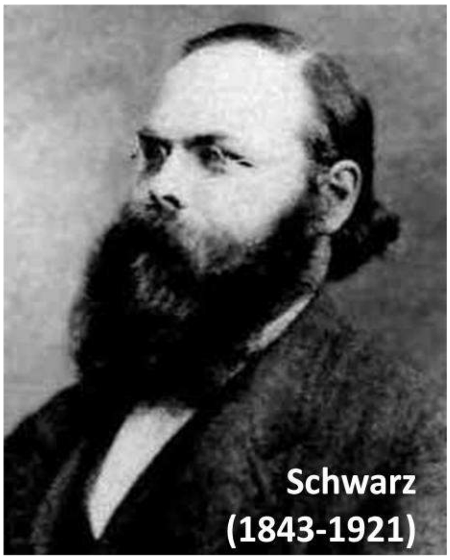
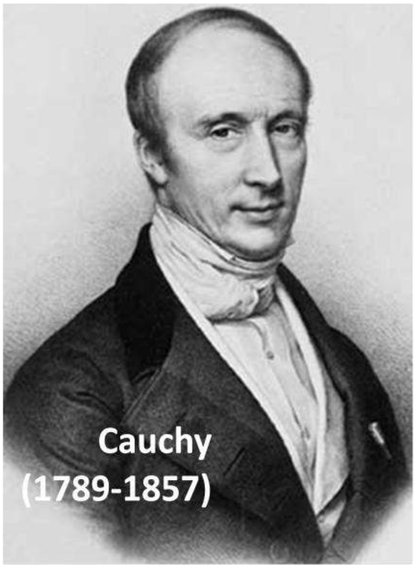
KARL HERMANN AMANDUS SCHWARZ was a German mathematician, known for his work in complex analysis. Among other things, Schwarz improved the proof of the Riemann mapping theorem, developed a special case of the Cauchy–Schwarz inequality, and gave a proof that the ball has less surface area than any other body of equal volume. His work on the latter allowed Émile Picard to show solutions of differential equations exist. Schwarz originally studied chemistry in Berlin but Ernst Eduard Kummer and Karl Theodor Wihelm Weierstraß persuaded him to change to mathematics.





BARON AUGUSTIN-LOUIS CAUCHY was a French mathematician reputed as a pioneer of analysis. He was one of the first to state and prove theorems of calculus rigorously, rejecting the heuristic principle of the generality of algebra of earlier authors. A profound mathematician, Cauchy had a great influence over his contemporaries and successors. His writings range widely in mathematics and mathematical physics. "*More concepts and theorems have been named for Cauchy than for any other mathematician (in elasticity alone there are sixteen concepts and theorems named for Cauchy)*." Cauchy wrote approximately eight hundred research articles and five complete textbooks.

Perturbed Infinite Quantum Potential-Well: Eigenstates and Eigenvalues

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ABSTRACT
The main idea of this paper is to carry out numerical computational work on one dimensional perturbed quantum potential-well problem. We briefly discuss the perturbation caused by the added potential in the form of a single box function. Further, we provide numerical information of our perturbed eigenvalues and present plots for perturbed eigenfunction. Comparison of energy values and different eigenstates are made by assigning various values to the potential function.

Introduction

The quantum mechanical study of conservative physical system is based on the eigenvalue equation of the Hamiltonian operator [1]. However, Hamiltonian of very small number of physical problems of interest falls into the above category. In general, Hamiltonian of most of the physical problems is too complicated to obtain exact solution. Thus, we have to resort to approximation technique which enables us to obtain analytical approximate solution of basic eigenvalue equation. One of the very widely used approximation scheme is stationary perturbation theory. In studying a phenomenon or a physical system, the idea begins with a simple system which is responsible for the main feature of this phenomenon or the physical system whose analytical solution is already known. When the principle effects are understood, one adds less important effects known as 'perturbing' Hamiltonian. In quantum mechanics, a perturbation usually refers to a slight alteration in the potential function V(x). If the physical system is weakly influenced by the perturbation, most of the physical quantities like energy and eigenfunction can be expressed as correction to those of the simpler system. In this way, the problem can be formulated by adding small term to the exactly solvable problem and thus, the complicated system can be handled by the knowledge of simpler one. First order perturbation theory states that for lower orders, the shift in energy due to a perturbation is just the average additional potential energy experienced by the states of the original potential.

Erwin Schrödinger formulated his famous equation in 1926. Since then, researchers have proposed various analytical and numerical methods for this central quantum mechanical equation. But there are various difficulties to obtain the exact solution for Hamiltonian of even moderate complexity. The Hamiltonians of physical systems like particle in a box, the quantum harmonic oscillator, etc. are highly idealized model and are of significant interest to describe the most physical system. For example, adding a perturbative small constant potential V(x) over a narrow interval to the quantum mechanical model of the particle in box, we can calculate shift of energy level and change in eigenfunction.

Infinite Potential-Well: A Quantum Mechanical Approach

For infinite potential-well, the energy of the particle arises entirely from its kinetic energy. This is for the fact that particles cannot penetrate the region where the potential energy differs from zero. In the bound state problem, we are concerned with finding the allowable wavefunction (eigenfunction) and energies [2]. Therefore, a time–independent Schrodinger equation (TISE) needs to be utilized in solving particular kind of problem in quantum mechanics. In this case, particles are allowed to have certain specific energy levels excluding the zero energy level. This phenomenon is called the energy quantization. The normalized eigenwave solution to one dimensional unperturbed infinite potential-well is of following form.

$$\psi^0(\mathrm{x}) = \sqrt{\frac{2}{L}}\, Sin\left(\frac{n\,\pi\,x}{L}\right) \qquad (1)$$

And unperturbed energy value is given by

$$E_n^0 = \frac{n^2\pi^2\hbar^2}{2mL^2} \quad \text{where n=1, 2, 3..} \qquad (2)$$

One of the important facts about (1) is that it forms a complete set: that is any perturbed function can be written in terms of linear combination of these functions.

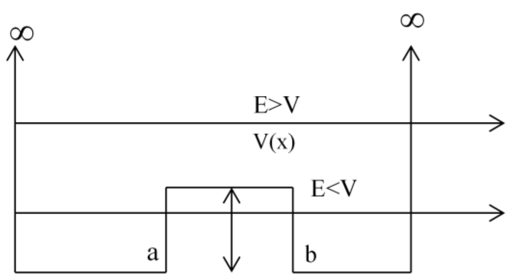

Figure 1.1 *Graphical interpretation of perturbation through an arbitrary potential function V(x)*

Figure 1.1 gives graphical representation of a "perturbed" situation for an infinite quantum potential-well. The perturbed potential function here is V(x) over a narrow interval [a, b].

$$H' = \begin{cases} V(x), & \frac{1}{2}(L-a) < x < \frac{1}{2}(L-a) \\ 0, & 0 < x < \frac{1}{2}(L-a), \frac{1}{2}(L+a) < x < L \end{cases} \qquad ($$

Thus up to the first order. For the nth state of interest, we have

$$E_n = E_n^o + \lambda E_n^{(1)} = E_n^o + \lambda H'_{nn}$$

$$\psi = \psi_n^0 + \lambda\psi_n^0 = \psi_n^0 + \lambda\sum_{k\neq n}^{20}\frac{\langle k|H|n\rangle}{E_n^o - E_k^0}\psi_n^0$$

where all the quantities on the right hand side are known.

Figure 2.1 through Figure 2.6 represent the unperturbed wavefunction $\psi^0(x)$ for different quantum states as well as their perturbed wavefunctions**.** The possibility of two important situations is as shown in fig, that is, individually shifted energy level will either be greater or less than the perturbed potential V(x). For E< V(x), we observe decaying property on the barrier interval, that is on [a, b] and for the case E> V(x), we observe an oscillating pattern.

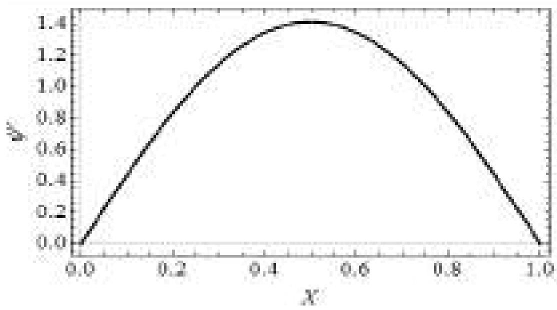

Figure 2.1: *Unperturbed ground state wave function*

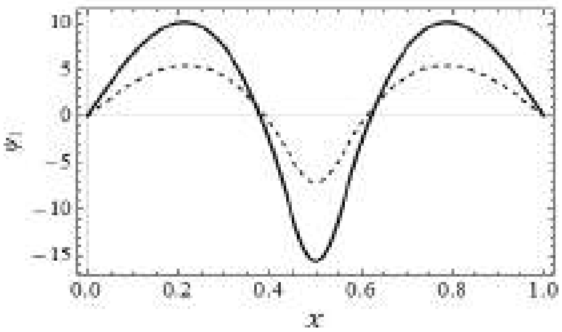

Figure 2.2: *Perturbed ground state eigenfunction with first order correction. Perturbed eigenvalue E1< 50, 100.*

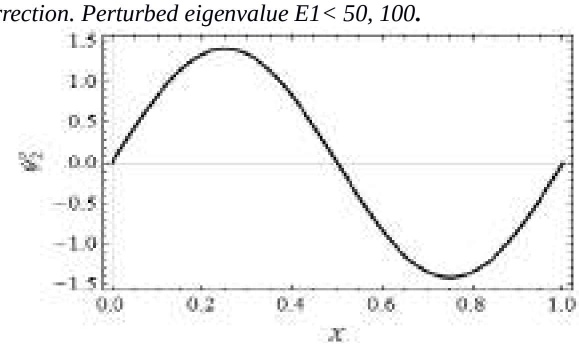

Figure 2.3: *Unperturbed first excited state wavefunction*

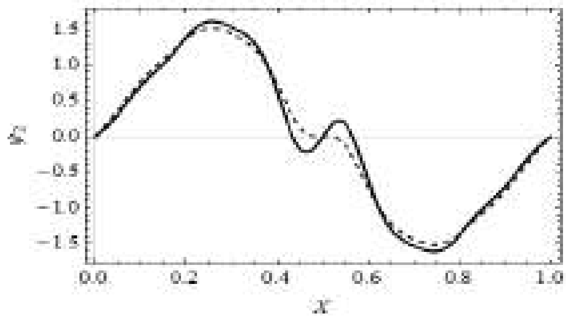

Figure 2.4: *Perturbed first excited state eigenfunction with first order correction. Perturbed eigenvalue E2< 50, 100. E1< 50,100*

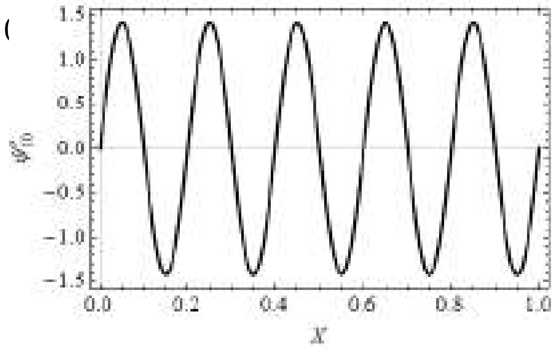

Figure 2.5: *Unperturbed 10th excited state eigenfunction.*

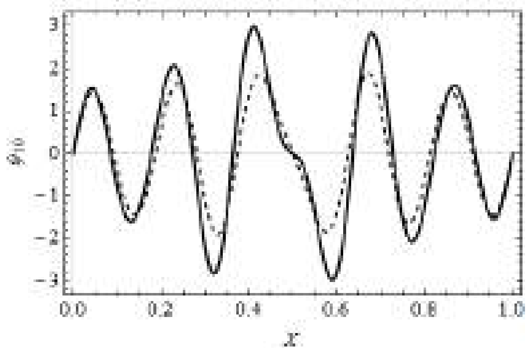

Figure 2.6: *Perturbed 10th excited state eigenfunction with first order correction. Perturbed eigenvalue E 10 > 50, 100.*

We consider V(x) = $100\varepsilon_0$ and $50\varepsilon_0$ (ε_0 unperturbed ground state energy) defined on interval [a, b] = [0.45, 0.55]. Table 2.1 shows the first twelve perturbed energy values, where the values corresponding to the quantum state *n*=7 and *n* =10 is found to be greater than V(x) ($50\varepsilon_0$, $100\varepsilon_0$)respectively

Table 2.1: First twelve perturbed eigenvalues (E_n) and comparison for different V(x) defined on [a, b] = [0.45, 0.55]. The symbol N represents quantum level, the energy value is $E^0_{n/}\varepsilon_0$ (ε_0 unperturb ground state energy), the perturbed energy is E_n for V=$50\varepsilon_0$. The last column lists the Perturbed Energy E_n for V=$100\varepsilon_0$.

N	$E^0_{n/}$	E_n V=50	E_n V=100
1	1	10.9182	20.8363
2	4	4.32255	4.64511
3	9	18.292	27.5839
4	16	17.2159	18.3662
5	25	33.1831	41.3662
6	36	38.4772	40.9545
7	49	55.8394	62.6788
8	64	67.8306	71.6613
9	81	86.5465	92.0929
10	100	105.0	110.0
11	121	125.553	130.106
12	144	149.78	155.559

Conclusion

We have successfully calculated perturbed eigenvalue E_n and obtained the corresponding perturbed eigenfunction i.e. the wavefunction $\psi(x)$for different quantum states. We were also able to attain greater eigenvalue for our perturbed system. It was observed that perturbation of our system with greater potential value yields in greater energy value and vice versa. Also, in our case, parity of the wave function remains unchanged.

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Taylor's formula, the importance of which remained unrecognized until 1772, when Lagrange realized its powers and termed it "the main foundation of differential calculus."

BROOK TAYLOR was an English mathematician who is best known for *Taylor's theorem* and the *Taylor series*. In mathematics, a Taylor series is a representation of a function as an infinite sum of terms that are calculated from the values of the function's derivatives at a single point. The concept of a Taylor series was formulated by the Scottish mathematician James Gregory and formally introduced by the Brook Taylor in 1715. Taylor was elected a fellow of the Royal Society early in 1712, and in the same year sat on the committee for adjudicating the claims of *Sir Isaac Newton* and *Gottfried Leibniz*, and acted as secretary to the society from 13 January 1714 to 21 October 1718. From 1715 his studies took a philosophical and religious bent. As a mathematician, he was the only Englishman after Sir Isaac Newton and Roger Cotes capable of holding his own with the Bernoullis, but a great part of the effect of his demonstrations was lost through his failure to express his ideas fully and clearly.

Maria Mitchell was an American astronomer who, in 1847, by using a telescope, discovered a comet which as a result became known as "*Miss Mitchell's Comet*". She won a gold medal prize for her discovery which was presented to her by King Frederick VI of Denmark. On the medal was inscribed "Non Frustra Signorum Obitus Speculamur et Ortus" in Latin (taken from Georgics by Virgil (Book I, line 257) (English: "Not in vain do we watch the setting and rising of the stars"). Mitchell was the first American woman to work as a professional astronomer.

Laniakea: Our Home Supercluster

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ABSTRACT
This is a short article about large scale structure of the Universe i.e. Supercluster. Large scale structures in the Universe are formed due to gravitational instability. I will be trying to clarify location of earth among these large scale structures. Laniakea, a galactic supercluster is the structure in which our milky way is located.

Supercluster

Superclusters are among the largest structures of the Universe made up of smaller groups and massive clusters of galaxies. They are the extended region of high galaxy concentration separated by large voids. They appear as an interconnected web of filaments. They are gravitationally very loosely bounded and has no clear boundary.

Superclusters can be studied in two ways:1) Galaxy projection and red-shift survey 2) Mapping of peculiar velocity of galaxies. Using redshift data, we can determine the recessional velocity of galaxies and it could give the estimate of distances of galaxies using Hubble law.

$$redshift(z) = \frac{observed\ wavelength - rest\ wavelength}{rest\ wavelength}$$

$$v = zc$$

$$v = H_o d$$

where v is the recessional velocity, H_o is the Hubble constant and d is the distance.

Their distance estimate and all sky distribution of their projection could be used to define a supercluster. In the latter technique, we find the regions where peculiar velocities of galaxies diverge. The surface of divergent point encloses galaxies with inward motion and this defines a supercluster.

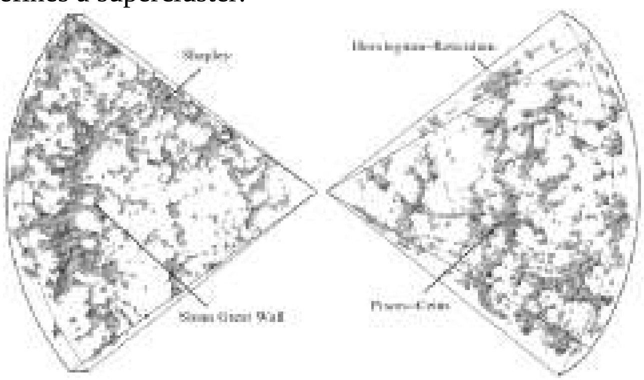

Figure 1: *Delaunay tessellation field estimator (DTFE) reconstruction of the inner parts of the 2dF Galaxy Redshift Survey [1]. It shows various superclusters.*

The standard model of cosmology predicts that on intermediate scale, the flow is irrotational, which means the velocity field is a gradient of a potential, $\boldsymbol{v} = -\nabla\varphi$where the velocity potential equals the gravitational potential mediated by a linear factor that depends on cosmological parameters. Thelocal minima and maxima of the potential (attractors and repellers respectively) are the drivers of the large scale flow.Flows can be inward on all three axes, the condition of a cluster, inward on two axes and outward on the third, the condition of a filament, inward on one axis and outward on two, hence a sheet, or outward on all three axes, hence a void [2].

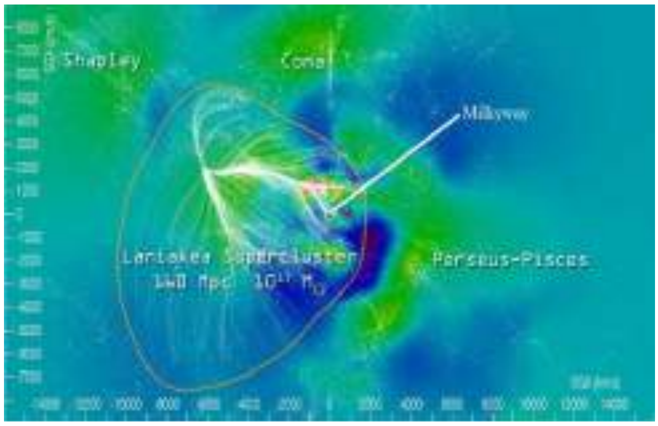

Figure 2: *Laniakea supercluster in the supergalactic equatorial plane[2].*

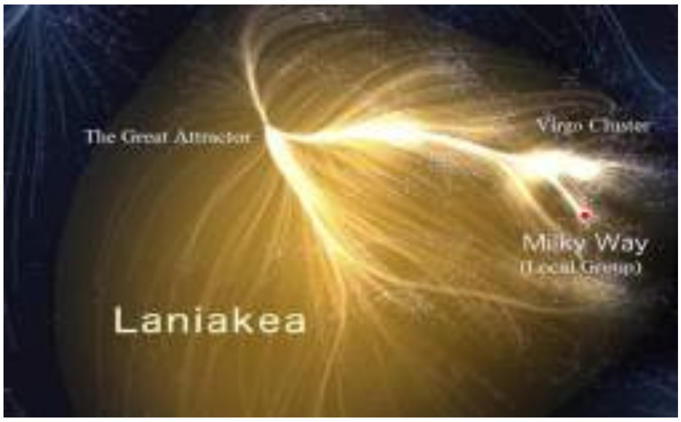

Figure 3: *Laniakea supercluster showing The Great Attractor, Virgo Cluster and Local Group. (Photo was generated using Nature video Laniakea Our home supercluster[3].*

Laniakea Supercluster

Laniakea (meaning “immense heaven” in Hawaiian) is home supercluster to our Milkyway. Apart from local group, it also contains Virgo cluster. It contains about 100,000 galaxies, all in constant inward motion. Its size is 160 Mpcin diameter and the region encompasses ~$1\times10^{17}M_{\odot}$[2]. We can find The Great Attractor that is very massive and heavily influences the motion of galaxies in this supercluster. If we take even larger scale is itself in motion with respect to cosmic expansion and hence is a part of something very very large.

Figure 3*: Milkyway galaxy [3].*

Figure 4: *Solar system [3].*

Earth is located in the solar system that is a part of Milkyway galaxy. The position of this galaxy within Laniakea is shown in Figure 2 and 3.

Conclusion

The study of peculiar velocity of galaxies in co-moving co-ordinate system is important in a sense that it helps in defining large scale structures like superclusters. Further, this method does not assume that mass distribution is proportional to the distribution of luminosity from galaxies and hence can easily account for dark matter as well.

Laniakea, a supercluster defined in similar way is our home supercluster. Our Milky way is one of the galaxies that are similarly sliding towards its Great Attractor as revealed by the peculiar velocity map.

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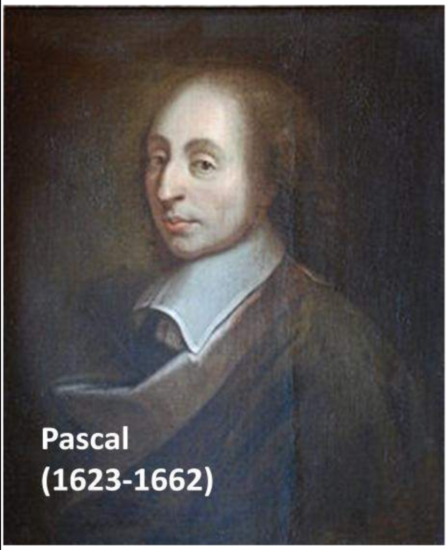

Pascal's work in the fields of the study of hydrodynamics and hydrostatics centered on the principles of hydraulic fluids. His inventions include the hydraulic press and the syringe. He proved that hydrostatic pressure depends not on the weight of the fluid but on the elevation difference.

BLAISE PASCAL (19 June 1623 – 19 August 1662) was a French mathematician, physicist, inventor, writer and Christian philosopher. He was a child prodigy who was educated by his father, a tax collector in Rouen. Pascal's earliest work was in the natural and applied sciences where he made important contributions to the study of fluids, and clarified the concepts of pressure and vacuum by generalizing the work of Evangelista Torricelli. Pascal also wrote in defense of the scientific method. In 1642, while still a teenager, he started some pioneering work on calculating machines. After three years of effort and fifty prototypes, he built 20 finished machines (called Pascal's calculators and later Pascalines) over the following ten years, establishing him as one of the first two inventors of the mechanical calculator. Pascal was an important mathematician, helping create two major new areas of research: he wrote a significant treatise on the subject of projective geometry at the age of 16, and later corresponded with Pierre de Fermat on probability theory, strongly influencing the development of modern economics and social science. Following Galileo Galilei and Torricelli, in 1646, he refuted Aristotle's followers who insisted that nature abhors a vacuum. Pascal's results caused many disputes before being accepted.

Mr. Sabin Regmi

2070 Batch TOPPER

Primarily, what inspired you to study Physics? From which class you thought of studying Physics and making it as a career? Was there any teacher or family member who influenced you and created a great impact on science(Physics)?

By the time I passed SLC, two of my family members (uncle and brother) were physicists. They recommended me to opt for science stream during +2. As I started studying physics, I was astonished by how lucidly physics could explain as tiny fundamental particles as quarks to the whole universe and almost all of the phenomena occurring in this universe. This is what ignited passion within me to learn physics more and pursue career on it.

By your experience, how can we study Physics so that it will be easier to understand?

Teachers are a very reliable source of knowledge. So, attending the lectures and paying attention to what the teacher wants to deliver to us will definitely help our study. I think *self-study is not bad either*. But, whether you are attending lectures or you are self-studying, practice and more practice along with interaction with teachers is very important. During study, you will often find things which are difficult to understand. Discussion of such things with teachers helps you a lot to understand physics. Going through the study materials available in the internet is very helpful as well.

