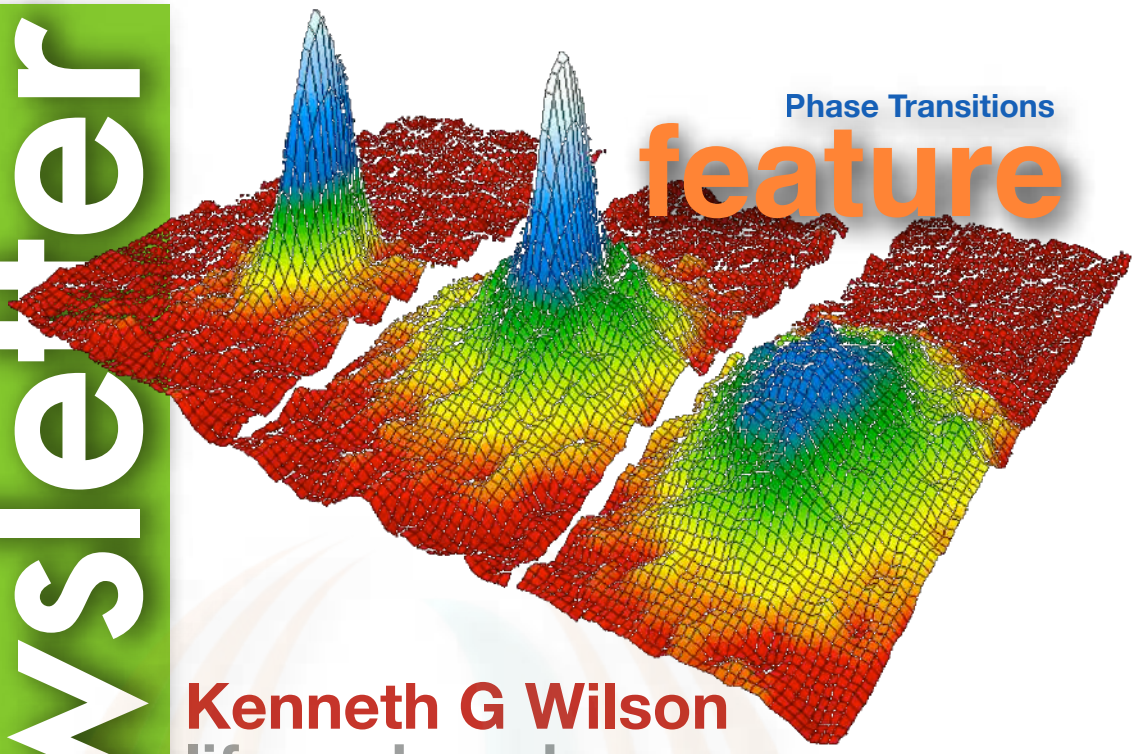
February 2014

Volume 2
No 2

pane newsletter



Phase Transitions

feature

Kenneth G Wilson
life and work

Dilip Kumar Choudhury and Akbari Jahan

Kenneth Geddes Wilson (1936 – 2013) made path breaking contributions to statistical mechanics, particle physics, and related fields. In 1982, he was awarded the Nobel Prize in physics for his theory on critical phenomena. On December 8, 1982 he delivered his much acclaimed Nobel lecture "*The Renormalization Group and Critical Phenomena*". The theory applies to the notion of renormalization and Renormalization Group of Quantum Field Theory in a novel way.

Phase transition is a phenomenon of matter from one state to other - the transition of ice to water or water vapour is a simple example. J. W. Gibbs, J. Van der Waals, and others illuminated many aspects of phase transition. However, one feature "*critical phenomena*" could not be well understood till the theoretical breakthrough of Wilson.

To understand it, let us discuss a concrete example. As a ferromagnet is heated, its magnetization is diminished, until at a critical temperature (the Curie temperature) it vanishes all together. Just below the critical temperature, the strength of the remaining magnetic field vanishes as fractional power (α) of the temperature difference $\sim (T - T_c)^{\alpha}$. The exponent α is called the critical exponent. Surprisingly, the same value of the critical exponent is observed in many different materials with different Curie temperatures. This property of the critical exponent is called universality. Thus, critical exponents are non trivial numbers, characteristic of macroscopic matter, not understood theoretically. The questions are - why do they exist, why are they universal, and how they can be computed. Leo Kadanoff [1] explained the first two questions in the following way.

Assume that a magnet has domains, within which the underlying spins share a common alignment. Below the critical temperature, the sample has a single domain, so that there is nonzero net magnetization.

Above the critical temperature, no single domain can cover the sample, so that the magnetization averages to zero. Near the critical temperature, there are domains that nearly covers the sample but eventually die. One can imagine the sample is populated by very large domains, which are permeated by huge sub domains, themselves permeated by still relatively large sub domains. By considering the differently sized domains as objects in their own right, Kadanoff gave a plausible explanation why the critical exponent exists and why they

Continued to Page 2

Kenneth Geddes Wilson (1936-2013) was an American Physicist, whose work revolutionised the way we think about certain phenomena today. Dilip Kumar Choudhury and Akbari Jahan are looking into his work in our feature article.