We all know that student life is very difficult. Did you face any problem while studying in CDP? If yes, can you share with us?

Yes, there were some problems not only me but all the students of my batch had to face especially in practical labs. One of them was the electricity problem in the general and nuclear labs. However it seems that electricity problem has been improved by now because of additional solar panel in our roof as well as inverter in the laboratory. Some damaged lab equipment also caused problems. We could not do X-ray and Zeenan effect like important experiments because of the error in the set up.

In order to finish post-graduate, you have spent about two and half year in CDP. What are the good aspects of CDP and the aspects that have to be improved?

Talking about the good aspects of CDP, the classrooms were good, the classes were regular, students could often interact with teachers, and we could attend seminars on different topics relating different fields of physics.

If there is something to be improved, it has to be the electricity problem in the labs and also the proper facility of internet in the department as well as library. The dissertations are not properly documented.

You are the topper of last batch of the annual system. Now semester system is running at the CDP. I am sure that you are watching closely & carefully about the advantages of the semester system. What is your opinion about this change?

I believe it is a good change. The internal assessments and the examinations at scheduled times are definitely the advantages of semester system. It will remove the problem of taking more time than it should to finish the masters' degree. It will keep the students engaged in study more than the annual system in which more students waited for the examination routine to start preparing for the examination and studied little in between. The evaluation system (GPA) helps students to know their placement at the international level.

Most of the students have thought about their future. Most students wish to go to foreign country for further study (MS or PHD)? What is your plan for the future as a topper?

My plan is also the same - to go foreign country for the further study. After completing my further study, I wish to come back and disseminate the experience and knowledge I gain over there to the science enthusiasts here and contribute something regarding research activitie in Nepal.

Sabin in his computation lab

As a young Physicist, how do you contribute to your country?

Nepal not being able to develop as strong physics environment as expected, I would always be trying to lure the best of the best to enjoy physics. Somewhere we have overlooked the gap between fundamental and advanced physics that has always halted the acceleration of physics over here. My friends and I will always try to address that gapand eliminate it. We will always be there to contribute in any manner we can to develop a strong physics environment in Nepal no matter wherever in this world we be at.

At last, do you want to share anything to your junior?

‘*Do not join physics just for the sake of studying physics and going abroad, but for learning physics and contributing something to the field of physics.*’

Current opinion is that Descartes had the most influence of anyone on the young Newton, and this is arguably one of Descartes' most important contributions. Newton continued Descartes' work on cubic equations. The most important concept was his very modern treatment of independent variables.

René Descartes was a French philosopher, mathematician, and scientist. Dubbed the father of modern western philosophy, much of subsequent Western philosophy is a response to his writings, which are studied closely to this day. Descartes's Meditations on First Philosophy continues to be a standard text at most university philosophy departments. Descartes's influence in mathematics is equally apparent; the Cartesian coordinate system—allowing reference to a point in space as a set of numbers, and allowing algebraic equations to be expressed as geometric shapes in a two- or three-dimensional coordinate system (and conversely, shapes to be described as equations)—was named after him. He is credited as the father of analytical geometry, the bridge between algebra and geometry, used in the discovery of infinitesimal calculus and analysis. Descartes was also one of the key figures in the scientific revolution. Descartes refused to accept the authority of previous philosophers, and refused to trust his own senses. He frequently set his views apart from those of his predecessors. In his natural philosophy, he differs from the schools on two major points: First, he rejects the splitting of corporeal substance into matter and form; second, he rejects any appeal to final ends—divine or natural—in explaining natural phenomena. In his theology, he insists on the absolute freedom of God's act of creation.

Dr. Elisa Fratini

ICTP Post Doc Fellow

(Dr. Fratini taught computational physics to M.Sc. (Physics) fourth semester students for about one and half months during April-May 2016.)

At First, Are you enjoying your stay in Nepal? How do you find Nepal?

Yes, of course, I am enjoying my stay in Nepal. I find Nepal very interesting, its very different from Europe.At First, The impact was quite strong because you have to deal with different issues especially ,Kathmandu, related with its chaotic life, pollution, its crowd and then if you go to mountains and remote areas, its very different. I enjoyed a lot travelling to Pokhara, Chandragiri, Sindhuli, Solukhunbu. I love the tradition of the country, people are trying to do better for themselves and for their country.I am really curious and eager to understand how the situation here can be improved.

How would you like to introduce yourself personally?

I was born in a quiet small town of Italy which is Macharada . I think I had quite good education even if I studied in a very small University. I always have been curious about understanding how the world is working. After that I discovered, I liked a lot teaching, traveling & so for this reason, I think all these combining factors are making me now going farther for my country for the research itself. I generally like helping people. In short, I am a curious & helpful person.

When did you realize you would study Physics and Is there any particular reason on choosing Condensed Matter Physics?

I was interested in Physics may be from High School. In Italy High School starts when you are more or less 14 years old. At that time, I discovered that I like Mathematics and even more the fact that the mathematics can explain the world somehow. For me, it was very fascinating the idea that by studying we could know deeper and deeper about basic laws and the structure of the world step by step. Then I thought Physics would be the subject I like most.

Talking about Condensed Matter Physics, I think the choice was depending a lot on the professors, I had in my master courses. I had two or three very good professors and They were really able to make me understand the beauty hidden in the small phenomena. I like the fact that basic laws of quantum mechanics could describe the matter, which are around us. Its really beautiful to see the strong mathematics describing the simple daily phenomenon.

Dr. Fratini delivering lecture at CDP during training program on Computational Physics

Please tell us something about your current research.

I am in condensed matter group & in particular I am studying ultra-cold gases and last two or three papers of mine were about disorder systems. When you study about ultra cold gases the first thing you understand is they are used as quantum simulators. In general people who study the ultra-cold gases may study at the same time several phenomena connected to quantum physics. The last papers were about disorder systems created with the experiment with the cloud of ultra cold gases. The disordered landscape is realized with LASER speckle. My PHD thesis was about mixture of bosons and fermions, how they interact with each other and so on.

In your experience, which particular character do you think is a must in a physics student?

I think its curiosity.Curiosity about the world and the laws governing it. We should dare to think in different way rather than satisfying by the first explanation. you *should have desire to go little further and always formulate the problem and try to solve it by yourself. We should try to make our brain working all the time. Physics is the way how you approach say life or in general problem. Even if you don't make career in Physics or you have different job, you should have this way of thinking.*

Nepal is quite behind in research activities particularly in Natural science. What sorts of steps do you think should be followed by Nepalese students to promote research activities?

I think that for sure you have to be connected with someone else who is doing research. If the research here is poor, you have to read papers and meet young researchers or students of other countries. In this way you will really understand how the research is going on and also how it works. Maybe, Invite people if they can come and try to work a bit with them. Go abroad if you can but it will not improve the situation here as the best students will go out and the average level of the country will be decreasing instead of increasing. But for example, Narayan sir did his program in Italy several years ago and then decided to come back. For this reason I am here because he has this link in Italy. And If there are other professors like Narayan, More people would come and more and more students like you would have a link and improve the situation here.

Male students have outnumbered the female students in our department. Is it a global trend? What its like to be female physicist? And what's your message to Nepalese girls pursuing their career in Physics?

Yeah, I think in Physics department, girls are in small number globally. Even in ICTP there were few girls in Physics than in other department. I think it does not matter if you are a girl while studying but at the time of choosing career it might be sort of problem because as a girl we have general tradition that a girl has to move with her husband after marriage, sometimes women have to change their career or even quit.

Dr. Fratini visiting Nepal

I think that they (Nepalese girls) have to think not of the fact that they are girls different from boys but the fact that they are people interested in Physics. So if you are discussing with the professors or friends do not notice too much to the fact that you are minority because for the moment that's not important but focus on your passion- why are you interested in physics, what do you want to do- and I don't think it is related to you are girl or not. Focus on your motivations and decision on why did you make this choice.

Beside Physics, What else do you like to do?

I like reading books, novels since my childhood. I also love photography. For last three years I have been teaching Italian language to foreign people particularly immigrant , refugee and so on. I also like traveling and also interested in social work.

You are still young and long way to go for retirement. So how do you want to see yourself after 15 years?

I don't know (laughs). I have not thought about it.

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

Experience

Sanjaya Sharma: Entrance Topper 2072

- As everyone knows that the entrance exam was taken all over the nation, it was possible that the fluctuation in small number could have a greater impact on the merit list and I also didn't know how other students attempted the entrance examination. So when I heard that I topped that I topped the entrance, I felt awesome.

- I prepared for the entrance exam almost for a year. In my personal experience, scoring good marks doesn't solely depend upon the hard work, rather it depends upon the way we choose the text books furthermore, it depends upon how we perceive examination. Frankly speaking, I never thought to be a topper-entrance exam-rather I was trying to make my knowledge of physics profound. Only hard work isn't sufficient to do the best, you need to be smart too. Technically speaking, we have really limited time at hand in the examination hall, so how you manage that limited time plays a crucial role.

- It was a kind of a dream to be in CDP and when I knew I passed (topped) entrance exam, I realized my dream came true. It feels good to be a part of CDP. I feel privileged to take lectures from renowned professors. Literally speaking, I always wished to get motivated with better ideas and I found it here. No need to say, CDP is the best destination for physics students in Nepal.

- In my coming days, I would like to organize few seminars on relevant physics topics. Also, I foresee myself publishing few research articles.

- I would like to say don't get afraid for entrance exam rather be excited to learn more, who knows something good is going to happen in future. While preparing for the entrance exam you need to go line by line through the text books, grasp the physical interpretation of the formulae, graphs etc. Realize it that you aren't put here just to learn what others teach rather you are put here to create something new to society. Have patience, you can embrace success in life.

Mr. Sanjay Sharma completed B.Sc. from Butwal Multiple College, Butwal whereas Mr. Puspa Raj Paudel did his B.Sc. From Prithivi Narayan Campus, Pokhara

Experience

Puspa Raj Paudel: Entrance Topper 2071

- I returned home immediately after taking entrance examination from Pokhara.There was a long gap between exam and result. When I went home and checked phone, there was some missed calls and words of congratulations from friends. Being quite surprised, I immediately called back, confirmed the result, got more congratulations, shared happiness and set my mind to head Kirtipur. My wish was to get listed within top 120. I had seen fairly good possibility of being selected within top 120 but never dreamt of being the topper.

- I have developed the habit and skills of self-study from the SLC level. I decided not to join any preparation class and hence gathered no experience of taking any mock-tests.

- As there was a long preparation time, I immediately went home after the B.Sc. exam. As entrance examination model was only of objective type questions, there was no need to mess-up with lengthy derivations. I went, mainly, through lines of B.Sc. text books once again. This time I focused on topics which were quite harder and conceptually unclear to me. I also extended my study to some topics which I have previously skipped.

- I feel lucky enough to be in CDP. It's much better than I thought initially. Apart from expert faculty members of CDP, foreign professors, scientists often visit in CDP. There are many chances to be a part of seminars, talks, workshops, and get ideas about recent trends in Physics. As it is a center of Nepalese Physics and Physicist, needless to say there is something which is not outside. Fusion of friends from almost all corners of Nepal is the next beauty of CDP.

- Computational Physics in a new emerging area of Physics. I think it is an appropriate field in countries like Nepal. So I want to gather sound knowledge of computational techniques.

- Never feel stress and pressure while reading rather just enjoy it. Sound sleep keeps body and mind refreshed. It is wise to refer recommended text-books and go line by line. Each line contains something important and useful.

An Encounter with
Prof. Dr. Mukunda Mani Aryal

Apsara Sharma Dhakal, Ek Narayan Paudel, Phanindra Wagle, Sujan Shrestha & Chabindra Gautam with Prof. Dr. Mukunda Mani Aryal at his room (Arubari)
Location: Arubari, Kathmandu
Date:2016/01/16

BRIEF PROFILE

Date of birth:	**2010 Jestha 8 B.S.**
place of birth:	**Sifal**
Schooling:	**Home, Biratnagar (5), Chabhil (6-10)**
I.Sc.:	**Trichandra campus**
B.Sc.:	**Trichandra campus**
M.Sc.:	**CDP, TU, Kirtipur**
M.Sc. Thesis title:	***Study of Agrillacous Sandstone from Kit Vanjyang Valley***
Ph.D.:	**Tufts University, USA**
Ph.D. Thesis title:	***Study of Some Properties of Cosmic Strings***

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

I was born in Sifal, Kathmandu. I completed most of my primary education at home. I completed my class five at Aadarsa School in Biratnagar when my father was posted there. Then, I continued my school up to SLC at Pashupati high school in Chabhil. As I remember, I often used to visit jungle near Pashupatinath temple with my friends. I was a devotee of Sivaji from childhood. As an aim of life, I never imagined anything other than teaching profession.

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

There is no special reason. I passed S.L.C. in first division. My father suggested me to study science. No entrance was required for medicine or engineering then. Everyone with first division could easily enroll in the subject they want. I couldn't do well in I.Sc. I was better at physics than other subjects. My score in physics was better. So, I eventually selected physics for my higher education.

3) Please tell us more about your university life?

I couldn't do well. I didn't understand anything even when I was studying B.Sc. in Trichandra. There were a lot of students. I couldn't figure out what we have studied and what we haven't. But I had learned the periodic table by heart thinking that to know a periodic table is to know whole chemistry.I used to live in Chabhil. I used to go to college by foot. As it was a panchayat system, there was no student politics as much.

I passed SLC in 2024, I.Sc. in 2027, B.Sc. in 2029. After B.Sc. I taught in Chabhil school for a short time. I came to University campus Kirtipur at the age of 19.

In central department of physics, we were very few students studying M.Sc. We were seven and to remember few, they were Bimal Karki, Shankar Sharan Karki, Umeshwor Joshi, Shridhar, Shiddarth, etc. Teachers were very hard working. They were Mishra sir, Bhyahut sir, Shekhar Gurung sir, Devi Dutta Paudel sir (head), jha sir. I did M.Sc. thesis on title '*Study of Agrillacous Sandstone from Kit Vanjyang Valley*" under the supervision of Mishra sir. We had to go to work for Rastriya Bikash Sewa for one year after M.Sc.

4) What was the procedure to go to US for higher study i.e. Ph.D.?

Tuft University, where Prof. Aryal did Ph.D.

There was no provision of GRE, TOEFL etc. Students used to go US on full scholarships like Ford scholarship etc. I went there for the first time as a teaching assistant. I used to teach at Trichandra and central department. Some professors from US universities used to come to Nepal under "physics interviewing project" every two years to select graduate students. The year I was interviewed, there

were three professors, Gary Goldstein of Tufts university was one of them. He offered me a place in his university. Boston being a center of knowledge with both Harvard and MIT located there, I too decided to go to Boston.

5) How long have you spent in Tufts university for your Ph.D.? Tell us more about Ph.D. thesis?

I spent about five and half year for my Ph.D. My head professor asked me to work on particle physics experiment as it had greater scope of getting job. But I insisted in doing theory on Cosmology. The title of my thesis was "study of some properties of cosmic strings. Earlier, Universe was homogeneous and isotropic.Concept of cosmic string was introduced to explain large scale structure formation in the universe. As cosmic string was already massive, all other particle would gravitationally fall around it and later form large scale structures of the universe. We basically studied gravitational effects on cosmic strings. Thesis was stapled collection of 4-5 papers that we were able to publish.

6) What did you do after Ph.D.?

After my Ph.D., I was unable to get post doc on Theory. I got a job on bubble chamber experiment in Brown University with recommendation from Head of Department Jack Schneps. I analyzed the data of big bubble chamber (12 ft.) in Fermi Lab. In the chamber, photograph is taken from three directions which will give three two dimensional picture of particle tracks. The first program I worked on was Three View Geometric Program (TVGP) which would use three (x,y) co-ordinates and give (x,y,z) co-ordinate in three dimension. I worked in it for some time but that was not much of a success for me as there was no chance of publication. Bubble chamber was outdated then as there was much efficient silicon micro strip detector. In our experiment, we used neutrino as incident particle. Then I worked on Bubble Chamber experiment of TOHO to study muon decay. Data acquisition was my job. I worked for three and half year in Brown University. Next I got job on Ohio State University. Our whole group was transferred to Kansas state university after a year. That was an emulsion experiment. I got a chance to work on lifetime of beauty quark under a very good professor Noel Stanton. We often had to go to Fermi Lab. In this experiment, I used to write computer program necessary for it. I have good contribution on the paper on lifetime of beauty quark. I worked here for three years.

There was a room in Fermi lab called blackhole room. They used to say once you enter inside, you won't go out as you would always be very busy.

7) Among many of your publications, which one do you consider as one of your most favorites?

There is not a specific one. I would consider the paper on beauty lifetime as a better one. During my work on Cosmology, I used to frequently visit library. In the banks of Charles, there are Harvard and MIT. It was like miles and miles of library. During one of my visit on library, I read a paper related to a strut separating two black. I prepared a paper with a concept of string passing through a blackhole. It is highly cited. At the end of my Ph.D., I was almost jobless. I worked in a library. Then, my professor Villenkin gave me a work on inflation. I wrote computer program for it and we published a paper "*The fractal dimension of inflationary universe*". The paper has more than 300 citations.

8) Then you returned to Nepal. Did you immediately started teaching?

I returned to Nepal in 2051 BS after twelve years of stay in US, five and half for Ph.D., and six and half for two post docs. As I had exceeded my study leave from Tri-Chandra Campus, I again started teaching as a volunteer. After two years, I was reinstated in my original post as a lecturer after a leave of 14 years.

9) What differences did you find in the department when you were a student and when you were a teacher?

New building was built. Attitude of teachers as well as students was also changed. Knowledge base was better. Student could get any information easily through internet. E-mail service was started in the department which was also of good use. Then, when I was a student, Mishra sir etc. used to stay till evening and practical was very good. But we had very few resources as book.

10) What differences do you find between education system of Nepal and US?

In US education system is very good. There are a lot of ways for students to get grants. There are a lot of industries that employs students for R&D. Let's not say our system is bad but our education should be we need not teach unnecessary theories repeatedly. Students should be given some projects and they should be guided to obtain some result. They should be able to obtain some useful result and publish papers. The curiosity and creative energy of students should be used in their young age instead of making them dull with age with unnecessary theories and delays.

11) Who influenced you most as a teacher?

Professor Alexander Vilenkin was very influential. From Nepal, Mishra sir, Udaya sir influenced me a lot.

Prof. Aryal's personal library at his home.

12) What type of student do you like most?

There is nothing like that. Let's say students should not disrespect Mata Saraswoti. Student should be honest and love the truth. They should vie for truth. They should not hide weakness but try and improve it. They should be energetic with limitless imagination.

13) What would you suggest new students who want to study physics?

Sky is the limit. We study Cosmology, we study everything about universe. But atoms and molecules too have their own universe. We can also study materials like graphene and phosphorene that may have good applications for human.

14) What would you suggest students who are planning to go abroad for story?

They should keep their eyes and ears open. They should remain in contact with seniors who are studying abroad. They should meet all the requirement set by University they want to apply. They should make themselves very competitive according to modern standard. Even if we do small work, we need to do it perfectly.

15) Who is your favorite physicist that you wish to meet if you got chance?

I have greatest respect for Steven Weinberg among all physicists. I wish to meet him. He has written so much that I am still reading it.

16) What do you think is the question still to be answered by physics and you would like to solve it?

We already have discovered gravity. We might even find hidden dimension later on if it exists. I think life after death is still to be answered by physics but it might be hidden for good cause. We don't have another earth but we have already built atom bomb that can destroy it. We cannot ascertain usefulness of such knowledge. I sometime think about life after death. We can devise a test to verify if ….

17) Sir, what do you think about spiritualism (adhyatmabad) and materialism (bhautikbad), can they be viewed as same or are they entirely different?

I think they are same thing, there is symmetry. What symmetry does is, if you read the old books of tantras, you would see same geometric structures, like look at hexagon of Saraswoti, positions of quarks are arranged in similar hexagon, group theory applies here. Spiritualism or materialism, whatever you call it, it is the study of nature. From what everything started, mathematics, at first when we do some experiments, we get some result,then we add some logic and we make axiom, this is how mathematics starts. For that we need space and time. When you have space, you start to translate from this point to that point. You already got translational group. When you have time, you can arrange it as yesterday, today and tomorrow, which occurred earlier or later, you have already got the order, preorder, postorder.There is a very good book by Saunders, who discovered category theory, I am reading that book, he starts from there. How mathematics started is when we got space, then we imagined translational group, when we got time, then we got order, preorder, post order etc. Starting from here, we can explain entire mathematics. Spiritualism is nothing different, it is the same thing. I don't see any significant difference. The only difference might be the concept of what happens after death.

18) We generally say eastern philosophy is quite advanced in spiritualism than western philosophy. What do you say about it?

There is not much difference. The difference we see is only artificial. For an example, they consider Jesus Christ as an incarnation of unicorn, very pious. There is a biblical story in which people try and sexually attract it to their place in case of drought believing it might bring rain. We too have similar story in Ramayana in which one horned Shringa rishi did the yagya so that King Dasharath would get child. King used to send Apsaras(angels) totry and persuade him to come to his kingdom to remove drought. If you look at the religious stories, they are similar and hence those were the same people and those stories were same. If we remove politics, there is no difference. As I often used to say electron gives green light inside oscilloscope but gives red color in experiment calculating e/m some might say electron gives green color and some might say red. It's the same thing.

19) Why has the eastern civilization lagged behind western civilization? Do we have differences on way of thinking with them?

Earlier there was famine in western Europe. They depended upon fishing for food. Population was not that large. It was hard to live due to very cold weather. We had plenty of food and hence got lazy. They had to struggle even to live. There are not much differences in thinking if we look at great philosophers/learned people. Politics might have played role. Until they discovered penicillin, eastern medicine was better. After they discovered electron, they excelled in everything.

I don't know. Sometimes it's good not to have scarcity so that we can concentrate on thinking. Sometimes it is good to have hardships. Same country or same civilization hadn't been on dominating position for always. It changes. If you ask about present situation, westerners have better professional ethics than us. We lacked that. Politicians could not show statesmanship. Even professors could not be honest.Westerners have better economic status now. Hence, they might have been better.

20) Our ancient astrology can well predict heavenly motions and eclipses. We have very good cultures like planting and worshiping Tulsi, peepal, etc. which are very scientific.

Yes, we do have many good things but some bad people also have inserted their things in between to fulfill their malicious intention. Those things that are false get blown away with time. Only a true medicine is continued to be used not a fake medicine as it cannot bring desired effect. On the matter of knowledge and science, there is no east, west, north or south.

21) Sir, will you tell us about your political life? Do you have any complaints about politics? What is your view about student involving in politics?

I was active in politics for some time before going to US. We wrote some books on communist ideology. We used to distribute pamphlets supporting Jhapali andolan. We had a group in Chabhil called Chabhil Communist Party which was very influential. We had a good relation with Parijat didi. Yubraj Karki, Ashok Rai were my students. Rabi Laxmi, Pampha Bhusal also used to come to us. My major contribution was conduction of "Pachau Ekatako Rastriya Sammelan" in Chabhil. After I went to US, I changed my mind and I became inactive in politics. Talking about complaints, more or less, everyone has complaints about politics. Look at Panama paper leak. World leaders are linked to it. Politician has to feed party workers for political gains. They try to secure future of even their coming generations. They indulge in corruptions, be it our country or abroad. But I don't have grudges towards anyone.

Even in our department, students used to practice politics through SAP. We don't have it now.

22) What is your view on how wecan develop our country?

As our Udaya sir told, science is the only way to develop our nation and *Garibi Niwaran Kosh* won't improve our economy. We should invest more time and money on science research. We should water a seedling not the bare sand. I have belief and big expectation on my students who are studying science and doing research works. I think we can contribute to the development of our country through the development of science and technology. We should use our water resources properly. We can develop Cable cars that run on electricity. We should try and generate employment. Government should provide proper care to its people.

23) People had to struggle to become successful. Would you tell us about your struggle?

I am not even a successful person. I didn't need to struggle. But I think I didn't waste even a second of my life. You can call it my struggle. But it was automatic to me as ahabit. I didn't feel it as a struggle. I avoided alcohol and drugs, gambling, girls etc. I didn't even buy a lottery ticket. That was against my principle. I used my time for experiencing other fruitful activities. I studied various literatures like Patanjali Yogdarshan, Mahabharat etc. I learnt more mathematics.

24) Looking at your past you don't have any regrets?

No, I don't have any regrets. But I still think I shouldn't have given that much time on politics. I should have concentrated my whole time and efforts on study instead of doing many things like a canal with many branches. But being born as a human, we might as well need to taste all 'ras' like SHADRAS.

25) Tell us about your literary life. Which is your favorite literary creation other literary persons?

I started writing poems from my school days. I have written few stories. Being a Shiva devotee, I wrote a story called "Shamundra Manthan and Shiva" which was published on Samakalin Sahitya produced by Nepal Pragya Pratisthan. In that story, Shiva drinks the Kaalkut poison to save the world risking his own life. Writing requires a lot of time for me.

I like a poem written by Rabindranath in Geetanjali. That is "Jo gaana yaha gaane aaya, o aajtalak me gaa na saka, sur hi sadhata raha abtak par haaye na usko baadhsaka, mere pranose banirahi kewal gaane ki byakulata". I think I was born to teach

26) We have semester system in CDP. What differences have you found between previous system and this system?

I like to compare this with various political system change in our country. Whatever was the political system in our country, it has brought no significant differences. Whatever be the system of education, it is good until teachers and learners are good. Until there are Professor who does not enjoy teaching and students who does not enjoy studying, no system is going to work. In the semester system, there is change in evaluation system as there are internal tests etc. Students who go abroad are like our brand ambassador. If we could give them real evaluation and if they could perform well abroad, it will show our quality of our education. We should equally preserve our history and past achievements alongside of using new technology and systems. As we are traditionalist and consider books as Mata Saraswoti, we would prefer books, though the use of internet to obtain knowledge and information is also equally important.

27) Any suggestions for improvement.

I stopped thinking about policies as I felt I am not useful for it. To improve it, ingredient i.e. students and teachers should be good. Examination and evaluation should be good. There should be creative teaching learning environment. Whenever we learned something, we should instantly have thought about its applications. As there is a saying "Parachute and mind is useful when open", we should try to keep our mind open.

28) What is the happiest moment of your life?

In some way, I am always happy. I am never too sad and never too happy. Happiness and sadness are equal in my life. People feel happy when they find themselves better then few others.

Happiness comes from satisfaction when desire corresponds with achievement. I won't say our desire should be zero but there should not be cut throat competition for achievement.

Prof. Aryal with RONAST Young Scientist Award

29) Do you think you were born little too soon so that you were unable to fully experience the modern technological advancement and amenities?

We experienced different kind of fun in our days. We had competitions with similar people. Now the competition is in different level due to technological advancement.

30) What would you say about research activities of department? What do you think about quality of the research?

There are a lot of research works going on in the department. Mostly, the research is done on Gaussian. There are a lot of students doing research in it as it has better scope.

People are always on rush. They want to publish papers fast, frequently and in large number but they should consider maintaining quality of research too. There should be honesty in the professors. Some professors doing thesis in Gaussian published their work even by ignoring imaginary frequency which results in unstable states. Some teachers teach in private campus too but had they been given enough salary, they might have concentrated more on research work in the department.

31) You have got "RONAST Bigyan tatha Pravidi Pragya Puraskar - ka,2062" from NAST. Tell us about it.

We had a bus service in the department. Dhaudel sir who knew me from our travel in the bus recommended my name for the prize to my surprise and I got it.

32) How is your daily life routine?

I sleep at 8:00 pm and wake up at 2:00 am. After returning from washroom, I do the pranayama for an hour. I had asthma. I breath in the medicine for asthma. At around 4:30, I go to temple. I walk or jog as my body allows for around 4 to 5 mile every morning. I walk less in the morning if later I have to go to college. I track my walking and fitness using an android app. After I return, I go to college if I have to. Nowadays I have around 4 periods per day. During day, I spend my time reading books as far as possible. I sometimes read sloks or sometimes whatever else attracts my mind. I read in laptop or mobile. I like reading but my great weakness is that I couldn't fix my destination.

33) How long have you been teaching in the department?

I started teaching in 2034 BS in Tri-Chandra college. I almost taught for 39 years including 14 years as leave.

34) What is your plan after retirement?

I am planning to read Category Theory, Translation Theory by Saunders. As I will be free from any obligation to teach or pass any exam neither will I need to prove any theorems or invent one, I will enjoy reading freely. I won't teach in private collage. We worship Mahakali (by keeping body healthy), Mahalaxhmi (by feeding, earning money), Mahasaraswoti every day. Although god didn't make me excellent I am satisfied as I am. I have good health, have enough money to live and have learnt few words.

35) What do you think our life is from all your experience till now? How do you evaluate it?

Is there a purpose of life? Hinduism says there is purpose in life. Asatoma sad gamaya, tamasoma jyotirgamaya, mritayorma amritam gamaya, Professor of Buddhism Richard Phillip says there is no purpose of life but man can give a purpose to his life. Is there a life after death? Is this just a chance? Is this just a statistics or is there a hidden cause? Maybe there is life after death and may be Einstein is another reincarnation. Rienmann struggling for the same theory and later he came to get it.

There are two things. When was consciousness born? We can see some life form if we have RNA, DNA, but they are complex molecules. Biology was born very late. Life appeared as some algae one billion years ago. Universe was created some 13.7 billion years ago. It may have generated some sound like Oum. How was it after 10^{-43} seconds after bigbang? Gravitational wave detection might add some information. Was consciousness created alongside the creation of universe? Space might have the consciousness of elasticity, expanding and contracting. That consciousness might have developed later. Our religious doctrines tell us god created universe, let there be life.

Prof. Aryal with editorial board members

Let's go on thinking about it. Someday somebody might know the answer.

36) What is the message of Mukunda sir to all students of physics or students in general?

Everyone has their unique requirement. I have nothing to say but they should remain honest in their field. We should be content with whatever we get. Physicist should rise above their nationality similar to the laws of physics that are universal in nature. World is ours.

Time Reversal Symmetry in Superconductor and its Breakdown in two-band Superconductor

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ABSTRACT

In this paper, I have discussed about superconductor in general and time reversal symmetry breaking. Also consequences of this phenomena are discussed. All mathematical supports are kept myself.

The resistivity of many metals, alloys and semiconductor drops nearly to zero when they are cooled at sufficiently low temperature. This phenomena is known as superconductivity and specimen is known as superconductor, first observed by Kamerling Onnes in 1911 [1]. Below the critical temperature T_c, specimen behaves as a superconductor whose charge carrier is Cooper pair that behaves as a boson particles. To develop two-particle wave function for Cooper pair, Bloch statement i.e. "At lowest energy state, particles have zero total angular momentum so that two particles must have equal and opposite mometa" ,is very useful to understand Cooper pair more clearly [2]. So, an orbital with wave vector **k** and spin up is occupied, then orbital with wave vector –**k** and spin down must be occupied. Similarly if orbital with wave vector **k** and spin up is vacant, then orbital with wave vector –**K** and spin down must be vacant. This forms cooper pairs. Length of cooper pair is very large as compared to the atomic radius.

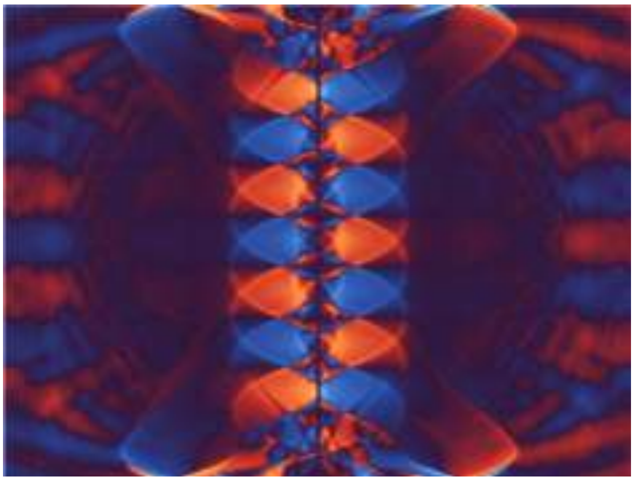

Figure 1: *A route to a time-reversal symmetry-broken state for d-wave superconductors is shown to occur via the formation of a necklace of fractional vortices around the perimeter of the material, where neighboring vortices have opposite current circulation. This vortex pattern is a result of a spectral rearrangement of current-carrying states near the edges [source: https://www. sciencedaily. com/releases/2015/10/151002081717.htm]*

Time reversal symmetry describes the behavior of physical laws when't' is replaced by '-*t*' i.e. positive sense of time can't be distinguished from negative sense of time [3]. Time reversal symmetry invariance applies to the event on particle scale but not on ordinary macroscopic scale. Let us take an example, if we observe a motion picture film which event on particle scale i.e. particle formation or decay, the event will appear equally likely whether the film is run forward or backward. Melvin has stated a theorem regarding time reversal symmetry which states that the process seen directly in matter look exactly like those on film of process in anti-matter taken through a mirror and run of backward [4]. In particle physics, there is CPT(charge, parity and time) theorem which states that all interactions (weak and strong) are invariant under combined operation of C, P and T, taken in any order. If in any weak interaction CP invariance breaks down, then CPT invariance requires the breakdown of time reversal symmetry[5].

Superconductivity is frequently observed in many alloys whose mean free path for electron is very small. It indicates that to treat **K** as a good quantum number, pairing of two electrons must be related with each other by time reversal symmetry and are able to retrace their path through the material[6]. This is the main concept for time reversal symmetry in superconductor. Superconductivity is highly related with magnetic field in the sense that superconductive state breaks down due to large magnetic field. So large current can not be flown through the superconductor. So there is current modulation. This current modulation behaves as potential well or barrier[7]. Tunneling of cooper pairs in two band superconductor is complex than simple Josephson tunneling. In two band superconductor, there are two types of tunneling. One is intraband tunneling i.e. tunneling from one superconductor to another superconductor through insulator. Another is interband tunneling i.e. tunneling between two electronic bands of same superconductor. These two tunneling are very important to study the dynamics of fluxon completely.
If interband interaction is much smaller than intraband interaction, then there exists soliton which is confirmed by Y Tanaka. Actually soliton is a solitary wave which shows great stability in collision with another solitary wave. Such soliton traps extra flux inside the superconducting ring. As a result there will be no more flux quantization in that superconducting ring. Then we can find unusual phenomena of fluxon. Time reversal symmetry breaking also can be found theoretically. This phenomenon provides us many abnormal behavior of superconductor. There is disappearance of Meissner effect which is the central property of superconductor.

So superconductor behaves as a perfect conductor rather than a superconductor [8]. Also there is specific heat jump as a result of time-reversal symmetry breaking in two –band superconductor.

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Watercolor caricatures of French mathematician Adrien Marie Legendre (1752-1833) by French artist Boilly. His picture is not available. Legendre's name is one of the 72 names inscribed on the Eiffel Tower.

Adrien-Marie Legendre made numerous contributions to mathematics. Well-known and important concepts such as the Legendre polynomials and Legendre transformation are named after him. He is known for the Legendre transformation, which is used to go from the Lagrangian to the Hamiltonian formulation of classical mechanics. In thermodynamics it is also used to obtain the enthalpy and the Helmholtz and Gibbs (free) energies from the internal energy. He is also the namegiver of the Legendre polynomials, solutions to Legendre's differential equation, which occur frequently in physics and engineering applications, e.g. electrostatics.

Side view sketching of French politician Louis Legendre (1752–1797), whose portrait has been mistakenly used, for nearly 200 years, to represent French mathematician Adrien-Marie Legendre, i.e. up until 2005 when the mistake was discovered.

Expulsion from Germany: moving to America

In the early 1930s Noether's career was finally taking off. Her name was becoming known, and she was receiving invitations to speak at important mathematics conferences.

Then, in January 1933, everything changed. Adolf Hitler came to power. By April of that year Noether, who was Jewish, had been dismissed from the University of Göttingen by order of the Prussian Ministry for Sciences, Art, and Public Education. Sadly, in Nazi ideology Emmy Noether's religion was of more significance than her extraordinary genius.

Fortunately, her genius *was* valued somewhere. Bryn Mawr College in Pennsylvania, USA – a women's college – obtained a grant from the Rockefeller Foundation and, in October 1933, Emmy Noether sailed on the *Bremen* to begin work as a lecturer in America.

The following year she also began lecturing at the Institute for Advanced Study in Princeton.

A year later she was dead.

Biochemical Technique in Photosynthesis

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ABSTRACT

Photosynthesis is a very important phenomenon. By this process green plant, algae, and (cyno and photosynthetic) bacteria converts carbon dioxide into organic food i.e. carbohydrate in the presence of solar energy. On the other hand, this process is also important for us.At the beginning of the evolution of life in the Earth there were photosynthetic bacterias and primitive algaes which sustained and developed their life by this process which eventually leaded to our evolution. In modern time, we are, one way or another, using plants for our survival and development. For example, to keep our eyes healthy we consume green vegetables, use vitamin to overcome disease, or some of us may have obsession for green tea.Hence,here we discussed about the Photosynthesis and key components that are essential for itscompletion. In fact, it is a coordinated processwhich occurs in four steps: solar energy harvesting, charge separation, electron transport and ATP synthesis. In addition, discussion onRb. sphaeroid reaction center and quinones were also presented.

Introduction

We are concerned with the things that is directly or indirectly related with us and show care and curiosity about the things that are beneficial. We use photosynthesize foodstuff in our daily life. Figure 1 shows some common ways of its consumption. For example, we use variety of green plants in burgers. In fact, the bread of the burger itself is prepared from photosynthesize foodstuff like wheat. In addition, we consume green vegetablesto be healthy. Furthermore, consumption of fruits, rice, mushroom etc.is also examples of usage of such foodstuff. They become integral part in the human development.

Moreover, during evolution of life in the Earth the photosynthetic bacterias and primitive algaes sustained and developed their life by the photosynthesis. Their survival and development leaded to the existence of more and more developed species and eventually made possible for our evolution. Hence photosynthesis is very important phenomena for both plant and us.

***Figure 1**: Some ways of consumption of photosynthesized foodstuff*

Photosynthesis

Photosynthesis is the process by which green plant, algae, and (cyno and photosynthetic) bacteria transforms light energy into chemical energy. There are two types of photosynthesis: oxygenic and bacterial. In the oxygenic photosynthesis, oxygen is evolved as water is reduced during photochemical process. For example, green plants do so. In contrast, in the bacterial photosynthesis, as water is not used during the photochemical process, so oxygen is not evolved. Example of which is photosynthesis in purple bacteria. In either case, it is a coordinated process which occurs in four steps: 1) solar energy harvesting, 2) charge separation, 3) electron transport and 4) ATP synthesis [1].

Solar Energy Harvesting

Pigments are the basic element involved in the photosynthetic process. Out of total pigments more than 19 of 20takes part in a light absorption, such pigments are called light-harvesting pigment-protein (LHP). Chlorophyll-a, Chlorophyll-b, carotenoid are some example of such pigment. The main work of LHP is to capture solar energy and without losing it send to the reaction center. Figure 2 shows light harvesting antenna molecule.

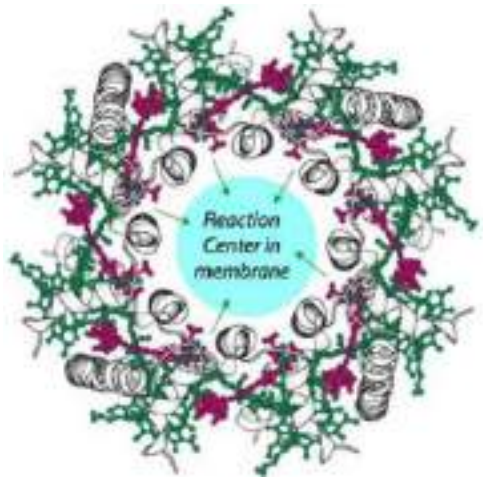

***Figure 2:** Structure of light harvesting antenna molecules [2]*

Reaction Center

Charge separation and electron transport are considered to be the essential phenomenon for completion of photosynthesis in reaction center (RC) where various pigment proteins are present that may be distinctive depending on species. For example, reaction center of nonsulfer purple bacteria contains four bacteriochlorophyll a (BChl a), two bacteriopheophytin (BPh), two ubiquinones (Q_A and Q_B), and a non-heme iron, whereas plant reaction center contains Chl special pair, singleChl (A_O), quinones (plastoquinone A_1), iron sulfur cluster (F_X, F_A, F_B, ferredoxin). However, their nature of work is almost same. They either loose or transport electron and eventually lead to the creation of proton gradient across the membrane.

The solar energy while reaching RC stimulates excitation of special pair of chlorophyll or bacteriochlorophyll as shown in figure 3.

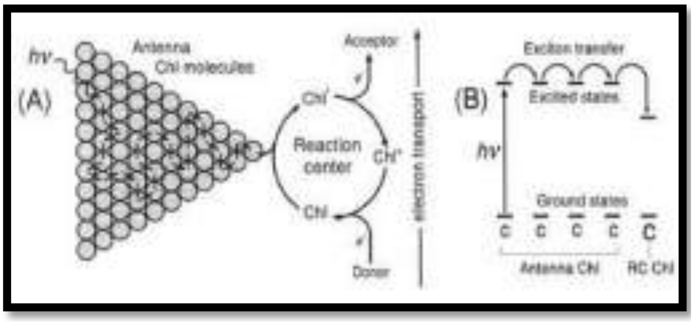

Figure 3: *(A) simplified representation of the photosynthetic unit consisting of the light harvesting antenna chlorophyll molecules and the RC, (B) energy diagram showing exciton transfer among the antenna chlorophyll molecules and trapping by the reaction center [3]*

Such excitation leads to the loose of electron and lost electron is carried out by other pigment present in the center. Althoughall types ofRCs have Q_A and Q_B, different RC's may have different other unique carries in addition to them.Most importantly, acceptors except Q_B, which takestwo electrons, can only take one electron. The reason behind this is due to different redox potential of sites. So, Q_A can only reduce to semiquinone stage before it has to surrender its electron to Q_B. On the other hand, Q_B can fully reduce to quinol or hydroquinone form. Figure 4 shows different form of quinone in the electron transport process.

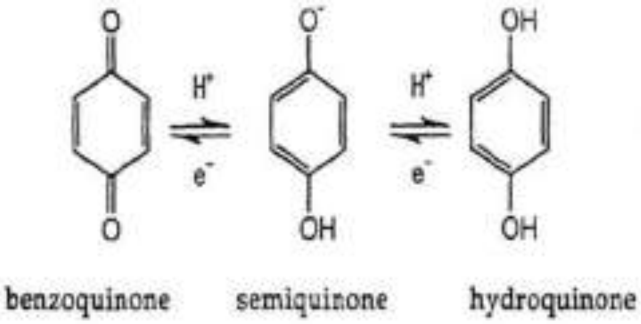

Figure 4: *Different form of quinones in RC*

It is relatively easy to study photosynthesis system of purple bacteria compare with others and abundant researches are/were going on/done in it. To elucidate RC further,coming topic discussed about the RC of the purple bacteria.

Rb. Sphaeroid Reaction Center

Reaction center (RC) of the nonsulfer purple bacteria, prokaryotic photosynthetic organism grow in the aquatic, harsh habitat where very deem light can reach, isRhodobacter (Rb.) Sphaeroids. Different pigment molecules presented in this RC are respectively four bacteriochlorophyll a (BChl a), two bacteriopheophytin (BPh), two ubiquinones (Q_A and Q_B), and a non-heme iron. Here, out of four, two BChl acts as an electron donar (D) and L-side of BPh, Q_A and Q_B acts as an electron acceptor. When trapped solar energy by LHP enters the RC, it excites D. The excited D* has one electron to loose and is transferred through the sequence of BPhL, $Q_A$and Q_B.

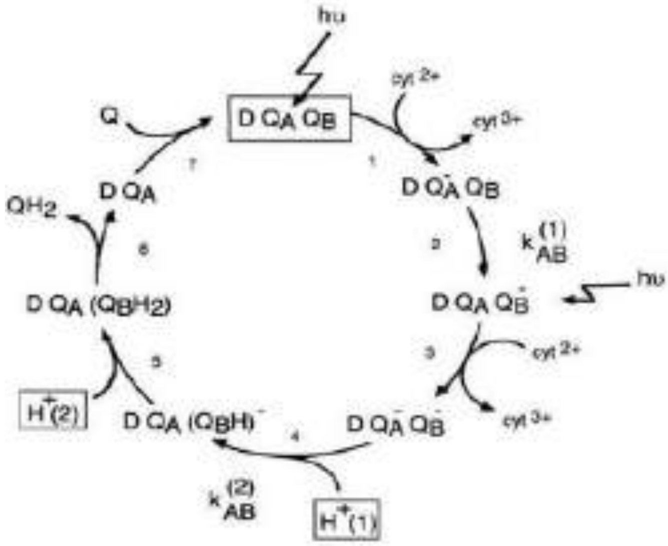

Figure 5: *The quinone reduction cycle in bacterial RCs. Q_B is reduced in two one electron reactions k^1_{AB} and k^2_{AB}, and binds two protons, $H^+(1)$ and $H^+(2)$. The reduced QH_2 leaves the RC and is replaced by an exogenous quinone thereby resetting the cycle Quinones [4]*

Figure 5 shows pictorial diagram of whole coordinatedprocess in the bacteria photosynthesis. In which, solar energyexcites D and when it loses an electron it becomes cation. It comes to the ground state after getting electron from the surrounding. Now, the electron is transferred via a bacteriopheophytin molecule to a primary quinone $Q_A$and finally to a secondary quinone Q_B.

Quinones

It is important to know quinone because it plays significant role in the electron and proton transfer during the photosynthesis.

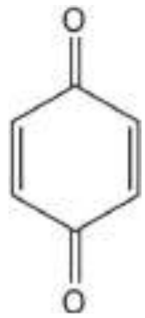

Figure 6: *Structure of a Quinone*

Figure 6 shows basic structure of a quinone molecule. It must contain a quinone ring and two carbonyl atoms and by adding different side groups we can get infinite number of different and distinctive variety of other quinones. Figure 7 shows structure of quinones that may present in different RCs.

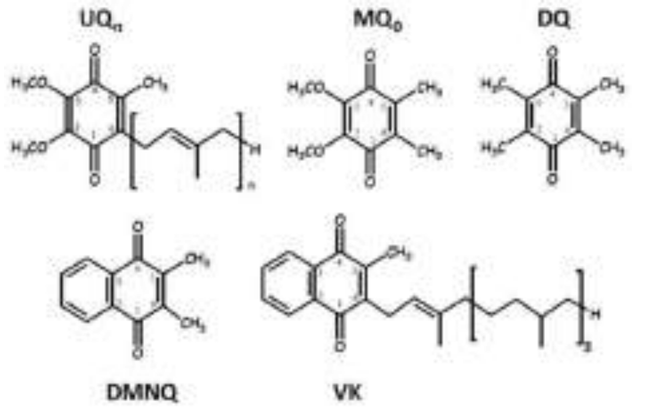

Figure 7: Structure of ubiquinone (UQ_n), Dimethoxy dimethyl benzoquinone (MQ_O), duroquinone (DQ), dimethyl naphthoquinone (DMNQ), Vitamine K_1(Phylloquinone).Duroquinone is a Plastoquinone analogue in which methyl groups have been substituted at C_5 and C_6 and Menaquinone is identical with Vitamine K_1 except for the degree of saturation of the tail at C_6 [1].

Bacterial reaction centers and PS II contain two special quinones namely $Q_A$and Q_B. The $Q_A$can carry only one electron to $Q_B$at a time and hence only reduce to semiquinone form; while $Q_B$can get two electrons that are transported by $Q_A$and hence reduced to the hydroquinone form.

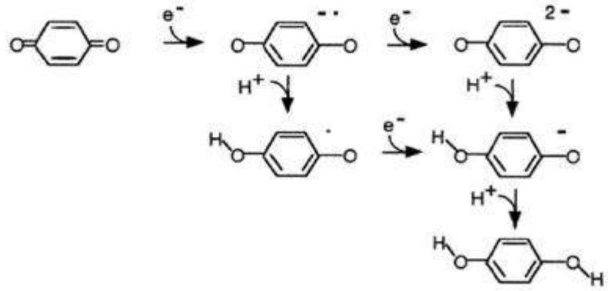

***Figure 8:** Different quinone states resulting from electron and proton binding [5]*

Although $Q_A$and $Q_B$are chemically identical, they carry out different properties in their respective binding sites. For example, $Q_A$is a menaquinone (MQ) in Rhodopsuedomonas (Rp.) viridis and a ubiquinone (UQ) in a Rhodobacter (Rb). Sphaeroids, it is a tightly bound one-electron acceptor whereas Q_B, which is UQ in both RCs, is loosely bound and can accept two electrons **[5]**. As shown in Figure 8quinones are in the different form in the reaction center (RC). In biological system, they are found in neutral (Q, defined as a zero oxidation state), reduced (Q^-, semiquinone anion radical), and doubly reduced protonated (QH_2, dihydroquinone) forms. In addition, the protonated semiquinone radical ($QH^\cdot$) and doubly reduced ($QH^-$and Q^{2-}) forms, which are possible intermediates in biological reactions, have been generated in different solvents **[6, 7]**. Different quinones are found in the biological system: ubiquinonesare found in mitochondria and in many bacteria,menaquinones occur in many bacteria,and plastoquinones are present in choloroplast. Some organism contains only a single type of quinone, but several bacteria possess both ubi- &mena- quinones, whilst green plants have ubiquiones in their mitochondria and plastoquinones in their chloroplasts **[8]**.Table 1 below shows different Q_A and $Q_B$in different RCs.

Table 1: Kinds of quinones in several photosynthetic bacteria [3]

Species	**Q_A**	**Q_B**
Rb. sphaeroids	UQ	UQ
Chromatium or Rp. viridis	MQ	UQ
cf. aurantiacus	MQ	MQ

Conclusion

Thus, photosynthesis is an important phenomenon that captures energy for life on earth. Many chemicals process occurs for the photosynthesis to happen. The earliest photosynthetic organisms like purple bacteria were anoxygenic and all photosynthetic RCs were derived from single source while green plants use water as an electron donor evolving oxygen as a waste product which is useful for human being in different aspects for agricultural and energy applications.

Acknowledgement

Sincere acknowledgement goes to Dr. Hari Prasad Lamichhane for his help and support.

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Max Born was very disappointed not to share the 1932 Nobel Prize for Physics with Heisenberg. Making things worse, he was forced to leave Germany after rise of Hitler.

Solar Neutrino Problem has been Solved

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ABSTRACT
Deep inside the Sun, pairs of protons fuses together to form heavier atoms, releasing mysterious particle called neutrinos. Various experiments suggested that number of neutrinos detected at earth is not exactly same as given by theory. This disagreement can be resolved by theory of neutrino oscillation.

Introduction:

A neutrino is an electrically neutral elementary particle with half integer spin. In Italian, neutrino refers to little neutral one. In 1931 Wolfgang Pauli explained the Beta decay process first time. In order to describe the Beta decay process, Pauli discusses an undetectable, mass less particle that assists in carrying away energy. The word "neutrino" was first used by Enrico Fermi during a conference in Paris in 1932 in order to distinguish this light neutral particle from neutron. Neutrinos are extremely common in universe: stars make them in vast number and they were even more copiously produced in first few second of Big Bang. As they do not carry charge they are not affected by electromagnetic force and are Leptons, so they are not affected by nuclear force. Neutrinos are therefore affected by electroweak force. According to standard model, neutrinos have no mass and there are three flavors: electron neutrino (ν_e), muon neutrino (ν_μ) and tau neutrino (ν_τ). Perhaps they are most enigmatic particle in the universe.

Neutrinos can be created in several ways such as during thermonuclear reaction in sun, in nuclear reactor, in certain types of radioactive decay, in supernova and also when cosmic rays hit atoms. The majority of neutrino received by earth is from thermonuclear fusion reaction in sun that is considered to be the main source of energy in the stars like sun. The modern theory of stellar nuclear synthesis was developed by Hans Bethe in 1930's and later expanded by John Bahcall. The energy production in the sun is carried out by two groups of thermonuclear fusion reaction *viz.* Proton-Proton (pp) chain reaction and Carbon-Nitrogen-Oxygen (CNO) cycle. In pp chain reaction conversion of four protons into He nucleus plus two positrons and two electron neutrinos takes place.

$$4\, H^1 \longrightarrow He^4 + 2\, e^+ + 2\nu_e$$

The energy released during this process is 26.73 Mev. The neutrinos interact with matter very slowly so that it can easily escape from the sun core in about two seconds and give the direct information about conditions near the center of sun whereas thermal energy takes more than 10^5years to reach the surface and is liberated into free space as radiation. The pp–chain reaction is completed in three branches: pp-I, pp-II and pp-III. The neutrino production in ppI branch is much larger than other two branches.

Since neutrinos are produced with the release of 26.73 Mev energy, the total number of neutrinos released is about$\frac{2L}{26.73\ Mev}$, where L is luminosity of Sun = $3.9*10^{26}$ Watts. Hence the neutrino intercepted by earth's cross section per second is ~ 6 $*10^{10}$. Despite this impressive number, the neutrino interacts so weakly with matter that the probability of detecting any one of them is minuscule.

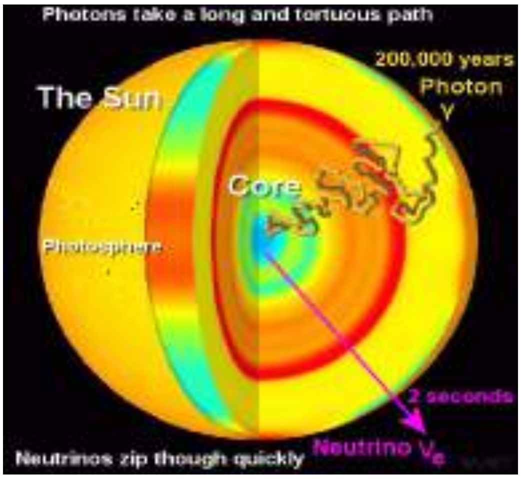

Figure 1: *Solar Core*

What solved the solar neutrino problem?

Since late 1960 several neutrino detection experiments such as Homestake, SAGE, Gallium experiment (GALLEX), IMB, Kamiokande and Super-Kamiokande were carried out. The first neutrino detection experiment was performed by Ray Davis and John Bahcall. Ray Davis' Chlorine – 37 solar neutrino experiment predicted the number of neutrinos emanating from the Sun but the result is problematic. It showed that their number was only about a third of what was predicted by the theory. This disagreement is called solar neutrino problem. Thisdiscrepancy may be due to a fault in the observational technique or in solar model or to some unknown properties of the neutrinos. If the solar models are not correct, the central temperature of the sun would have to be about 20% lower than thought, which contradicts observed solar luminosity. One reliable way to address this problem is the possibilities of conversion of some of the electron neutrinos into other, an unobservable particle during their passage to earth. In this experiment only neutrino from the pp II and pp III branches were observed. As energy production in this reaction is small fraction, it was not clear what the consequence of these results for solar models were. In

1990's, neutrino produced in main branch were observed (about 60% of predicted flux was observed), however the neutrino problem still remained unsolved. This problem is explained on the basis of neutrino oscillation.

Figure 2: *2015 Noble Prize winner: There are three types of a very small and elusive particle in the standard model called the neutrino. In the experimental facility in Japan & Canada,* ***Prof. McDonald*** *&* ***Prof. Kajita*** *studied neutrinos created in nuclear reactions in the sun. Measurements showed deviations, which were explained by the neutrinos switching between the different types. This means that they must have mass. The Standard Model, however, is based on neutrinos lacking mass and the model must be revised.*

The fundamental idea behind the oscillation is quantum mechanical phenomenon of mixed states and so things like the uncertainty principle come into play. As a result, we can either measure a neutrino's mass or its flavor, but never both. This means that we can say neutrinos have mass but we can never say that the electron neutrino has particular mass. If we know the flavor of neutrino, then that flavor is the superposition of the three mass types. This means each flavor is a specific superposition of different mass eigenstates and each mass eigenstate has slightly different speed. So if an electron neutrino is produced in a nuclear reaction, its superposition of mass states will gradually shift because of the different speeds. In quantum theory, each mass state has a different wave length, so their waves start to interfere as they shift. This effect is known as neutrino oscillation. The existence of oscillation implies a non-zero mass difference between oscillating neutrino species, which in turn means that at least some of the neutrino should be massive. According to neutrino oscillation, if neutrinos have small mass, an electron could change into other two flavors, a muon neutrino or tau neutrino as it passed through the outer parts of the sun. The oscillation can be modified when neutrinos propagate through matter. This is so called MSW effect, is important to understand because neutrinos have to travel through the dense matter in the solar core on their way to the Earth.

The first strong evidence for neutrino oscillation came in 1998 from Super Kamiokande. It was able to detect the muon neutrinos (produced in upper atmosphere by cosmic rays) changing to tau neutrinos. As this experiment was mainly focused in the detection of the muon neutrinos, no tau neutrinos were observed.

In 2001, the most recent neutrino telescope, the Sudbury neutrino observatory (SNO), Canada, released data that solved the solar neutrino problem. The sun produces electron neutrino but some other flavors of neutrino also reach the earth. SNO detected all three types of neutrinos coming from the sun and was able to distinguish electron neutrinos from other two flavors but it could not be able to distinguish muon and tau flavors. Electron neutrinos have been arriving on earth disguised as muon or tau neutrino. On the journey to earth, neutrino spontaneously switch from one being electron flavor to other two flavors. As a result, only about a third of the neutrinos that reach earth are electron neutrino that explains why early neutrino detectors measured third the expected amount. And thus, it leads to the resolution of long standing solar neutrino problem.

Conclusion:

The observation of SNO and Super-Kamiokande of oscillation phenomenon implies that neutrino has a non – zero mass, which was not included as a part of the standard model. For the discovery of the proof of neutrino oscillation and thus neutrino mass, Takaaki Kajita of Super-Kamiokande observatory, Japan and Arthur McDonald of SNO, Canada were jointly awarded the 2015 Noble Prize for Physics.

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Max Born was forced to leave Göttingen as a Jew after the rise of Adolf Hitler. He spent three years in Cambridge, and alter became Professor of Natural Philosophy in the University of Edinburgh, where he stayed until 1953. After his retirement, Born returned to Germany. Finally in 1954, he was awarded Nobel Prize for Physics for the statistical interpretation of quantum theory, sharing with fellow nuclear physicist Walther Bothe.

Numerical Study of Finite Potential Well

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ABSTRACT

Few of the applications of computational physics are to understand physics in depth, validate the theoretical prediction and solve problems which cannot be solved analytically. Though, analytical solution of finite potential well can be obtained, it's not very easy to understand all the physics behind it. In this work, I have solved even and odd state equation for one dimensional finite potential well with different set of parameters using self written FORTRAN program. Dependency of eigen state inside one dimensional potential well in particle's mass, width of well and depth of the potential well is analyzed.

Motivation

Studying physics is always fun but mastering fundamental concepts and problem solving capacity is not that easy. Although most of the natural phenomena are simple, the language describing that, in physics, may not be so. It's always good to have knowledge to the fullest about every problem that we study. Text and reference books contain all the resources but it's up to reader to grab the information and understand all the underlying principles. Sometimes the relation explained in equation and words may delude but numbers never lie. Numerical calculations and computer simulation are the best ways to be crystal clear about any problem. Computer simulation helps us to make rigorous concept about the physical phenomenon and such detail is seldom found in text books. Computer simulation of finite potential well problem, a very fascinating problem of quantum mechanics, is presented here.

Introduction

A finite potential well, in 'let us consider a spherical cow' sense, best represents bound state quantum mechanical system. Quantum mechanics manifests it's all colors in it and energy quantization and evaporation of system with energy less than the well's depth itself amazes zealous readers. Attractive potential seen by an electron near to proton is an example of potential well. In more generalized sense, an atom is spherical potential well in electron's eyes.

One dimensional finite quantum well of depth V and width 2a is shown in fig-1[1][2]. A quantum particle with mass m and energy E less than the depth of potential is taken in it. Under these assumption one can easily write Schrodinger wave equation for regions $x<-a$, $-a\leq x\leq a$ and $x>a$, and solve them. Taking wave function and their first order derivatives of two regions to be equal at the boundary, we can get solutions: [2]

b = a tanaa . . . (i) and , b = -a cotaa . . . (ii)

where $a = \sqrt{\frac{2mE}{\hbar^2}}$ and $b = \sqrt{\frac{2m(V-E)}{\hbar^2}}$; where $\hbar$ is reduce Planck's constant.

Equation (i) is even state solution and (ii) is odd state solution[1]. Our interest is to find out the all possible values of energies that the particle can take in the potential well.

Methods and Tools

Equation (i) and (ii) are converted into Fortran program in Ubuntu 14.04 environment. gFortran compiler is used to compile program and find out the roots of these equations. Xmgrace is used for plotting data generated from the program. Appropriate units are used according to the nature of the problem to simplify the calculation. In this simulation, reduced Planck's constant is taken 6.5921220 x 10^{-16} eV sec Å and its square is [1]. Potential, energy of particle, mass of the particle and width of well are measure in the units of eV, eV, electron mass and angstrom respectively.

Results and Discussion

Different numbers of roots are found for each of the equation mentioned above. Number of solutions for (i) and (ii) gives the number of even and odd eigenstates in the finite potential well in which the particle can remain. To find the effect of particle's mass, depth of well and width of the well on the number of eigenstates simulation was done for various combinations of parameters V, m and 2a. Numbers of solutions obtained for (i) and (ii) with different parameter such that $0\leq E\leq V$ are resented in table 1 below:

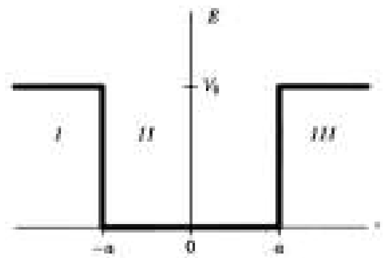

Figure 1: *One dimensional finite potential well*

Table 1: Number of even and odd solutions for finite potential well problem at different values of V, m and 2a. The second and third columns give the depth of the potential (V) and mass of the particle (m) in terms of electron mass. The fourth column lists the width of the well in Å (2a). The last two columns give the number of even (n(E)) and odd solutions (n(O)), respectively.

S.N.	V (eV)	m	2a	n(E)	n(O)
1.	10	1	12	4	3
2.	50	1	12	7	7
3.	10	1838	12	133	133
4.	10	1	14	7	6

For this simulation it is found that the number of quantum state in one dimensional quantum well of finite depth increases with increase in either one of m, V and 2a keeping other two constant. For very high value of m and 2a, the quantum system contains very crowded eigen states. For very large potential, the finite well becomes infinite quantum well. If the E exceeds V, particle cannot be confined in the well. There is nonzero probability of escape of particles even with E<V.

Figure (2), (3), (4) and (5) illustrate the (i) and (ii) as a function of position for parameters tabulated above, in sequential order. Wave functions are along y-axis and potential well positions are along x-axis. The value of energy at which wave function cuts y=o axis corresponds to the eigen energy. Number of point of intersection gives the number of quantum states in the well. From these graphs, all possible even and odd eigen states in which particle can stay and energy eigen values that particle can have can be obtained.

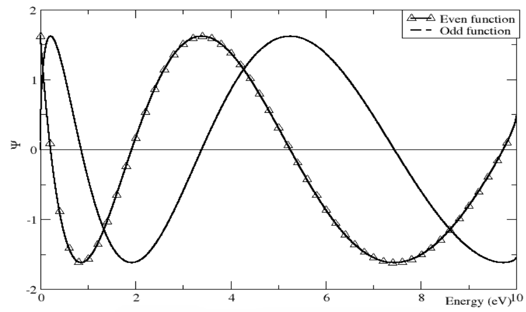

Figure 2: *Even and odd solutions for finite potential well*

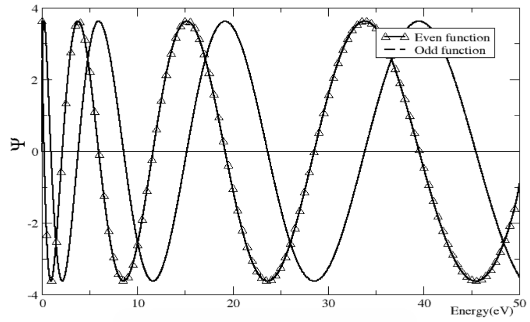

Figure 3: *Even and odd solutions for finite potential well (V=10, m=1 and 2a = 12) as a function of energy (V=50, m=1 and 2a = 12) as a function of energy.*

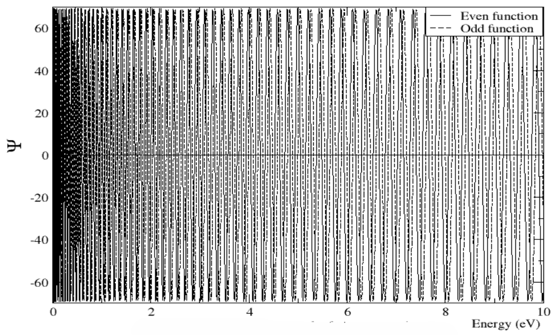

Figure 4: *Even and odd solutions for finite potential well.*

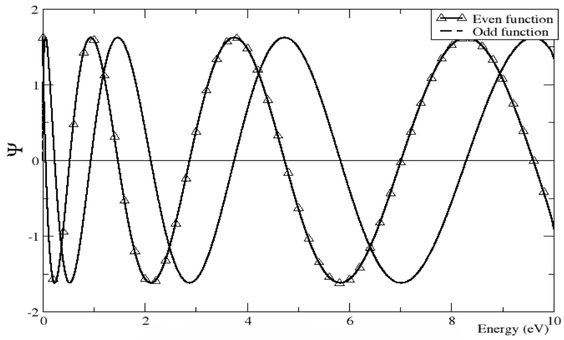

Figure 5: *Even and odd solutions for finite potential well (V=10, m=1 and 2a = 12) as a function of energy (V=50, m=1 and 2a = 12) as a function of energy Figure (2), (3) and (4) corresponds to even and odd state solutions of an electron in potential well of different depth and different width. Figure (4) represents solution of proton in potential well of depth 10 eV and width 6Å. By comparing fig-2 and fig-4, it can be said that a potential well with discrete energy levels for electron may have continuous energy states.*

Eigen energies for all possible states were calculated with the simulation program. In each of the cases lowest energy level corresponds to the first even eigen state. Eigen functions with different sets of parameters tabulated above are plotted below in figure (6), (7) and (8) as a function of position taken in angstrom unit. Each of the eigenfunction is shifted by corresponding energy eigen value to have better understanding at a single glance. The even and odd nature of solution is clearly seen from symmetry and asymmetry of curves with respect to x=0 axis. These plots also show that the lower level energies are more crowded than the higher level energies. Spacing between energy levels increases with increase in eigen state.

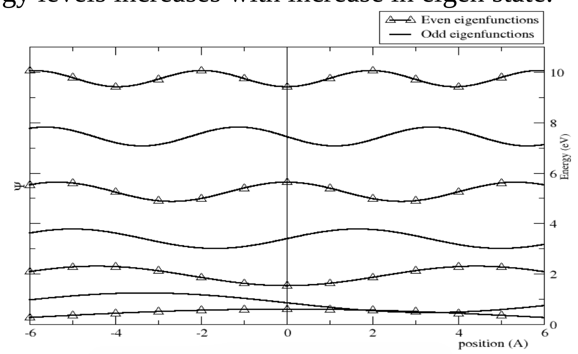

Figure 6: *Even and odd eigenfunctions*

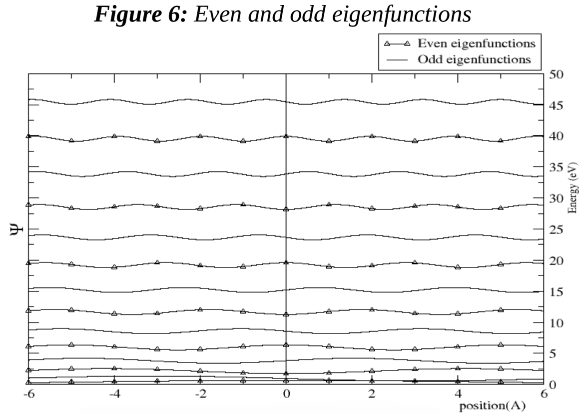

Figure 7: *Even and odd eigenfunctions.*

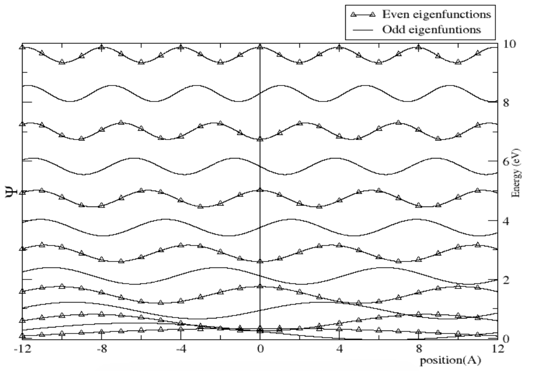

Figure 8: *Even and odd eigenfunctions.*

From these figures, it is clearly seen that mass of particle, width and depth of potential well play crucial role in number of possible energy states. Fig-4 depicts that proton have very crowded and it can be said that the well has continuous energy level for proton. It can be inferred from this, for a given potential well proton can have much more energy states than electron.

Conclusions

Even and odd eigen state of finite potential well calculated numerically for different set of parameters verified that number of quantum state in potential well depends upon factors such as mass of particle, width of well and depth of the well. Increase in system's mass, potential depth of well and width of well increases the number of eigen states. For very large mass and large width of box, finite well tends to behave classically with continuous energy states. For very large value of potential, it behaves like a infinite potential well. Apart from helping to understand about details of finite potential well, this simulation presents the importance and beauty of computational physics.

Acknowledgement:
I acknowledge Prof. Dr. Narayan P. Adhikari for his suggestion and help to do this simulation work.

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Lise Meitner was an Austrian physicist who worked on radioactivity and nuclear physics. Otto Hahn and Meitner led the small group of scientists who first discovered nuclear fission of uranium when it absorbed an extra neutron; the results were published in early 1939. Meitner and Otto Frisch understood that the fission process, which splits the atomic nucleus of uranium into two smaller nuclei, must be accompanied by an enormous release of energy. This process is the basis of the nuclear weapons that were developed in the U.S. during World War II and used against Japan in 1945. Nuclear fission is also the process exploited by nuclear reactors to generate electricity.

Meitner spent most of her scientific career in Berlin, Germany where she was a physics professor and a department head at the Kaiser Wilhelm Institute; she was the first woman to become a full professor of physics in Germany. She lost these positions in the 1930s because of the anti-Jewish race laws of Nazi Germany, and in 1938 she fled to Sweden, where she lived for many years, ultimately becoming a Swedish citizen. Meitner received many awards and honors late in her life, but she did not share in the 1944 Nobel Prize in Chemistry for nuclear fission that was awarded exclusively to her long-time collaborator Otto Hahn. In the 1990s, the records of the committee that decided on that prize were opened. Based on this information, several scientists and journalists have called her exclusion "unjust", and Meitner has received a flurry of posthumous honors, including the naming of chemical element 109 as meitnerium in 1997.

Physics in War and Heisenberg Controversy

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ABSTRACT

World knows that the Germany lost the Second World War. In the defeat of Germany the role played by physics was unforgettable. How German Nuclear Weapon Project failed? What role did betrayal, sabotage and power of physicist play in the Second World War? How Heisenberg, one of the German theoretical physicist, who used to be happy in quantum realm put himself under the contradictory pressure of war and politics?In this article I will try to find answers to these questions.

"*When men are engaged in war and conquest the tools of science becomes as dangerous as a razor in the hands of child. The fate of mankind depends entirely on our sense of morality*."-Albert Einstein

Einstein was correct. It has been seventy years since the world war has ended, the effect of it can still felt today. This fiercest conflict in the history cost over eighty five million lives, destroyed one trillion dollar in property, and inflicted economic, social and political wounds that have never healed. In fact this war was not merely the war between axis and allies, it was the racing between German and allies physicist, competition of science and the demonstration of early stage of nuclear arm race. Physics in particular was given lion's share of credit for the success of allies' forces and the war is often considered as "the physicist war". The use of atomic weapon in the Second World War force the human mankind to reanalyze the use of physics in war, whose ethical justification are still debated.

With arising conflict between the rival nations, it had become clearer that the wars are fought not only in battle field; it is the struggle between scientific technologies, practical utilization of physics and over all military potential. Development and use of Radar, establishment of ambitious Manhattan Project and Cryptanalysis project were some of its example. It is often believed that the atomic bomb ended the war, but it was radar that won the war. In Second World War radar was developed by Britain by the combined effort of Watson Watt, Tizard and Dowding which empowered air defense technique and helped to destroy enemy aircraft coming from afar in dark and fog. The head of the physics department of MIT, John C- Slater made a great contribution to radar research. His work contributed in the development of X-band magnetron, which made radar possible to use for defense purpose.

The discovery of nuclear fission by German physicists Otto Hahn and Strassmann made the development of atom bomb theoretically possible, so both allies and axis power accelerated their research in the field of nuclear chain reaction. In 1939, Einstein wrote letter to American president Franklin D. Roosevelt warning that Germany could make the extremely powerful nuclear bomb. In fact continued German aggression forced some physicist to think that Germany might be working on an atom bomb. Among those concerned were physicist Leo Szilard and Eugene Wigner. But they had no influence with those in power so they explained the problem with Einstein. When Roosevelt received the letter, he gave order to investigate the issue raised by the letter. As a result Manhattan project was established for the production of nuclear weapon where as Germany designed German nuclear weapon project. Allies physicist had fear that the Germany could first make the atom bomb which can be seen in Oppenheimer's statement, "It is possible that the German will have by the end of this year, enough material accumulated to make large number of atomic bombs which they will release at the same time on England, Russia and this country.

Figure 1: *Physicist J. Robert Oppenheimer at Oak Ridge on February 14, 1946. Oppenheimer was called "father of the atomic bomb" for his role as the head of the secret weapon laboratory.*

Manhattan project was led by the renowned physicists like Oppenheimer, Enrico Fermi, Ernest O. Lawrence, and Compton and was inspired by celebrated physicist like Einstein. In this ambitious project more than one lakh people were employed and about two billion dollar (about 26 billion dollar in 2016) was invested. The group of brilliant physicist devoted to project used three different techniques for isotope separation i.e. to separate uranium-235 from uranium-238. Lawrence and his team used electromagnetic separation, while Philip Abelson investigated thermal diffusion and Murphree directed his research into gaseous diffusion.

Research was carried out in two different ways on the basis of nuclear reactor technology. Harold Urey's team used heavy water as neutron moderator whereas Arthur Compton forwarded his research using graphite. The use of graphite instead of heavy water made all the differences in the result of war. The main reason that Germany lost the war was due to the fact that Heisenberg denied forwarding the research using graphite.

Figure 2: *A 1940 meeting at Berkeley with (from left to right) Ernest O. Lawrence, Arthur G. Compton, Vannevar Bush, James B. Conant, Karl T. Compton and Alfred L. Loomis.*

Despite of many efforts of Walther Bothe, he could not convinced Heisenberg to use graphite as a neutron moderator. Heisenberg wrote that "Pure graphite was less suitable as a moderator in a uranium pile than had it first seemed" which would indicate that Germany would continue its research using heavy water which they used to obtain from the plant in Norway. But unfortunately, in the February of 1943, a team of saboteurs destroyed the facility which is popularly known as "*Norwegian Heavy water Sabotage*". So Germany was left with only two and half ton of heavy water for further experiment and hence was one of the major factors which prevent Germany to achieve self-sustaining atomic reaction. In fact Heisenberg did not know that the graphite they had tried was too impure to sustain chain reaction. So despite of having brilliant minds likeWernerHeisenbergWalther Gerlach, Erich Schumann, Walther Bothe, Germannuclear project couldn't succeed.

Figure 3: *The German experimental nuclear pile at Haigerloch.*

Heisenberg controversy

Werner Heisenberg, father of uncertainty principle and charismatic figure, who has always been a source of inspiration for many young physicists, played central role in the development of German nuclear weapon project. The dependency of project on Heisenberg can be felt by the statement of one of the noble laureate who fled away from Germany, "If anybody in the world could make the atomic bomb, Heisenberg could". It has been about forty years Heisenberg had died, historian of science continued to debate the role he played during Second World War. Some even raised serious doubt about his personal morality. Some blamed him as a moody scientist who was guided by the German anti-Semitic mentality.

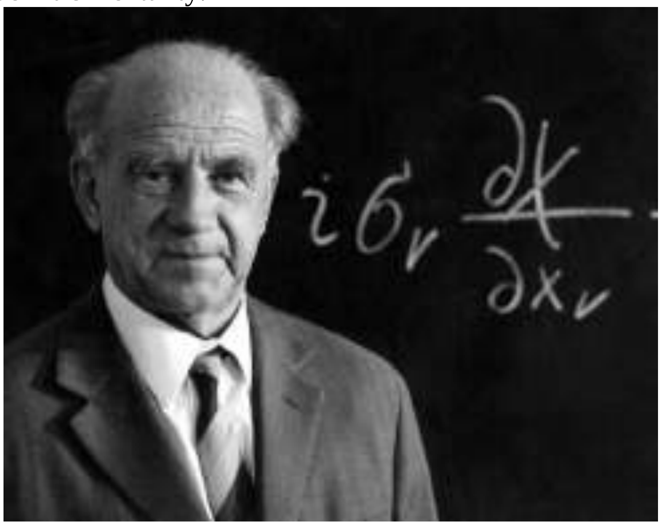

Figure 4: *Werner Heisenberg (1901-1976)*

On the other hand some believed that Heisenberg could have made atom bomb but he deliberately delayed the project because he didn't want to give atom bomb in Hitler's hand. It can be more clarified by the statement said by Heisenberg to Otto Hahn, "*If the German had been in the same position as the American and said themselves that nothing mattered except that Hitler should win the war, they might have succeeded where as in fact they didn't want him to win*". This fact becomes clearer after the war. By the time America dropped '*Little Boy*' in Hiroshima, most of the leading German physicists were detained by western allies and interned in Farm Hall. British intelligence had kept microphone in Farm Hall to know the extent of strategy of German physicists. One of the bugged conversations supports the Heisenberg previous statement. Carl von Weizsacker, one of detainee explained; "*I believe that the reason we didn't do it was because all the physicists didn't want to do it, on principle. If we had all wanted Germany to win the war, we would have succeeded*".

Conclusion

Whatever the historians say about Heisenberg, I strongly believe that the association of Heisenberg with Nazi regime was one of the fundamental reasons which psychologically made many historians to raise questions about Heisenberg character. Heisenberg was fine theoretical physicist but might be due to lack of his experimental skills German nuclear weapon project could not succeeded and there might be many reasons political, economical, strategical in the failure of German nuclear weapon project but most importantly Enrico Fermi was not with them: a scientific Manhattan leader who had a "*unique double aptitude for theoretical and experimental work*".

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PHYSICS NEWS 2016

Neutrino Magnetohydrodynamics

Neutrinos interact only weakly with ordinary matter. Yet in certain astrophysical contexts, such as supernova explosions, the coupled interactions between neutrinos and dense, highly ionized plasma contribute significantly to a system's evolution. Modeling such systems is complicated enough even in the absence of neutrinos, and it normally requires analytic approximations or detailed numerical simulations. Adding neutrino effects entails further compromises; past approaches, for example, typically consider energy exchange between neutrinos and a neutral fluid. Now Fernando Haas and Kellen Alves Pascoal (*Federal University of Rio Grande do Sul, Brazil)* and Tito Mendonça *(University of Lisbon, Portugal)* propose a new framework for integrating relevant aspects of neutrino and plasma physics. Their approach, which they dub neutrino magnetohydrodynamics (NMHD), systematically extends MHD, which treats a plasma's electrons and ions as fluids and considers the dynamics of the magnetic field they produce, to include the weak interaction, which in particle physics describes the coupling between neutrinos and electrons. Adopting standard simplifying assumptions from MHD theory, the researchers obtain a set of 11 coupled partial differential equations that they show should hold over a range of astrophysical conditions. In particular, they find that neutrinos can prevent magnetic field lines from freezing, even in an ideal plasma. They also derive a new, neutrino-driven plasma instability that should play a central role in a supernova's strongly magnetized environment. **(F. Haas, K. A. Pascoal, J. T. Mendonça, *Phys. Plasmas 23 , 012104, 2016.)***

Anaximander (BC 600) is responsible for the idea that the earth needs nothing below it to support it. He said that the earth floats in the center of infinity, held in position because it is an equal distance from all the other parts of the universe. In doing so, he transformed the way we think of our planet and simultaneously introduced the idea of a force of attraction between the earth and the planets and stars in the heavens.

The Invisible Universe

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ABSTRACT
Dark matter is a type of matter that cannot be seen with telescope but accounts for most of the matter in the universe. The existence and properties of dark matter inferred from its gravitational effects on visible matter, on radiation, and on the large-scale structure of the universe. Dark matter has not been detected directly, making it one of the greatest mysteries in modern astrophysics. Dark matter neither emits nor absorbs light or any other electromagnetic radiation at any significant level.

Introduction

According to the plank's mission team, and based on the standard model of cosmology, the total mass- energy of the known universe contains 4.9 % ordinary (baryonic) matter, 26.8% dark matter and 68.3% dark energy. Thus the dark matter is estimated to constitute 84.5% of the total matter in the universe, while dark energy plus dark matter constitute 95.1% of the total mass- energy constant of the universe. To the human eye, space appears serene and void but to the "eye" of an X- ray telescope, the universe is totally different- a violent, vibrant, and ever- changing place. Temperatures can reach millions of degrees and objects are accelerated by gravity to nearly the speed of light and magnetic fields more than trillions time stronger than the Earth's cause some stars to crack and tremble.

The Chandra X- ray telescope is NASA's space telescope which is upto 50 times more sensitive than only X- ray telescope before it. Chandra X-ray observatory, will allow scientists from around the world to obtain unprecedented X- ray images of these and other exotic environments to help understand the structure and evolution of the universe. The observatory will serve as a unique tool to study detailed in a laboratory that cannot be replicated here on Earth- the universe itself.

Figure 1: *NASA's great observatories weigh massive young galaxy cluster[2].*

The Chandra X-ray observatory will provide unique and crucial information on the nature of objects ranging from comets in our solar system to quasars at the edge of the observable universe. The observatory will provides answers to some questions, such as what and where is the "*Dark Matter*" in our universe? Galaxy clusters are largest and most massive objects in the universe. These galaxies are bound together into a cluster by gravity. Observations with the Chandra X-ray observatory will map the location of the dark matter and help us to identity it.

Astronomers have used data from three of NASA's great observatories to make the most detailed study yet of an extremely massive young galaxy clusters. This rare cluster, which is located 10 billion light years from the Earth, weighs as much as 500 trillion suns.This object has important implications for understanding how these megastructures form.

The centers of many distant galaxies are incredible sources of energy and radiation - specially X – rays. Researchers theorize that massive black holes are at the centre of the active galaxies, gobbling up any material- even a whole star that passes too close. Detailed studies with the Chandra X-ray observatory can probe the faintest of these active galaxies, and study not only how their energy output change with time, but also how these objects produce their intense energy emission in the first place.

We know that X-rays are absorbed by the Earth's atmosphere, space based observatories are necessary to study these phenomena. To meet this scientific challenge the Chandra X-ray observatory, NASA's most powerful X-ray telescope was launched in July 1999. Complementing two other space observatories now orbiting Earth- the Hubble space Telescope and the Compton gamma ray observatory – this observatory studies X-rays rather than visible light or gamma rays.

The observatory will allow scientists to analyze some of the greatest mysteries of the universe. The Chandra X-ray observatory was carried into low earth orbit by the space shuttle Columbia. The observatory was deployed from the settle's cargo bay at 155 miles above the Earth. Two firing of an attached inertial upper stage rocket and several firing of its own on-board rocket motors after separating from the inertial upper stage placed the observatory into its working orbit.

Unlike the Hubble space telescope's circular orbit that is relatively close to the Earth, the Chandra x-ray observatory was placed in a highly elliptical (oval shaped) orbit. At its closest approach to Earth, the observatory will be at attitude of about 6,000 miles. At it's farthest, 86,400 miles. It travels almost the third of way to the moon. Due to this elliptical orbit, the observatory circles the Earth every 64 hours, carrying it far outside the belts of radiation that surround our planet. This radiation while harmless to life on Earth can overwhelm the observatory's sensitive instruments. The X-ray observatory is outside this radiation long enough to take 55 hours of uninterrupted observations during each orbit. During periods of interference from Earth's radiation belts, scientific observations are not taken. The Chandra X-ray Observatory has three major elements. They are the spacecraft system, the telescope system

The Spacecraft System

The spacecraft module contains computers, communication antennas and data recorders to transmit and receive information between the observatory and ground stations. The onboard computers and sensors, with ground-based control center assistance, command and control the vehicle and monitor its health during its expected five-year lifetime. The spacecraft module also provides rocket propulsion to move and aim the entire observatory, an aspect camera that tells the observatory its position relative to the stars, and a Sun sensor that protects it from excessive light. Electrical power is provided by solar arrays that also charge three nickel-hydrogen batteries that provide backup power.

Observatory Operations

The Smithsonian Astrophysical Observatory controls science and flight operations of the Chandra X-ray Observatory for NASA from Cambridge, Mass. The Smithsonian manages two electronically linked facilities – the Operations Control Center and the Science Center

The evidence for powerful blasts produced by a giant black hole has been discovered using NASA's Chandra X- ray observatory. This is one of the nearest supermassive Blackholes to Earth that is currently undergoing such violent outbursts.

Figure 2: *NASA's Chandra finds supermassive blackhole [3].*

Astronomers found this outburst in the supermassive blackhole centred in the small galaxies NGC 5195. This companion galaxy is merging with a large spiral galaxy NGC 5194, also known as " The whirlpool". Both of these galaxies are in the messier 51 galaxy system, located about 26 million light years from the Earth.

In Chandra's data, Schelegel and his colleagues detect two arcs of X- ray emission close to the center of NGC5195. "*We think these arcs represents fossils from two enormous blasts when the blackhole expelled material outwards into the galaxy*", said co-author Christine Jones of the Harvard- Smithsonian centre for Astrophysics (CFA). These results were presented in January 2016 at the 227th meeting of the American Astronomical society.

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Physicists at CERN have discovered four new "tetraquark" particles – unusual arrangements of four fundamental particles called quarks. The new particles are highly unstable, decaying almost immediately into other particles. The new particles are called "exotic" because they are made of four quarks. Quarks usually group together in twos and threes. Physicists at the Large Hadron Collider beauty (LHCb) collaboration made the discoveries by monitoring the decays of B mesons (so-called beauty particles) formed in CERN's Large Hadron Collider. The results have not yet been peer reviewed, but have been published in two papers on the arXiv.org pre-print server, where physicists share their results prior to peer review.

Prediction and Detection of Gravitational Radiation

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ABSTRACT
The genius man Einstein formulated General theory of relativity (GTR) by using tensor algebra to explore hidden fact about Universe. GTR tell us that matter (Energy and Momentum) curves space-time geometry. Therefore as the matter moves (i.e. planets), curvature of space-time change continuously and ripple of flow of Energy can be obtained. These ripples are called gravitational-radiation.

Introduction

One of the greatest achievements of **GTR** is Prediction of Gravitational Radiation. Since there is many analogous between electromagnetic radiation and Gravitational Radiation we solve Einstein field equation like Maxwell equation. Mathematically there are two approaches to describe Gravitational Radiation the simplest one is weak field approximation. In this method we simply solve Einstein field equation in Newtonian limit (weak static field) and making linear differential wave equation like Maxwell equation by imposing harmonic coordinate condition: $g^{ab}\,\Gamma^{c}{}_{ab} = 0$ gives $\Box^2 h_{ab} = 0$. Its solution predicts Gravitational Radiation analogous to Maxwell equation. Its solution predicts that Gravitational Radiation have only two polarization state i.e. $e_{xx} = -e_{yy}$ and e_{xy} with helicity 2. These polarization tensor tell us that '+' and '×' polarization as in figure below.

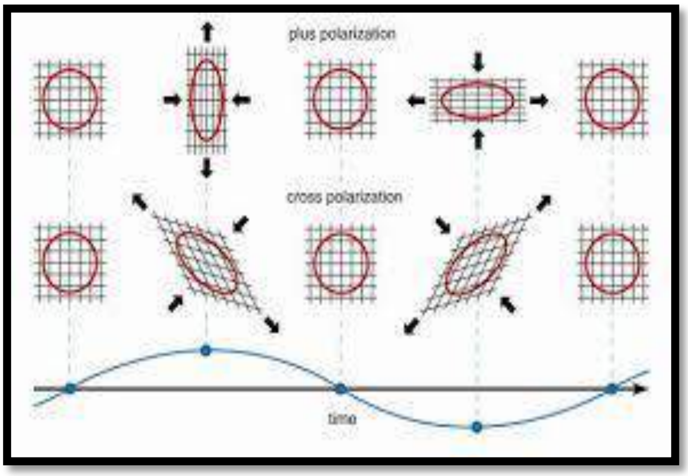

Figure 1: *Polarization[4]*

These polarization are at 180° .The wave solution of field equation predicts many properties like scattering, absorption and Energy momentum of Gravitational Radiation.

Many physical phenomena in the universe cannot be explained by electromagnetic radiation (interaction) i.e. supernova explosion, Black hole –black hole merging. In such a case only Gravitational Radiation can explain because electromagnetic radiation are scattered out. About 96% of universe (dark energy, dark matter) cannot be explained by electromagnetic interaction but Gravitational Radiation can explain it because dark energy, dark matter doesn't have charge but have energy and momentum. The origin of universe (big-bang) can only be explained by Gravitational Radiation because of huge amount of energy released in big-bang process. Thus its detection is very important to understand universe more closely. To detect Gravitational Radiation there are many experimental set up among them few are described below:

1. **Resonant mass detector**: This is similar to principle of linear harmonic oscillator. In this detector initially no oscillation (damped) is obtained but in the presence of Gravitational Radiation damped oscillation can be seen and we can detect it. The first laboratory detector built by **Joseph weber** in the 1960s. Due to very low amplitude of Gravitational Radiation obtained in this process it is not a good detector.
2. **Space craft tracking**: in this detector we use communication data between earth and interplanetary space craft. By analysing small fluctuation in the time of radio signal sent to space craft we can detect it. Due to solar wind, noises are produced and its sensitivity is not high as required.
3. **Laser interferometer**: This is very advance and large experimental set up. It uses simple interferometer principle and it has very high sensitivity. There are many laser interferometer like **Ligo**, **Vigro** in Italy(3km), **Geo** 600 in Germany(600m) and **Tama300** in Japan(300m) detector etc. Among these detector currently Ligo predicted the Gravitational Radiation successfully. Among above detector Ligo is explained below:

LIGO (Laser Interferometer Gravitational wave Observatory):

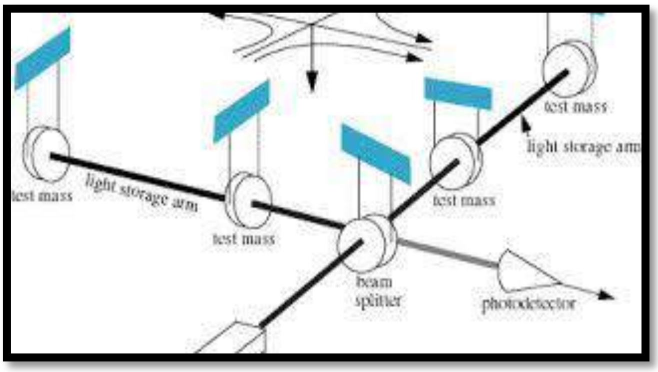

Figure 2: *Sketch of LIGO project[4]*

It is large scale experimental laboratory cofounded in 1992 by **Kip Thorne** and **Ronald Drever** of Caltech and Rainer weiss of MIT. It is joint project between scientist at MIT, Caltech and many universities.

Initial Ligo operation between 2002 and 2010 failed to detect Gravitational Radiation so its sensitivity is improved and advance ligo version which is 4 times stronger than initial ligo is used. In 2015 to such advance detector was used (one in Livingston, Louisiana and other in Handford, Washington. Its mission is to directly detect Gravitational Radiation as predicted by Einstein in 1916. It has two long armed (one is 4 km and another is 2 km) sensitive tunnel. In this interferomete, the laser beam splitted and going to the two tunnels and back and forth due to mirror present at the end of this tunnel. In the absence of Gravitational Radiation these two laser beam have same phase and cancel out. But in the presence of Gravitational Radiation it stretch and compress space-time geometry and wavelength of laser beam changed and phase also changed. This changed is captured in detector. Ligo experimentally detect Gravitational Radiation due to merging of two black hole which is 1.3 billion light year ago and announced recently in 11 February 2016.

Due to detection of Gravitational Radiation we are now can explain dark energy, dark matter, energy released during big-bang, many large explsion, properties of space-time geometry. Its detection opens new way towards the universe.

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PHYSICS NEWS 2016

Quantum Entanglement: Loophole Free

Quantum mechanics posits that a measurement on one of two entangled systems instantly changes the wavefunction of the other, no matter how distant. Might that counterintuitive effect be avoided through a supplementary theory of local hidden variables, in which a measurement's outcome depends only on events in its past light cone? In 1964 John Bell showed that the question is not merely philosophical: The two types of theory can be distinguished through a series of measurements on separated systems. Experimental Bell tests have come down on the side of quantum mechanics, but until recently, they've all failed to close one or more important loopholes. The so-called locality loophole is open when the measurements are too slow, so a hidden light-speed signal emanating from one might affect the outcome of the other; the detection loophole is open when the measurements are too inefficient, so the detected trials could display entanglement-like correlations even when the set of all trials does not. Now three groups have demonstrated experiments that close both those loopholes simultaneously. First, Ronald Hanson and colleagues (Delft University of Technology) performed a Bell test on two diamond defect spins located in labs 1.3 km apart. They prepared the spins using an entanglement-swapping scheme, as sketched in the figure: entangling each spin with a photon, then jointly measuring the photons at a central location. Each spin was then measured in a basis chosen by a random number generator (RNG). More recently, groups led by Sae Woo Nam (NIST) and Anton Zeilinger (University of Vienna) used a more conventional setup: generating entangled photons at a central source and then measuring them at detectors tens of meters away. The loophole-free results are important, not so much as proof that quantum entanglement is real, but as a stepping stone toward perfectly secure quantum cryptography: Methods for fooling Bell tests on purpose by exploiting the loopholes are similar to those for hacking quantum cryptosystems ***(see Physics Today , December 2011, page 20). (B. Hensen et al., Nature 526 , 682, 2015; L. K. Shalm et al., http://arxiv.org/abs/1511.03189; M. Giustina et al., http://arxiv.org/abs/1511.03190.)***

Einstein Quantum Debate to Black Hole Entropy

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ABSTRACT
The entanglement entropy is very important phenomena in field of physics, which deals with various fields such as quantum gravity, quantum information theory and condensed matter physics as well. Its demand is very high in recent age to solve the elusive phenomena such as Schrödinger's cat paradox in microstate, black hole information paradox as well. Whether one macro sate hidden the microstate can define all the nature of black hole ascribing the entropy or not.

Introduction:

If we suppose a cup of tea thrown with entropy into a black hole, once it cross the boundary surface of event horizon; the term entropy would disappear. Hence, at glance, this stuff manifests that second law of thermodynamic explicitly violates, which states that entropy never decreases in nature. This means that randomness propriety even preserves by a cup of tea but cannot hold it longer time once again black hole had absorbed its entropy and settle-down.

Usually, General theory of Relativity deals with macroscopic particles (gravity and curvature of space-time), whereas quantum mechanics deals with microscopic particle (sub – atomic and, their components). In 1915, Einstein, who published beautiful theory so called General theory of Relativity, which changed to concept of the Universe. The General theory of relativity helps to understand the space and time more, which probes the time as new dimension in space.

A black hole may depict as a deformity in space-time, or locale of very high curvature. Is there any stuff to associate entropy with it? Is this possible at all?

There are some concepts to understand the black hole entropy (Bekenstein 1972, 1973)

a. A black hole, which is usually formed from the collapse of quantity of matter and radiation, its entropy never, vanished. However, an observer, who is sitting outside cannot accessibly carrying contents and interior's phenomena of hole based on entropy. Thus, a thermodynamics deception of the collapse of matter and gravitational wave (radiation) would not make any base of entropy from observer viewpoint because these are unobservable.
b. According to Ruffini and Wheeler (1971), there are three parameter such as mass (M), electric charge (Q) and angular momentum (J) for thermodynamics black hole.

In thermodynamics, many internal system of microstate are all compatible with the one macro (state).i.e. multiplicity.

Bekenstein was one of those brilliant minds who motivated some conjecture term in between black hole entropy and black hole surface area with the help of Hawking radiation that changed the concept of black hole's entropy. The definition of black hole entropy introduced in between second law of thermodynamics and "area theorem"; black hole entropy is directly proportional to its surface area A, that means" event horizon of black hole never decrease; it increases in most transformations of the black hole".

$$S_{BH} = \text{surface area of even horizon}/\ 4G_N$$
$$= (k_B A)/\ (4L_P^2) = c^3 A/\ (4G_N \hbar) \qquad \dots \dots \quad (1)$$

This is called the *Bekenstein- Hawking entropy* for black hole. Where $L_P = (\hbar G_N / c^3)^{1/2}$ is called Planck length. G_N stands for Newton's gravity, ħ = Planck – Dirac constant. The generalized second law of thermodynamics was introduced (example of cup of tea®) which states that the sum of total black hole entropy S_{BH} and the ordinary entropy of matter and radiation fields in the black hole outer region S_O, never decrease.

$$(\Delta S_o + \Delta S_{BH}) \geq 0 \qquad \dots \dots \qquad (2)$$

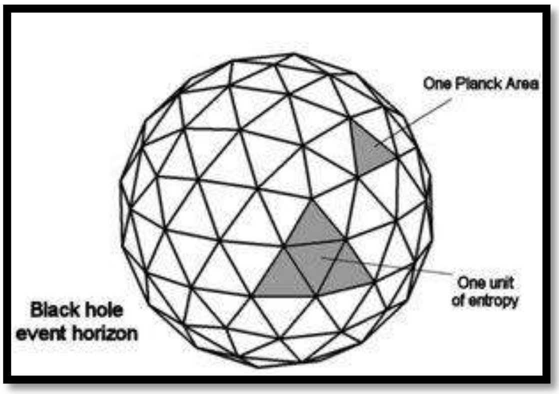

Figure 1: *Bekenstein- Hawking entropy is ¼ unit a Planck area spans by event horizon of a black hole.*

The Paradox's Origin:

The main focal point of origin of a heated debated between Einstein and Bohr for understanding of quantum world. In second decades of 19^{th} century, the quantum mechanics was a milestone for Albert Einstein to convince. In 1935, Einstein, Podolsky and Rosen (EPR) states the concept of quantum entangled by taking an example; To measure position of one particle at S_2 , one could infer other position of particle S_1 that probes the same momentum , even at arbitrary distance, which contraries the non-locality Copenhagen Interpretation of Quantum mechanics. Even Einstein redefined (1946) the EPR's paper (1935); could not get any logical justification of quantum entanglement. i.e. are these really entangled happen even one particle is situated here and other the edge of galaxy? In other hand, Schrödinger's cat paradox has still risen up as an elusive problem, whether cat dead or alive in same quantum state or not. Is this possible in real world or not?

Quantum entanglement is an elusive phenomenon that occurs when pair of particle is inextricably interlinked together, even at arbitrary distance, in such way that action performs on one particle have an effect on other one. for e.g. Imagine one electron is situated here , other the edge of our galaxy, to measure their spinning “UP” one electron has fifty per cent of time and the same percent “DOWN” occur. Von-Neumann later used the term entanglement in the case of black hole to introduce the entropy-Entanglement entropy.

Definition of entanglement entropy

Consider a system divides as two subsystems A and B as shown in fig below. We put such system at zero temperature and, total system is described by pure quantum ground state $I\psi\rangle$. Thus, density matrix for pure quantum state is defined by:

$\rho_{total} = I\psi\rangle\langle\psi I$

In this case, von- Neumann entropy at total system is solely vanished, $S_A = - tr_A\, \rho_A \log \rho_A = 0$.

Now, Von-Neumann entropy or entanglement entropy defines the subsystem A as follows:

$$S_A = - tr_A\, \rho_A \log \rho_A \;,\; \rho_A = tr_B\, I\psi\rangle\langle\psi I \qquad \ldots.. \quad (1)$$

where ρ_A represents the reduced matrix, which can be calculated by partial tracing over subsystem B of total density ρ. To illustrate this figure, for e.g. at black hole event horizon time being constant, S_A as a entropy measure for subsystem A who are sitting outer region where the system B is considering inside region of a black hole horizon.

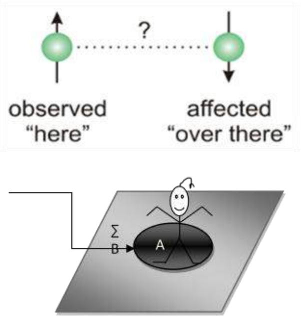

Figure 2: *2D flat surface containing surface areas B enclosed the subsystem A.*

This manifest to agree with convenient approach to measure how closely entangled a given wave function.

Two Challenge: Entropy and Information

Black holes are regions of space so dense that nothing even light, can escape. A black hole formed by collapsing the matter and radiation both contains the entropy. I.e. information never lost. In the case of quantum phenomena, energy and information may escape from black hole. What Hawking demonstrated the entanglement concept over black hole nearby its horizon-pair of particle appears, where the black hole eats one particle (reduced black hole mass very slightly), other escaped as carrying energy from event horizon. In the case, quantum particle entangled at same state in instant, according to hawking – “*information paradox*”.

More precisely, one could look at the area law of black hole entropy and ask what are the roles of microstate to probe the entropy? As we know that one macro state always hides the multiplicity of microstate, say (S).The system at which state of each constituent defines the microstate. In case of black of entropy, there are basic three basic parameter include to understand the entropy in the ordinary view point i.e. Mass (M), charge (Q), angular momentum (J) of black hole. We can write, $S_{BH} = S_{BH}(M,Q,J)$. If any one alters its value arbitrarily, no variation in area of black hole takes place (see eq^n -1).

Moreover, Von- Neumann entropy of a black implies that there is no any signal received by observer who are sitting on the subsystem A, presumed that other subsystem B is an analogous to inside of a black hole horizon. For e.g. , If Saya fell down into the black hole and Atit stayed safely outside. Atit thought that Saya has a poor condition; even he could not get any voice from event horizon. Nevertheless, there would not seem as scenarios of Saya what Atit thought like that. If so, can we measure the state of Saya’s poor condition by the help of Atit? Would there be possible to exchange the love? It may be possible- imagine Atit and Saya try to tearing up the pair of photons apart, their love still persist.

Conclusion

Bell’s experiment provides more relief to understand the Einstein’s spooky action at a distance (quantum entangled) and, help to connect non-locality Copenhagen interpretation of Quantum mechanics experimentally. The EPR debate to Bell approach birth a new soup of quantum mechanics – quantum entanglement. Bekeinstein’s contribution was also a remarkable in the history of black hole thermodynamics, where the entropy of a black hole depends on its surface area not a volume. Last but not the least, Von- Neumann entropy is delight traced out to the core concept of mysterious of a black and, condensed matter physic as well. This stuff is very important in the quantum world.

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Radiation Exposure Complexities

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ABSTRACT
Different types of observable health effects are seen if a human being is exposed to radiation above the tolerances limit whether it is occupational, patient as direct receiver, accidental receiver due to explosion and disaster. Acute effects and delayed effects like cancer of different parts of a body is observed due to radiation overexposure.

Radiation is often categorized as either ionising or non-ionising depending on energy of radiated particles. High energy radiation, such as gamma rays , x-rays, high energy UV-rays possessing sufficient amount of energy to damage DNA of both cancerous and healthy cells is known as ionising radiation. Whereas low energy UV rays, visible lights, microwaves, radiowaves, etc. are classified as non-ionising radiations. Someone exposed to radiation means that the person or body interacted with radiation to some extent. Radiation dose is the energy deposited in our cells, tissues due to radiation exposure. It is measured in Gray, Sievert, rem, rad.

- 1 Gray(Gy) = 1 J/Kg and 1 Gy = 100 rad
- 1 Sievert(Sv) =1J/Kg and 1 Sv = 100 rem

Figure 1: *Emission of gamma rays during nuclear explosion*

When atoms in living cells become ionised one of the three things usually happens - the cell dies, the cell repairs itself, or the cell mutates incorrectly and can be cancerous. Radiation therapy is effective in cancer treatment because cancerous cells can be killed or controlled by the radiation exposed to the targeted volume. However nearby healthy cells and tissues are also damaged , but they can repair and recover soon. Background radiation has very less effect overall in the organism but when exposed to larger amount , even for short duration, can cause defects, radiation poisoning, and even death may occur. In smaller amount, human beings too, are radioactive due to presence of potassium-40 which does account 0.012 percent of entire worlds potassium. If you eat banana a day for a year, you are exposing yourself to about 3.6 mrem (0.036 mSv) because of potassium present in banana. Scientists are in complete agreement that doses greater than 50 rem (0.5 Sv) cause observable acute health effects. The expert have determined that exposure to doses of 10-50 rem (0.1-0.5 Sv) may increase our chances of cancer. Above 100 rem (1 Sv), if you receive, even for short time, you might experience nausea, fatigue, etc and would require medical attention. Above 500 rem (5 Sv) in short period of time may cause death within few days.

All the system works in a highly coordinated manner to produce a unified individual. Whole body radiation overexposure affects all the organs and systems of the body. However, since the radiosensitivities of all the organs and system vary, the pattern of response, diseased syndrome in an overexposed individual depends on the magnitude of the dose. Nausea, vomiting, malaise, fatigue, rise in temperature, blood change are common to all categories.

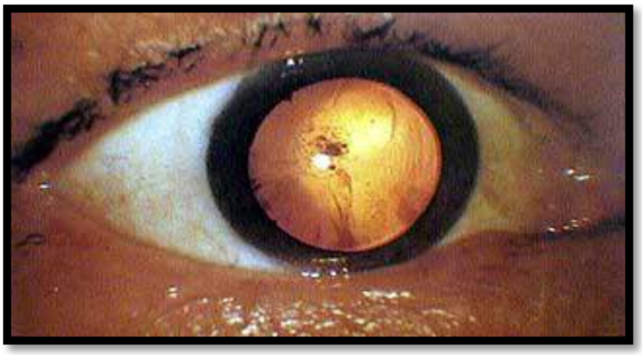

Figure 2: *Cataract of eye lens because of atom bombing*

Changes in blood count has seen in the individual with wholebody-gamma-ray doses when the dose is as low as 140 mGy and are almost certain to appear when the dose is greater than about 500 mGy. After an acute sublethal dose blood counts falls very sharply until a minimum is reached and slow recovery takes place within weeks to several months. Death may occur between one and two months after exposure if medical intervention is not successful. Plutonium a radioactive materials, is found to be accumulated in the periosteum, endosteum and trabaculae of the bone. All the bone seekers are considered toxic because small amount can damage the radiosensitive bone cells and hemopoietic tissue in bone marrow leading to bone cancer, anemia, and hemopoietic syndrome. On 4 July, 1934, Marie Curie, famous physicist and Nobel laureate, died from aplastic anemia (a rare disease in which bone marrow and hemopoietic stem cells that resides there, are damaged), believed to have been suffered from her long-term exposure to radiation.

The Gastro Intestinal syndrome follows a total body dose of about 10 Gy or greater and Central Nervous System syndrome occurs dose in excess about 20 Gy. Deaths within several weeks in GI syndrome, and within hours to several days in CNS syndrome is most likely outcome despite heroic medical efforts.

The Gonads are particularly more radiosensitive. A single dose of only 300 mGy to the testes may result in temporary sterility and exposure to gonads less than 4.4 Gy, may lead to aspermatic among men for several years. For women, a 3 Gy dose to ovaries may lead to temporary sterility. The threshold radiation dose for permanent sterility in men is 3500-6000 mGy , and for women 2500-6000 mGy. Similarly, teratogenic effects can result from radiation exposure of an embryo or foetus. When the radiation dose in equal to or greater than 0.15 Gy in 3-7 weeks of gestation period and 0.25 Gy after, it can lead to malformation, retardation, congenital effects, cancer induction, foetal death. At the very first weeks embryonic cells tend to be killed rather than survive a teratogenic radiation dose. Cataracts have been observed among many physicists working with radionuclide including Marie Curie, nuclear bomb survivors. On the basis of occupational exposure data it is estimated that the fast neutron threshold dose for cataracts in human lies between 0.15 and 0.45 Gy.

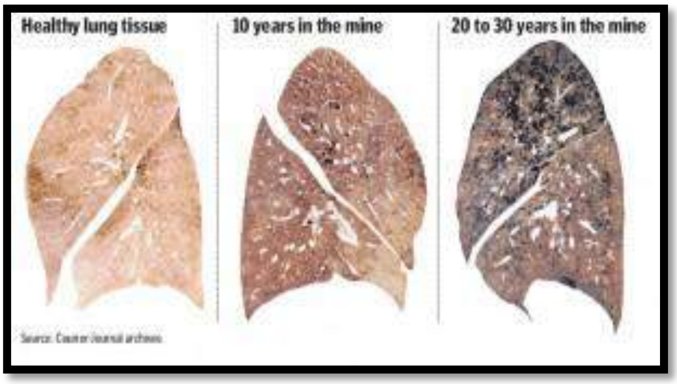

Figure 3: *Stages of lungs among minors.*

Carcinoma of skin was the first type of malignancy associated with exposure to x-rays among early x-ray workers, physicists, physicians and dentists. Other problems such as erythema, pigmentation, epilation, blistering, necrosis, and ulceration are seen when dose exposure of about 3Gy and more. Within threshold dose or higher there will be healing due to regeneration of the cells around the perimeter. Leukemia is one of the most likely forms of malignancy resulting from whole body exposure to radiation.

It is seen among the nuclear bomb survivors, especially children appeared about two years after attack and peaked around four to six years later. Irene Joliot-Curie, a Nobel laureate in Chemistry, died due to leukemia and was believed due to long term overexposure and an accidental overexposure of polonium exploded on her laboratory in 1946. *Bergkrankheit* (miner's disease) was known to be lung cancer only about 100 years ago. Overexposure to external radiation may cause lung cancer as large incidence of lung cancer is seen in a large number of women undergoing radiotherapy for cancer in uterine cervix. It was also significantly seen on Japanese bomb survivors. A dose of 1 Gy is estimated to increase to increase the likelihood of dying from lung cancer by about 32 percent in men and 40 percent in women. The threshold dose of thyroid cancer was estimated to range from 0.0008 mGy to 2842 mGy with a median value of 104 mGy. A relatively large number of children and adults were reported of thyroid cancers in both nuclear weapon testing program in Nevada and Chernobyl nuclear power point disaster.

Although overexposure to radiation increases the likelihood of cancer, no physician, no matter how expert he or she is in pathology can say with certainty that any particular cancer would not have occurred if the patient had not exposed to radiation. Association of cancer with radiation exposure can be made only statistically through, epidemiological studies though such data are contradictory and inconclusive. Monitoring devices also helps to know the degree of exposure, from which occupational personnel can be careful.

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Are Mars' moons Phobos and Deimos captured asteroids or were they born in a collision, like our moon? New simulations suggest the latter – and the crash also spawned another larger moon that was torn apart and tumbled onto the planet's surface a mere five million years later. Planetary scientists from Belgium, France and Japan simulated collisions between the young Mars and a protoplanet about a third its size.

Cosmic Rulers

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ABSTRACT

In this article I will explain the importance of precise distancecalculation of large scale structure and and its use in explaining theoreies in gravitation and cosmology.

Cosmology is the study the universe on its largest scales. The Planets of our solar system, the sun and the stars beyond, make up only a tiny fraction of the whole universe. Beyond the stars we see in the sky, emerging from the dark empty space in-between, distant galaxies that are themselves large collections of stars and planets.

Figure 1: *The SDSS 2.5-meter optical Telescope at Apache Point Observatory in New Mexico, USA. Credit: The SDSS collaboration.*

For the last 40 years astronomers have been systematically mapping the position of distant galaxies in an attempt to make accurate 3-dimensional maps of the universe. This has been a long and tough effort, however in the last few years with advances in technology, we are now able to map the distribution of galaxies over a significant fraction of the observable universe.

One of the largest cosmological maps comes from the Sloan Digital Sky Survey (SDSS). The SDSS is a large international program made up of hundreds of scientist.This group of scientists are working to map the Milky Way, search for extrasolar planets, and solve the mysteries of the universe.

The current phase of this program, SDSS-III, began to collect data in 2008, using a 2.5-meter optical Telescope at Apache Point Observatory in New Mexico, USA. SDSS-III consists of four surveys, each focused on a different scientific theme. One of these surveys, the Baryon Oscillation Spectroscopic Survey (BOSS), is mapping the spatial 3-D distribution of bright galaxies called lu-minous red galaxies or LRGs.

The 3-d map of the universe is like a city map without a reference scale. Our job is to find the scale. For instance if I show you a map of Kathmandu, you can't guess how large any object is without having some object you know the size of to compare it with. If, on this map, you know the length of Bagmati Bridge, you could use this length to roughly guess how far it is from Maitighar to Jaulakhell. We want to measure distances in the universe in the same way, so we have to look for something out there that has a known length scale, just like the Bagmati bridge.

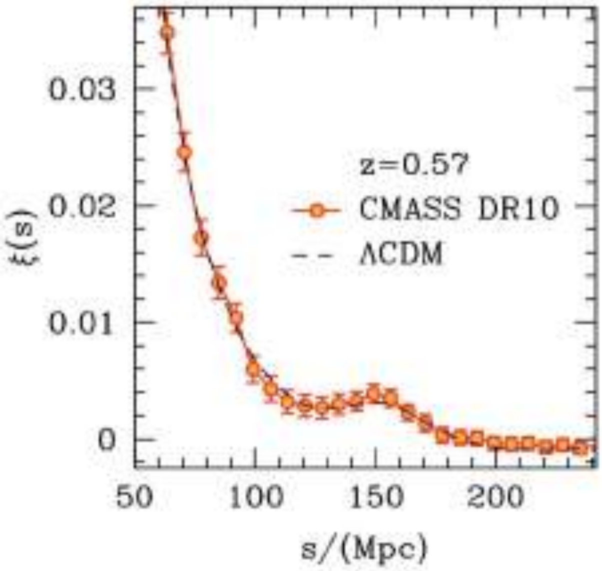

Figure 2: *The two-point correlation function of the BOSS DR10 CMASS sample. The orange data points are the measurements for the observed galaxies, the dashed line denotes the expectation from the currently accepted cosmological model. Credit: Ariel G. Sánchez and SDSS collaboration.*

There is fortunately something that we can use: the distribution of galaxies itself encodes a natural length scale, a kind of 'cosmic ruler'. Due to a physical process in the very early universe, when there were not stars or galaxies and all the matter was in the form of a hot gas, waves were created and moved through this gas. The distance between the peaks of the waves can be calculated from theory. Later as the universe expanded, this gas cooled and it collapsed under the force of gravity to form stars and galaxies. However the imprint of the wave in the early gas phase remains, and it can be seen in the distribution of galaxies today. However, the distance is huge; it is approximately 150 Megaparsecs (a unit of distance used in astronomy) which is 4,600,000,000,000,000,000,000 kilometers! The imprint is very small and difficult to detect. However over the last several years, as larger astronomy surveys have obtained more and more data mapping larger patches of the universe, we have been able to measure this length scale in the clustering of galaxies. We can see this the figure 2, where it shows the clustering strength of galaxies as a function of distance, on small scales galaxies are clustered strongly together because of gravity, on larger scales the clustering becomes weaker, however at a certain scale (around 150Mpc) we see an extra small bump. This is called the baryon acoustic oscillation (BAO), which is the left over imprint of the initial wave, and it is now our standard cosmic ruler for measuring distances in the universe. But as you can see in the figure the exact location of the BAO bump is difficult to measure accurately, we need more points on the plot.

So why are distances important for cosmology? Well the measurements of distance can tell us about how the universe has expanded over its lifetime. 15 years ago astronomer discovered that the universe is not only expanding, but the expansion is getting faster and faster, i.e the galaxies are being pulled apart from each other at an ever increasing rate. We still do not know the reason why this is happening. There are many ideas to explain this strange phenomenon, but more and better measurements of the distances are needed to help figure out which idea or theory is correct.

One popular theory to explain the accelerated expansion proposes that the universe is filled with an unusual substance called Dark Energy that has no mass and has a negative pressure that literally pulls space apart. Another, competing explanation is that our theory of gravity is not exactly correct.

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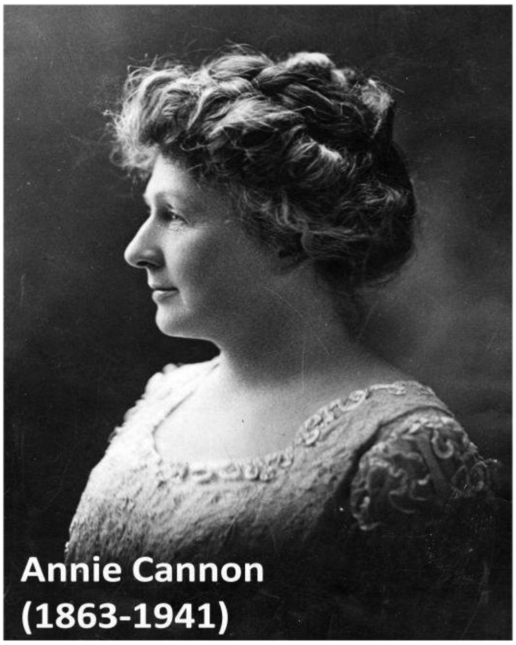
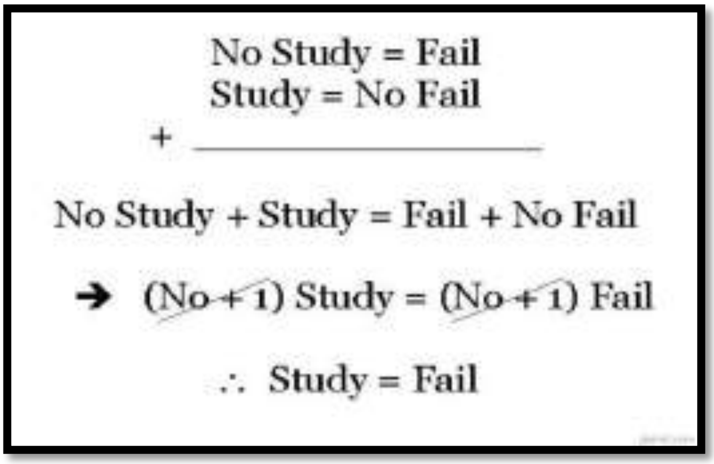
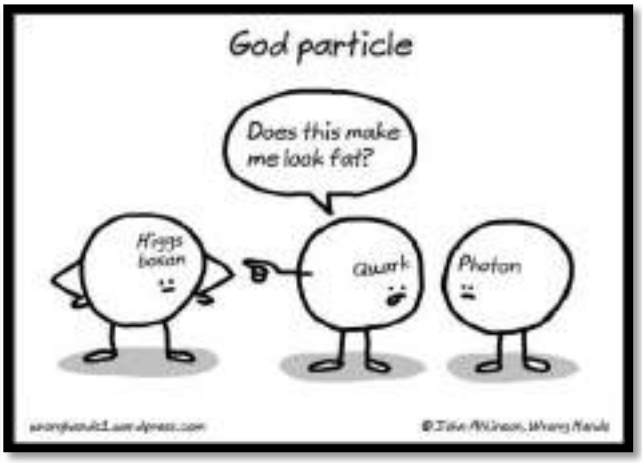


Annie Cannon (1863-1941)

Annie Jump Cannon was an American astronomer whose cataloging work was instrumental in the development of contemporary stellar classification. With Edward C. Pickering, she is credited with the creation of the Harvard Classification Scheme, which was the first serious attempt to organize and classify stars based on their temperatures. She was nearly deaf throughout her career. Cannon studied under Sarah Frances Whiting, one of the few women physicists in the United States at the time, and went on to become the valedictorian at Wellesley College. She graduated with a degree in physics in 1884 and returned home to Delaware for a decade.





Symmetry

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ABSTRACT
Geometrization of symmetry was quite impossible before Einstein. Until twentieth century, scientists used to think that conservation principles (of momentum, energy), Lorentz invarience, gauge invarience were the consequence of the dynamical laws of nature rather than consequence of SYMMETRY. Later Einstein declared that, symmetry principle is the fundamental law of nature that constrains the allowable dynamical laws.

INTRODUCTION

If a certain operation is performed on a object and looks the same as did before, then the object is said to have some sort of symmetry. Most of the objects preserve some sort of symmetry in nature i.e. we can say naure loves (favours for) symmetry as we do. A sphere is an example of most symmetric object, not only the physical object appering in the universe but also different physical laws existing today preseve some sort of symmetry. (1) Newton's law, Maxwell's equations also show symmetricity hence we conclude that the concept of symmetry is not a new one although geometrization of symmetry was done by Einstein in the beginning of twenty century. Among different physical parameters, velocity of light may be considered as the best example of symmetry.

SPATIAL SYMMETRY:

Let us consider two exatly same experimental setup placed in two different places and run the experiment. i.e., one object is placed at position, r and next one is moved from position position r to $r+\alpha$. Mathematically we can say as follow:

$R = \hat{A}\, r = r + \alpha$; where Â is the position operator.

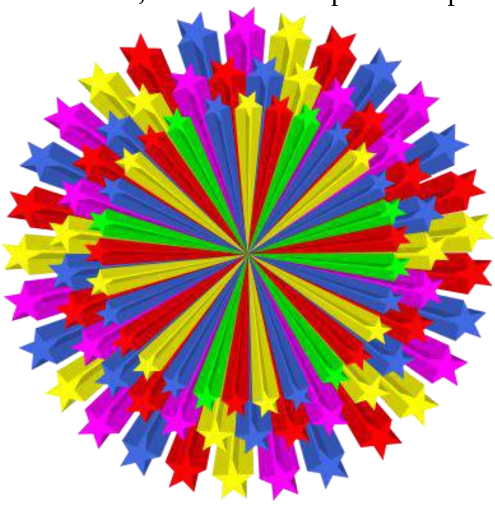

Figure 1: *Rotational Symmetry (2)*

Eventhough we have done an operation on position and position changed from r to $r+\alpha$, we observe that whatever went in one exaperimental setup,placed at position r, in certain order in time, will occur in the same way in next experimental setup placed at position r+α,under the similarly managed external condition. That is to say if we place two different thermometers in different place of room then reading from both the device will be same at each order of time.

TEMPORAL SYMMETRY:

While doing different experiments in our laboratory we have been seeking consistancy in our datas, whenever be the time of experiment. What does it signify? Knowingly or unknowingly we are aligned with the temporal symmetry. Let us consider a experimental setup and run experiment today at t time (Let at 1:00 pm), next day repeat the experiment at time $t+\Delta$ (Let it also 1:00 pm). Mathematically,

$T = \hat{U}\, t = t+\Delta$; where Û is the time operator.

Obviously the result obtained from both the experimental setup run at different time t and $t+\Delta$ should be same under the similarly managed external conditions. Really the value of gravitational potential energy at fixed height from the earth surface, measuring at different time will give the same result as our expection.

Figure 2: *Natural Symmetry (1)*

SYMMETRY IN QUANTUM MECHANICS AND CONSERVATION LAWS:

Let us consider two different wave functions differing only in the phase factor and find the probability of the two wave functions separately, what we find is value of probability is same from both. So, symmetric wave functions that differ only in phase factor giving same probability value signifies the validity of well known principle "*conservation of particle number*". (3) Similary quantum mechanical correlation of spatial symmetry signifies the "*conservation of momentum*" and the temporal symmetry is also related with the conservation principle called "*conservation of Energy*".Next consider an object rotating in an axis through certain angle ends in a state with no difference from initial.If we apply this simple rotational symmetry in quantum mechanics then we get that angular momentum of that object is quantized in integral multiple of ($h/2\pi$). The angular momentum of rotational symmetric bodies should be conserved. When chloromethane molecule, which has a tetrahedral structure, hydrogen atom directly connected with the carbon atom is symmetric, such physical symmetry is related to the inherent properties of the hydrogen atom. The symmetric hydrogen atoms are called isochronous, because they precess with same larmour frequency when they are placed in external magnetic field. Hence when we examine the chloromethane by ^1H NMR (Nuclear Magnetic Resonance) experiment we can not distinguish them by this experiment. So symmetry in the physical structure imparts significant in the inherent properties of the object.(4)

Figure 3: *Symmetry in human life (2)*

CONCLUSION:

I think that, different people in the our society are satisfied through different ways, no one is perfect (or imperfect) in all respect.Two extreme conditions-a fully satisfied person or a person with null satisfaction-if exist in nature the situation will be surely worse.The world is neither for so called "*superman**" nor for "*negative superman**" as both the situation are unfavourable for the continuation of world. Analogously I can say that, eventhough nature favours for symmetry but there will neither be *"perfect symmetry*" nor *"perfect assymetry"* as both extremum cases are unfavourable. A balancing situation "*nearly symmetry*" is mentained by the nature as the controlling tool over the universe.

*Here I have used the term superman for a person who can do what he want and have all sorts of facilities and satisfaction in all respect while negative superman is exactly opposite of it.

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PHYSICS NEWS 2016

Insect wing could serve as radiation dosimeter

Dragonflies, houseflies, and other insects may one day be used to help gauge radiation levels at nuclear power plants and after nuclear incidents. Ionizing radiation causes electrons in the atoms of the insects' wings to be ejected. The resulting holes can act as particles, which then move around the electrons. When exposed to UV light, the holes and electrons can recombine; when they do, a flash of light is emitted. Now Nikolaos Kazakis of the Athena Research Center in Greece and colleagues have tested the radiation sensitivity of several types of winged insects by exposing them to different doses, shining a light on them, and measuring the flashes. Because insects are short-lived, they are mostly uncontaminated by natural radiation. Although the researchers were able to measure exposures of 10–2000 Gy, the technique was not sensitive enough to detect lower radiation exposures. In addition, any exposure to sunlight reduced its effectiveness. However, say the researchers, the technique could still have its uses. And because insects are ubiquitous, there will always be plenty to be found in dark places such as air ducts and basements.

The Game of Simultaneity: Light Cones in GTR vs STR

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ABSTRACT

The game, light cones playing here is not the game of competition.It is just the game to maintain the 'flow of metric' from one ideal rubber sheet (geodesic path) to another in a simultaneous way thus satisfying causality condition. Being 'observer' of the game,I am just pointing out these things in very simple form.

Introduction

Warm up is good before starting the game. So let's do it first with the clear concept of light cone. Light cone actually encapsulate 4-D structure (3-space and 1-time) giving the flavor of unity. But ancient Euclidean geometry lacks that as it divides space-time. This flavor of unity, as basic advantage we received from light cone, separates relativity into two conditions:

1. Along light cone it satisfies STR (special theory of relativity).
2. Within light cone it satisfies GTR (general theory of relativity).

It can be shown in figure1 as:

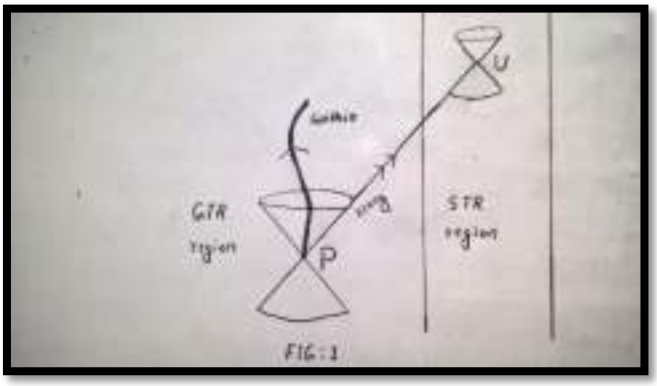

Figure 1: Showing STR and GTR region.

Light cones are simply the players of the game that we are going to observe. Bringing the players i.e. light cones into the game is just to maintain the causality condition i.e flow of metric from one ideal rubber sheet to another following 'principle of simultaneity'.

Where the players i.e. light cones can play the game,as some ground is needed for playing. Actually, the ground on which light cones can play and are bounded under its boundary line, is very magical 'ideal rubber sheet' (In topology this is termed as achronal set). Magical in the sense that if one achronal set gets collapsed, some fundamental code that remains on metric 'g' gets transformed conformally according to $\bar{g} = \Omega^2 g$, creating another achronal set.

Now, it's turn of metric. Metric that is sewed on ideal rubber sheet, actually is the playing instrument which light cones play. This playing by light cones gives 'flow' to metric which gives lively nature to ideal rubber sheet. And on this reason only, ideal rubber sheet is able to give living sense to space-time curvature. So, we can say that metric is fundamental code of space-time curvature.

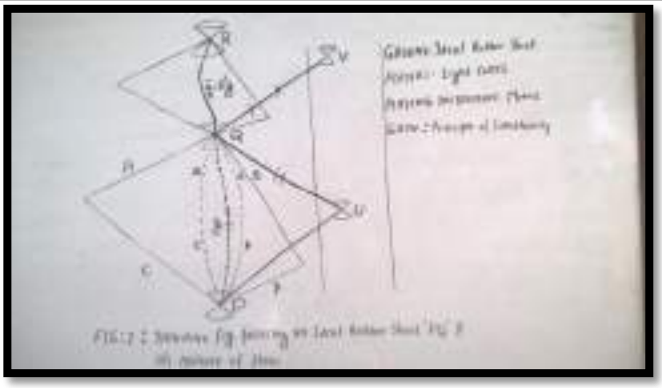

Figure 2: Focusing on Ideal Rubber Sheet PQ & its nature of law.

View the Moment of Game

Here, neither I am explaining the start point of the game and its cause nor the end point of the game and its result. I am only depicting here one of the moment of the game i.e. "PQ" and its nature of flow as shown in figure2. And this is my own intuitive figure.

So, now let's view the game:

When "P" starts to move carrying "g" towards "Q" within light cone in GTR through ideal rubber sheet, then simultaneous "U" starts to move towards"Q" along light cone in STR.This moment of game creates curvature 'abcd' in GTR. In topology it is termed as 'Domain of dependence'.

Further, when "U" along light cone in STR exactly meets null point along "Q" in GTR, then curvature in GTR attains its maximum level i.e. 'ABCD' Finally, when "Q" along light cone in GTR moves to "V" along light cone in STR, then whole curvature 'ABCD' i.e. whole Domain of dependence gets singular at "Q" in GTR. This moment of "Q" along "V" collapsed the ideal rubber sheet "PQ" creating another ideal rubber sheet "QR" on which metric flows with new identity $\bar{g} = \Omega^2 g$ conformally.

This process is what actually the game of simultaneity means. Mathematically, this moment of game of simultaneity can be viewed as: Flexible ideal rubber sheet "PQ" in GTR= 'UQ +QV' in STR.

Review of Moment of Game

While reviewing this moment of game, we can conclude that light cone in GTR fights with light cone in STR in each moment of game, not only creates the environment of game but also preplans for next moment of game. And the game continues….

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PHYSICS NEWS 2016

New state of matter detected in 2D materials

An international team of researchers have found evidence of a mysterious new state of matter, first predicted 40 years ago, in a real material. This state, known as a quantum spin liquid, causes electrons -- thought to be indivisible building blocks of nature -- to break into pieces. The researchers, including physicists from the University of Cambridge, measured the first signatures of these fractional particles, known as Majorana fermions, in a two-dimensional material with a structure similar to graphene. Their experimental results successfully matched with one of the main theoretical models for a quantum spin liquid, known as a Kitaev model. The results are reported in the journal Nature Materials. Quantum spin liquids are mysterious states of matter which are thought to be hiding in certain magnetic materials, but had not been conclusively sighted in nature. The observation of one of their most intriguing properties – electron splitting, or fractionalisation -- in real materials is a breakthrough. The resulting Majorana fermions may be used as building blocks of quantum computers, which would be far faster than conventional computers and would be able to perform calculations that could not be done otherwise. "*This is a new quantum state of matter, which has been predicted but hasn't been seen before*," said Dr Johannes Knolle of Cambridge's Cavendish Laboratory, one of the paper's co-authors. In a typical magnetic material, the electrons each behave like tiny bar magnets. And when a material is cooled to a low enough temperature, the 'magnets' will order themselves over long ranges, so that all the north magnetic poles point in the same direction, for example. But in a material containing a spin liquid state, even if that material is cooled to absolute zero, the bar magnets would not align but form an entangled soup caused by quantum fluctuations. "Until recently, we didn't even know what the experimental fingerprints of a quantum spin liquid would look like," said paper co-author Dr Dmitry Kovrizhin, also from the Theory of Condensed Matter group of the Cavendish Laboratory. "*One thing we've done in previous work is to ask, if I were performing experiments on a possible quantum spin liquid, what would I observe?*" Knolle and Kovrizhin's co-authors, led by Dr Arnab Banerjee and Dr Stephen Nagler from Oak Ridge National Laboratory in the US, used neutron scattering techniques to look for experimental evidence of fractionalisation in alpha-ruthenium chloride (a-RuCl3). The researchers tested the magnetic properties of a-RuCl3 powder by illuminating it with neutrons, and observing the pattern of ripples that the neutrons produced on a screen when they scattered from the sample. A regular magnet would create distinct sharp lines, but it was a mystery what sort of pattern the Majorana fermions in a quantum spin liquid would make. The theoretical prediction of distinct signatures by Knolle and his collaborators in 2014 match well with the broad humps instead of sharp lines which experimentalists observed on the screen, providing for the first time direct evidence of a quantum spin liquid and the fractionalisation of electrons in a two dimensional material. "*This is a new addition to a short list of known quantum states of matter,*" said Knolle. "*It's an important step for our understanding of quantum matter,*" said Kovrizhin. "*It's fun to have another new quantum state that we've never seen before -- it presents us with new possibilities to try new things.*"

CDP Activities: 100 Years of General Theory of Relativity
13 December, 2015

2015 marks an important milestone in the history of physics: one hundred years ago, in November 1915, Albert Einstein wrote down the famous field equations of General Relativity. General Relativity is the theory that explains all gravitational phenomena we know (falling apples, orbiting planets, escaping galaxies...) and it survived one century of continuous tests of its validity.

The Central Department of Physics organized one-day seminar on the occasion of 100 years of GTR on 13 December 2015. Prof. Mukunda Mani Aryal, Prof. Uday Raj Khanal and Prof. Binil Aryal delivered talks on various aspects of GTR and its implications. Mr. Subash Adhikari delivered an introductory talk in which he highlighted the Newtonian Relativity. There were more than 100 participants in the program. Fourth semester students Mr. Santosh Parajuli, Mr. Naresh Adhikari, Mr. Yadav Prasad Kandel, Mr. Pradip Sharma were the organizers.

The development of the theory was driven by experiments that took place mostly in Einstein's brain (that is, so-called "thought experiments"). These experiments centred on the concept of light: *"What happens if light is observed by an observer in motion?" "What happens if light travels in the presence of a gravitational field?"* Naturally, several tests of General Relativity have to do with light too: the first success of the theory and the one that made the theory known to the whole world, was the observation of the light deflection by the Sun. Nowadays, light deflection by astrophysical objects is a tool successfully used to explore the Universe: it is called gravitational lensing.

Light remained central even in subsequent tests of the theory. For example in the so-called gravitational redshift: light changes frequency when it moves in a gravitational field, another prediction of General Relativity, experimentally tested since 1959. But the most amazing prediction of General Relativity has not to do with light, but rather with its absence! Black holes are objects so dense that even light cannot escape their strong gravitational field! It is through these tools that we realized that the Universe is expanding, i.e. all Galaxies are moving away from each other. Even more recently it became clear that this expansion is in fact accelerating! As a consequence we realized that there is a new form of (dark) energy present in our Universe! It is worth noting that all these amazing and surprising discoveries were made possible by studying the light coming from distant astrophysical events in the framework of General relativity.

Prof. Dr. Uday Raj Khanal delivering talks on General Relativity.

General Relativity predicts that our Universe comes from a very energetic state, the Big Bang, and a sign of this is imprinted in the so called Cosmic Microwave Background: CMB. The CMB is the light produced in the hot Early Universe in the moment when its decreasing temperature finally allowed photons to travel freely. This very same light we can see today and provides us with precious information of how the Universe looked like when its age was only 1/30000th of its age today!

The first detection of gravitational waves, i.e. "ripples" in the space-time fabric, is another fascinating verification of General Relativity, so crazy that not even Einstein believed in it.

[Source:http://www.light2015.org/Home/CosmicLight/Einstein-Centenary.html]

CDP Activities: Masterclass on Experimental Particle Physics 16 January, 2016

The Central Department of Physics organized one-day seminar-cum-masterclass on 16 Jan, 2016. This program was supported by *Physics Without Frontiers*. *Milky Way Outreach Network (MiWON)* was the local organizer of the program. Altogether 43 B.Sc. final year and master level students actively participated in the masterclass. A few faculty of the department also attended the program. The program kicked off with welcome speech of Prof. Dr. Binil Aryal, head of masterclass hosting department. The program was divided into three parts: lecture session, hands-on session and career counseling.

The lecture session started with standard model introductory lecture of *Dr. Kate Shaw*, post doc at ICTP/CERN. In lecture titled "**Standard Model of Particle Physics**", Dr. Shaw explained about fundamental aspects of the standard model of particle physics. The lecture was very interactive and participant enjoyed it. Second lecture was delivered by *Dr. Suyog Shrestha*, CERN based Ohio State University post doc, on topic "**High Energy Physics Experiments**". In his lecture, he described about the experimental aspects of particle physics and the experiments that are going on at LHC. The last lecture of first session was by *Dr. Joerg Stelzer* from CERN. In lecture titled "**Detecting Particles and Reconstructing Events**", he described in detail about particle detection techniques and the detectors that are in use at LHC.

Hands-on session started after the lunch break. Volunteers of Milky Outreach Network assisted participants to install required software. At the beginning of second session, Dr. Shaw explained how to use software to identify particle using experimental data of LHC. Not just students but few faculty of the department also joined the hands-on session. All the participants enjoyed particle detection with great excitement.

Career counseling was the last session of the seminar. Dr. Suyog explained not only about the different short term project/ schools opportunities all around the globe but also about how to search for opportunity and make an effective application. His counseling has already won two of the previous year's masterclass students, now active in MiWON, summer school at ICTP and CERN. The program was wrapped up with certification and group photo. The success and effectiveness of the masterclass was distinctly visible on every participant's satisfied mood and cheerful face during the departure.

Physics Without Frontier team, host- Central Department of Physics, Tribhuvan University, Nepal and local organizer Milky Way Outreach Network concluded that the "*Particle Physics Masterclass*" was very successful. It gave participants a great opportunity to learn about the cutting edge research in Particle Physics along with chance to work on real data of LHC.

CDP Activities: Symposium on Plasma Physics & Material Science 8-9 April, 2016 (SPPMS 2016)

The Symposium on Plasma Physics and Material Science (SPPMS 2016) was jointly organized by the Central Department of Physics, Tribhuvan University, Kirtipur and Department of Natural Sciences (Physics), Kathmandu University, Dhulikhel during 8 and 9 April 2016 in the Seminar Hall of the Central Department of Physics at Kirtipur. The program was supported by the University Grants Commission, Sanothimi, Bhaktapur, Nepal.

The Symposium was inaugurated by Prof. Dr. Binil Aryal, Head of Central Department of Physics, Tribhuvan University, Kirtipur by lightning a plasma lamp. In his address, Professor Aryal expressed happiness in organizing such an event in the Department and encouraged the young participants to take part

actively. Prof. Dr. Lok Narayan Jha, former Head of the Department who pioneered the plasma physics activities in Nepal, briefly outlined the development in teaching and research of the subject in Nepal. Prof. Dr. Deepak Prasad Subedi, Associate Dean, School of Science, Kathmandu University and also the co-organizer of the event presented a brief description about the history and growth of plasma physics activities and research facilities in Dhulikhel.

The inaugural session was hosted by Prof. Dr. Raju Khanal, *Coordinator* of the Symposium who welcomed the participants, highlighted the objectives of the Symposium and also gave an overview of the activities.

Altogether 38 contributions from various fields of plasma physics and material science were presented during the Symposium, which was attended by 54 participants. In order to motivate young researchers towards the poster session two “Best Poster Awards” were announced. The awards, as recommended by the jury, were presented to Mr. Suresh Basnet (Central Department of Physics, Tribhuvan University, Kirtipur) for his poster entitled “Study of Multi-Component Magnetized Plasma Sheath using Fluid Hydrodynamics” and to Mr. Rajendra Shrestha (Department of Natural Sciences, School of Science, Kathmandu University, Dhulikhel) for his poster entitled “Generation of Atmospheric Pressure Plasma Jet and Study of Effect of Electrode Configuration in Jet Length”.

The Symposium offered a unique opportunity, especially to young researchers, to interact and listen to various people working in diverse area of their field of interest. The program was concluded with a discussion session about how to implement the wide aspects of plasma physics in Nepal. Everyone stressed in the need of organizing such events in future as it gives the exposure and confidence to anyone related to this field.

CDP Activities: Training Program on Computational Physics 14-15 May, 2016

The Central Department of Physics (CDP) organized training program on Computational Physics under ***capacity development program*** during 14-15 May 2016 in order to provide an extensive learning environment on 'computational physics' to the participants of physics faculties of the colleges where M.Sc. (Physics) program is running. The training program focused on computer programming, and its application to the unsolved problem of physics. Computational physics is the study and implementation of numerical analysis to solve problems in physics for which a quantitative theory already exists. Historically, computational physics was the first application of modern computers in science, and is now a subset of computational science. It is sometimes regarded as a sub-discipline (or offshoot) of theoretical physics, but others consider it an intermediate branch between theoretical and experimental physics, a third way that supplements theory and experiment.

The Central Department of Physics (CDP) has introduced *semester system* at the masters' level in Physics. From this academic session, all 9 colleges of the nation where M.Sc. (Physics) is running (Patan Multiple College, Amrit Campus, Bharatpur Multiple campus, Mahendra Morang Multiple Campus, Prithivi Narayan Campus and Sidhhanath Multiple Campus, St. Xaviers College and Golden Gate International College) are going to introduce semester system at this level. The total number of students in these colleges is about 700. A new research oriented course '***computational physics***' has been introduced for the fourth semester. From the coming academic year, this course has to be implemented in all colleges.

Nepal is an underdeveloped country with very limited resources and infrastructure for the research work in experimental research. In physics, different theories based on mathematical models provide very precise predictions on how systems behave. Unfortunately, it is often the case that solving the mathematical model for a particular system in order to produce a useful prediction is not feasible. This can occur, for instance, when the solution does not have a closed-form expression, or is too complicated. In such cases, numerical approximations are required. Computational physics is the subject that deals with these numerical approximations: the approximation of the solution is written as a finite (and typically large) number of simple mathematical operations (algorithm), and a computer is used to perform these operations and compute an approximated solution and respective error.

There were 80 participants, 52 were the physics faculties of TU (four faculties were from outside valley). The rest participants were Ph.D. and M.Sc. students. The resource persons were the Dr. Elisa Fratini, post doctorate fellow of ICTP, Prof. Dr. Narayan Pd Adhikari, Dr. Gopi Chandra Kaphle and Mr. Nurapati Pantha. There were 12 talks from the experts. Training Program is inaugurated by the head of the CDP, TU, Prof. Dr. Binil Aryal. Prof. Aryal highlighted the implication of this course particularly for physics researchers. Prof. Dr. Narayan Prasad Adhikari The program was organized at the Seminar hall of the Central Department of Physics, Kirtipur.

In addition to above mentioned experts, eleven fourth semester M.Sc. (Physics) students worked as tutors. They were helping participants to install UBUNTU and other necessary softwares in their laptops. Mr. Puspa Raj Paudel and Mr. Yadav Prasad Kandel presented seminar on their courrses.

The program was supported by the University Grants Commission, Sanothimi, Bhaktapur, Nepal. The IEEE and ICTP provided the technical support.

CDP Activities: B.Sc. IV Year Faculty Orientation Program 21-24 Asar (Kathmandu) & 15-18 Srawan (Hetauda) 2016

The B.Sc. Fourth Year Orientation program was held in the Kathmandu (Central Department of Physics, TU, Kirtipur during 21-24 Asar 2072. There were 52 participants from the colleges of the Kathmandu valley where M.Sc. program is running. The Assistant Dean, IoST, TU, Prof. Dr. Chet Raj Bhatta inaguarated orientation program. Prof. Bhatta stressed the importance of training school in the University. Prof. Dr. Binil Aryal, HoD, Central department of Physics focused the role of ungraded faculties in conducting newly revised curriculum, which is as par in the international standard. The course structure is as follows:

Course Code	Course Name	Course Nature	FM
PHY401	Quantum Mechanics	Theory/Core	100
PHY402	Physics Lab (General)	Practical/Core	50
PHY403	Nuclear Physics & Solid State Physics	Theory/Core	100
PHY404	Physics Lab (Electronics)	Practical/Core	50
PHY405	Material Science	Theory	100
PHY406 PRO406	OR Project	OR Research	100
PHY407	Econophysics	Theory / Interdiscipli-nary	50

There was fruitful interaction between the resource persons and the participants. The newly introduced courses Material science and Econophysics remained a topic of interest. The B.Sc. Fourth Year Orientation program was held in the Hetauda (at Makwanpur Multiple College, a publicly run accredited TU affiliated college) during 15-19 Srawan 2072. There were 86 participants from the colleges of the nation outside valley where M.Sc. program is running. There was a huge interest of participants for this program. The Assistant Dean of IoST, TU, Prof. Dr. Chet Raj Bhatta opened the teacher's orientation program by sharing a strategic plan of IoST for coming years. He highlighted the role of permanent faculties in implementing new curriculum.

The participants raised many query about the newly introduced courses econophysics and material science. They argued the fact that these courses are completely new and it needs a huge effort for faculties to implement it. There was a hot discussion on the model question and existing evaluation system of Tribhuvan University.

The resource persons of both programs were as follows:

Quantum Mechanics: **Prof. Dr. Binil Aryal & Dr. Hari Lamichanne**
Nuclear Physics: **Prof. Dr. Lok N Jha**, **Prof. Dr. Raju Khanal**
Dr. Sanju Shrestha, **Mr. Ajay K Jha**
Material Science: **Prof. Dr. Narayan Pd Adhikari**
Solid State Physics: **Prof. Dr. Narayan Adhikari**
Mr. Nurapati Pantha
Econophysics: **Prof. Dr. Binil Aryal, Prof. Dr. Narayan Adhikari**
Project & Evaluation Scheme: **Prof. Dr. Binil Aryal**
Electronics Lab: **Mr. Hari Shankar Mallik**
General Lab: **Dr. Hari lamichanne & Dr. Sanju Shrestha**

Participants with resource persons

This program was supported by Institute of Science & Technology, Tribhuvan University, Kirtipur. All the participants as well as the authority of host college thanked the IoST for giving opportunity to organize this program.

CDP Activities: B.Sc. IV Year Laboratory Orientation Program 9-14 Magh, 2072 (Bharatpur)

Opening Ceremony: Vice Chancellor of TU Prof. Dr. Tirtha Raj Khaniya was the chief guest.

The Institute of Science & Technology (IoST), TU organized B.Sc. IV year lab orientation program at Birendra Multiple College, Bharatpur during 9-14 Magh, 2072. The Vice Chancellor of TU, Prof. Dr. Tirtha Raj Khaniya addressed the opening ceremony. Vice Chancellor Khaniya focused the importance of interactive learning and teaching environment for the coming generation. He said that the science discipline should take lead in this regard. The Assistant Dean of IoST, Prof. Dr. Chet Raj Bhatta highlighted the importance of the laboratory orientation program. The host campus chief stressed the importance of training school in the University and thanked IoST for giving opportunity to organize program at Bharatpur. The HoDs of Physics (Prof. Dr. Binil Aryal) and Chemistry (Prof. Dr. Megh Raj Pokhrel) department briefed the program. In the physics discipline, there were 63 participants from the colleges of the nation where B.Sc. (Physics) program is running.

Dr. Hari Pd Lamichanne demonstrtating an experimental set-up to the participants

The resource persons were Prof. Dr. Binil Aryal (HoD), Dr. Hari Pd Lamichanne, Mr. Prakash Man Shrestha, Mr. Pitamber Shrestha, Mr. Hari Shankar Mallik and Mr. Deependra Parajuli. Prof. Dr. Harihar Paudel, Prof. Arun K Shrestha, Mr. Dilli Pd Sapkota of host college actively involved in organizing the program.

Closing Ceremony: Addressed by Campus Chief of BMC, Bharatpur

A working manual of B.Sc. IV year experiments was prepared by the Central Department of Physics and distributed to all TU constituent and affiliated colleges where B.Sc. (Physics) program is running. The hands-on session was held in the program. Participants set up the experiments on the table, took data in the working manual. In addition, they analysed the data, perform error analysis and finally interpreted the result. There was fruitful interaction between the resource persons and the participants at every stage. The newly introduced experiments remained a topic of interest. These are half life, thermister, voltage doubler, tripler, multivibrators, integrator and differentiator. There was a huge interest of participants for this program.

CDP Activities: M.Sc. (Physics) 3rd & 4th Semester Faculty Orientation Program 21-25 Baisakh, 2073 (Pokhara)

The M.Sc. (Physics) third and fourth semester faculty orientation program was in Prithivi Narayan Campus, Pkhara during 21-25 Jestha 2073. The campus chief of PNC inaugurated the program. He hoped that the physics faculties of TU will be benefit from the orientation program. The head of the Central Department of Physics, TU, Prof. Dr. Binil Aryal highlighted the importance of this program for faculties and ultimately to the students. There were 77 participants from the colleges of the nation where M.Sc.(Physics) program is running. The program co-ordinator of Patan Multiple Campus, Prof. Dr. Indra Bd Karki thanked the Dean Office for organizing this event in Pokhara. The course structure of M.Sc. third and fourth semester is as follows:

Semester	PHY	Course title	CH
3rd	601	Electrodynamics II	3
3rd	602	Quantum Mech. II	3
3rd	603	Physics Practical III	3
4th	651	Quantum Mech. III	3
4th	652	Nuclear & Particle Ph.	3
4rd	653a	Electronics Practical	3
4th	653b	Computational Phys.	3
4th	653c	Project	3
3rd	611	Adv. Solid State Phy. I	3
3rd	612	Micro & Optoelec. I	3
3rd	613	Seismology I	3
3rd	614	Atmospheric Phys. I	3
3rd	615	Plasma Physics I	3
3rd	616	Biomedical Physics I	3
3rd	617	Gravita. & Cosmo. I	3
3rd	618	Astrophysics I	3
4th	661	Adv. Solid State Phy II	3
4th	662	Micro and Optoelec. II	3
4th	663	Seismology II	3
4th	664	Atmospheric Phys. II	3
4th	665	Plasma Physics II	3
4th	666	Biomedical Physics II	3
4th	667	Gravita. & Cosmo. II	3
4th	668	Astrophysics II	3
4th	699	Dissertation	6

There was fruitful interaction between the resource persons and the participants. The resource persons were Prof. Dr. Binil Aryal (Quantum Mechanics, Nuclear and Particle Physics and Astrophysics), Prof. Dr. Raju Khanal (Project work and Plasma Physics), Prof. Dr. Narayan Pd Adhikari (Computational Physics and Advanced Solid State Physics), Dr. Hari Lamichanne (Quantum Mechanics), Dr. Rajendra Parajuli (Electrodynamics II), Dr. Sanju Shrestha (Lab work), Dr. Gopi Chandra Kaphle (Computational Physics), Mr. Tika Ram Lamichanne (Nuclear and Particle Physics and Biomedical Physics). Prof. Dr. Indra Bd Karki, Prof. Dr. Purna Bd Chand and Prof. Arun Kumar Shrestha contributed the program by sharing their experiences. The existing evaluation system remained the topics of hot discussion. The M.Sc. Program Coordinators of all colleges were participated in the program. The organizers Associate Professors Surya Bd GC, Kul Prasad Dahal, Parsu Ram Paudel, Beni Madhav Dhungana of Prithivi Narayan Campus actively helped the program.

List of Our Graduates Leaving for USA during July-August 2016

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__Note:__ Symmetry family congratulates all seniors and wishes for the success in the future study. Editorial board acknowledges Mr. Nabin Kumar Raut and Mr. Tilak Ram Thapalia 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.

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Field of Research *:Galaxy evolution, clusters and superclusters o galaxies, dark Matter and dark energy, ISM interaction, Interstellar bubbles, etc.*

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: Academic Council, TU
: Standing Committeete, Faculty Board

Qualification

Post Doctorate :Institute of Astrophysics, Innsbruck University, Innsbruck, Austria (May 2002 –April 2004)
:University of Washington Seattle, USA (May 2004- April 2005)

Ph. D. :Institute of Astrophysics, Innsbruck University, Innsbruck; Austria (2002)

M. Sc. :Central Department of Physics, T.U., Kirtipur (1994)

Post Doctorate 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

Observation : Galileo Observatory, Canery Island, Spain (one observational run – as a Ph.D. student, during 2001)
: Asiago Observatory, Padua University, Italy (five observational run – as a expert astronomer, during 2002-2004)
:KEK Observatory, Mauna Kea, Hawaii, USA (four observational run – as a expert Astronomer, during 2005-2009)
IRAM Observatory, Spain (two observational run – as a expert Astronomer, during 2004-2005)

Selected Publications

- **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)
- **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)
- **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)
- **B. Aryal**, Winding sense of galaxies around the Local Supercluster, Journ. Research in Astronomy & Astrophysics (RAA) 11, 293 (2011)
- **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)
- **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)
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- **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)
- **B. Aryal**, S. Paudel & W. Saurer, Coexistence of chiral symmetry restoration and random orientation of galaxies, , Journ. Astronomy & Astrophysics (A&A) 479, 397 (2008)
- **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)
- **B. Aryal,** S. R. Acharya & W. Saurer, Chirality of spiral galaxies in the Local Supercluster, Journ. Astrophysics & Space Science, 307, p. 369-380 (2007)
- **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)
- **B. Aryal** & R. Weinberger, A new high latitude cone like far-IR nebula, Journ. Astronomy & Astrophysics 446, 213 (2006)
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- **B. Aryal** & W. Saurer, Spin vector orientation of galaxies in the region $19^h 26^m 00^s < \alpha\ (2000) < 20^h 19^m 00^s$, $-68^o < \delta\ (2000) < -65^o$, Monthly Notice of Royal Astronomical Society (MNRAS) 360, 125 (2005)
- R. Weinberger & **B. Aryal,** A Gaint Dusty Bipolar Structure Around the Planetary Nebula NGC 1514, Monthly Notice of Royal Astronomical Society (MNRAS) 348, 172 (2005)
- **B. Aryal** & W. Saurer, Spin vector orientation of galaxies in seven Abell clusters of BM type III, Journ. Astronomy & Astrophysics 432, 841-850 (2005)
- **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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- R. Weinberger & **B. Aryal**, Huge Dust Structures and Cavities Around PNe: NGC 6826 and NGC 2899, Edited by Margaret Meixner, Joel H. Kastner, Bruce Balick and Noam Soker, ASP Conf. Proc., Vol. 313. San Francisco: Astronomical Society of the Pacific, 2004., p.112-115 (2004)
- R. Weinberger & **B. Aryal**, Asymmetric mass-loss on the AGB: examples from IRAS data, Edited by Y. Nakada, M. Honma and M. Seki. Astrophysics and Space Science Library, Vol. 283, Dordrecht: Kluwer Academic Publishers, ISBN 1-4020-1162-8, p. 103-106 (2003)
- **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)
- **B. Aryal** & W. Saurer, Comments on the expected isotropic distribution curve in galaxy orientation study, Journ. Astronomy & Astrophysics Letters 364, L97-L100 (2000)

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Publications (Selected)

- Comments on the Dirac Field in Friedmann-Robertson-Walker Spacetime (preprint), Abdus Salam International Centre for Theoretical Physics, Trieste (Italy) IC/2006/136 (2006)
- Electrodynamics in Friedmann-Robertson-Walker Universe: Maxwell and Dirac fields in Newman-Penrose formalism, *Classical and Quantum Gravity*, **23**, 4353 (2006)
- Comments on the interacting Einstein-Hilbert Drop, Abdus Salam International Centre for Theoretical Physics, Internal Report, IC/IR/2004/14 (2004)
- Dynamics of extended objects: the Einstein-Hilbert Drop, arxiv.org/astro-ph/0410634 (2004)
- Dynamics of strings with Gaussian density and tension, *Mod. Phys.Lett. A* **15**, 675 (2000)
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- Density fluctuations in the early universe, *Proceedings of III National Conference on Science and Technology*, Royal Nepal Academy of Science and Technology, 442 (1999), Co- authored with P. Dhungel and S. K. Sharma
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- Further investigations of the Kerr-de Sitter space, *Phys. Rev. D* **32**, 879 (1985)
- Rotating black hole in asymptotic de Sitter space; perturbation of the space-time with spin fields, *Phys. Rev.D* **28**,1291 (1983)
- Massive spin-half particle in de Sitter universe, *Annals of Phys.* **138**, 260 (1982)
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- Perturbation of the de Sitter-Schwarzschild universe with massless fields, *Phys. Rev. D* **24**, 829 (1981)

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Qualifications : Ph.D. TU (2000)
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PhD Thesis : Study of Magnetic field generation and its effect on the energy transport in the corona of laser fusion plasma

Selected Publications

- Modeling of thermal transport using Fokker Planck equation in Laser Produced Plasma, Proceed ICPP 1996
- Effect of finite but weak electron inertia delay on plasma seath formation, PLASH, 2003, Ranchi
- An Introduction to Multiphoton Ionization and Study of ionization rate of Hydrogen Atom, IIIrd IUPAP International Conference on Women in Physics, 8-10 Oct 2008, Seoul South Korea

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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

- 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
- 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
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- Niraula O. P. and Wang B. L., A magneto-electro-elastic material with a pennyshaped crack subjected to temperature loading, Acta Mechanica, Volume 187, Pages 151-168, 2006 Wang, B. L. and Niraula, O. P., Transient analysis of thermal fracture in transversely isotropic magneto-electro-elastic material, Journal of Thermal Stresses, Volume 30, Pages 297-317, 2007
- 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
- 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
- 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
- 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
- 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
- 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
- Niraula, O. P. and Chao, C. K., Thermodynamic derivation in magneto-electroelasticity, Journal of Thermal Stresses, Volume 35, Pages 448-469, 2012
- 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

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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

- 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.
- 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.
- 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.

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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:

- "Numerical Experiments on PF1000 Neutron Yield", S. H. Saw, D. Subedi, R. Khanal, R. Shrestha, S. Dugu and S. Lee, J. Fusion Energy 33, 684 (2014)
- "Comparison of Measured and Computed Neutron Yield Versus Pressure Curve on NX2 at Different Operating Voltages", Prakash Gautam and Raju Khanal, KUSET 10, 1 (2014)
- "Diagnostics of Low Pressure DC Glow Discharge Using Double Langmuir Probe", B. Ghimire, R. Khanal and D. P. Subedi, KUSET 10, 20 (2014)
- "Nuclear Technology", R. Khanal, Rastriya Bigyan Diwas 2071 Smarika, p. 46 (2014)
- "Fitting of total current curve in the plasma focus device (PF400) using Lee Code", P. Gautam, R. K. Tiwari and R. Khanal, BMC J of Physics 2, 47 (2014)
- "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)
- "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)
- "Introduction to Numerical Experiment on Plasma Focus using Lee Model Code", P. Gautam and R. Khanal, The Himalayan Physics 5, 136 (2015)
- "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)
- "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)
- "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)
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- "The Study of Kinetic Energy of Ion ond Sheath Thickness in Magnetized Plasma Sheath", Roshan Chalise and Raju Khanal, Journal of Materials Science and Engineering A 5, 41 (2015)

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Selected Publications

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- 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)
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- **N.P. Adhikari**, R. Auhl and E. Straube, "*Interfacial properties of flexible and semiflexible polymers blends"*, Macromolecular theory and simulations, **11**, 315(2002).
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- **N.P. Adhikari** and D.R. Mishra, "*Electronic structure in metal clusters*", Journal of Nepal Physical Society, **15**,13(1998).
- **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).

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- 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
- 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
- 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
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- 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
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- Hari Lamichhane, Ruili Wang, Gary Hastings, "Comparison of calculated and experimental FTIR spectra of specifically labeled ubiquinones" Vibrational Spectroscopy (2011), 55, 279-286.
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- 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.

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- Magnetic ordering in Ni-rich NiMn alloys around the multicritical point: Experiment and theory. Physical Review B 85 (17),174405 (2012)
- 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)
- Study of Spin Glass Behavior in Disordered Pt x Mn1− x Alloys: An Augmented Space Recursion Approach. Advanced Science Letters 21(9), 2681 (2015)
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- Structural and electronic properties of Perovskite Hydrides AcaH3 (CaH3), BIBECHANA 13, 94-99 (2015)
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- Electronic and Magnetic properties of Double perovskites. Journal of Nepal Physical Society 3 (1), 50-54 (2016)
- Study of electronic structure and Magnetic properties of bulk (Pb and Ti) and perovskite PbTiO3. Assian Academic Research Journal of Multidisciplinary, 3(2) , 47 (2016)
- Adsorption and dissociation of Nitrogen and Hydrogen molecules on Palladium(Pd) and Plattium(Pt) clusters. Quantum Matter 3(5), XXX (2016)
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- Frist- Principles study of Structural, Electronic and Optical Properties of Pristine and X (Cu, Ag and Au) Doped BiOBr. Submitted to peer reviewed international Journal
- Study of electronic and magnetic properties of Heusler alloys Co2MnSb and Fe2MnGe: A first- principles approach. Submitted to peer reviewed international Journal

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Publications

- 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).
- 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).
- 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).
- Surface UV Radiation in Nepal: Satellite Retrieval System, *Journal of Nepal Physical Society*, Vol. 23 (1), pp 27-31, June (2007)
- UV Climatology in Kathmandu, *Symmetry, Central Department of Physics, Kathamandu*, Vol. III, pp 54-56 (2007).

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- T.R. Lamichhane & M.D. Bhatt; **A Text Book of Engineering Physics**, First Edition: 2004 along with Sixth Edition: 2014, published by Sunlight Publication, Kirtipur, Kathmandu, Nepal
- T.R. Lamichhane & M.D. Bhatt; **Physics for Engineering Entrance Examination**, First Edition: 2004, Published by FEEP-Advanced College of Engineering, Kupondol, Nepal

- T.R. Lamichhane; **DEA Objective Physics**, First Edition: 2004, Published by Dynamic Educational Academy, Thamel, Nepal
- T.R. Lamichhane; **Course Manual of Physics** (for Diploma in Engineering I/II), First Edition: 2005, Published by Advanced College of Engineering , Kupondol, Nepal
- Khem Paudyal, H.B Baniya & T.R. Lamichhane; **Numerical Examples in Engineering Physics**, First Edition: 2008 along with Second Edition: 2010, New Hira Books Publication, Kirtipur, Nepal
- T.R. Lamichhane; **Physics for Advanced Science Course**, First Edn. :2010,Nims, Bagbazar, Kathmandu, Nepal
- Prof. Dr. L. N. Jha, G. Shrestha, H. B. Baniya, M.S. Nepal, T.R. Lamichhane & M. Subedi; **Universal Physics - Part I,** First Edition: 2012, Second Edition: 2013, Published by Oasis Publication, Anamnagar , Kathmandu, Nepal
- Prof. Dr. L. N. Jha, G. Shrestha, H. B. Baniya, M.S. Nepal, T.R. Lamichhane & M. Subedi; **Universal Physics - Part II,** First Edition: 2012, Second Edition: 2013, Published by Oasis Publication, Anamnagar, Kathmandu, Nepal
- T.R. Lamichhane, M. S. Nepal & M. Subedi; **Universal Practical Physics for Class XI and XII**, First Edition: 2013, Published by Oasis Publication, Anamnagar, Kathmandu, Nepal
- Lamichhane T. R., **Biophysics: Opportunities and Challenges**, Symmetry, Vol. VII, 2012, PP-14-15, CDP, Kathmandu, Nepal
- Lamichhane T. R., **Radiation Exposure and Risk of Cancer**, Symmetry, Vol. VIII, 2013, PP-25-26, CDP, Kathmandu, Nepal

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Selected Publications

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- R P Koirala, Physical Aspects of Nerve Impulse, Symmetry, Vol VII, , PP 16-17, 2012, Nepal.
- R P Koirala, Measurement of Radiation, Symmetry, Vol VIII, 2013, PP 27-28, Nepal.
- R P Koirala, Biophysics: Introduction and scope, scientific outlook monthly, Vol I, 2013, PP 37-38
- R P Koirala, 'Fire' Behaviour of Radio-Nuclides and Radiotherapy, Symmetry, Vol IX, 2014, PP 21-22, Nepal
- R P Koirala, M N Singh, PKhanal, Principles of Physics I,Asmita Books publishers & Distributers (P) Ltd Nepal, 2015
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Selected Publications

- Magnitude and Time Response of Electronic and Topographical Changes During Hydrogen Sensing in Size Selected Palladium Nanoparticles: M. Khanuja, S. Shrestha, B. R. Mehta, S. Kala and F. E. Kruis, accepted for publication in J. Appl. Phy)
- 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).
- 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).
- Low fiB. Sen & C. K. Sarkar, pg. 377, Proceeding of International conference on Communications, Devices and intelligent Systems (CODIS 2004)
- 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, Proceeding of International conference on Communications, Devices and intelligent Systems (CODIS 2004)
- 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, Proceeding of International conference on Communications, Devices and intelligent Systems (CODIS 2004)
- 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)
- 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)
- 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)
- 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)
- 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)
- 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)
- 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)
- 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)
- 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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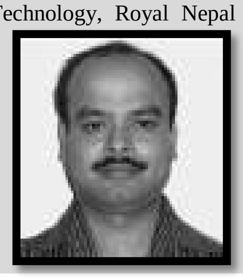

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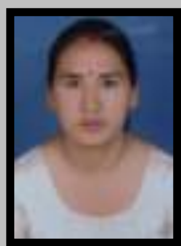

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