Prof Coudhury is a Senior Research Affiliate of PANE. Ms Jahan is a Research Scholar of Physics at Gauhati University.

contents

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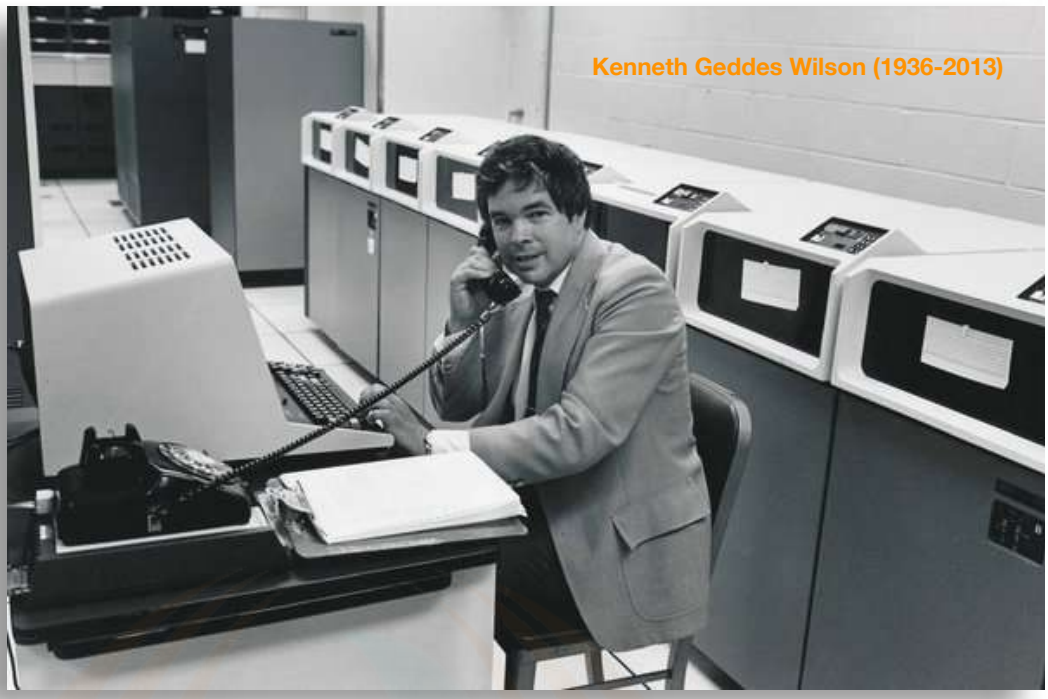
feature



Kenneth Geddes Wilson (1936-2013)

Continued from Page 1

are universal. But it falls short of quantitatively evaluating it. Wilson in his path breaking work [2] just did it. This picture can be viewed as explained below.

One has fluctuations on different length scales that overlap and affect one another. Since one is interested in the behaviour at large distance, one can find an effective theory that averages the fluctuations smaller than some cut-off. Wilson was able to develop equations that describe how the effective theory changes if the cut-off is varied slightly. This equation obtained from change of cut-off is called the Renormalization Group Equation (RGE). At the critical point, the dynamics is scale invariant, so the form of the effective theory must be independent of the cut-off. In collaboration with Michael Fisher [3], Wilson found a simple way to obtain their approximate solution.

The concept of renormalization and RGE are now well known in physics. Prior to Wilson's accomplishment, renormalization, even as applied by such great physicists as Feynman, Tomonaga, and Schwinger in 1940s, was a method of dubious validity and only of partial respectability. Similarly, RGE was also well known among the physics community since 1950s. Wilson was the first to show how to put it on a much firmer physical and mathematical footing. He showed that the RGE is more than a technical tool. It is primarily a method for connecting the behavior of one scale to the phenomena at a very different scale. It can therefore connect the physics at the scale of an atom with the observed macroscopic properties of materials.

Ever since 1970s, the tools and concepts put forward by Wilson have formed the basis of particle physics and condensed matter physics. The familiar concepts of running coupling constant, anomalous dimension, and fixed points all originated from Wilson's work.

From critical phenomena, Wilson also moved to particle physics. In 1969, he [4] outlined how one might apply field theory version of his work to strong interaction. Inspired by his work, Gross, Wilczek, and Politzer worked on strong interaction and showed that the relevant coupling constant decreases with shorter length scale (called Asymptotic freedom) [5,6] and could explain the results of the experiments on electron-proton scattering done at SLAC (Stanford Linear Accelerator Center) and MIT (Massachusetts Institute of Technology). The Quantum Chromodynamics (QCD) was born - thanks to Wilson! But when Wilson tried to work on low energy or long distance QCD, he faced a real challenge - how to compute physical properties like masses of strongly interacting particles in such theory! Wilson approach [7] was revolutionary. He formulated the theory in computer friendly term. His formulation leads to complicated definite integral in a space of enormously large dimension, which has to be performed numerically in computer. The lattice QCD (and in general, lattice gauge theory) was developed in that way in 1974. Since then, new powerful super computers and algorithms were designed to go ahead with this idea.

Physicist P. A. M. Dirac (1902-1984) considered renormalization too ugly to be correct, "I might have thought that the new ideas were correct if they had not been so ugly." Had he been alive today, Dirac would have changed his belief and perhaps patted Ken on the back.

Wilson was born on January 8, 1936, in Waltham, Massachusetts, the oldest of six children of E. Bright Wilson, a prominent chemist at Harvard University. His mother had also trained as a physicist. Wilson did his undergraduate work at Harvard, where he was a Putnam Fellow, and received his Ph.D. at the California Institute of Technology in 1961 under the legendary theorist Murray Gell-Mann, then did postdoctoral studies at Harvard as a junior fellow that included a year at CERN, Geneva. He joined Cornell as a physics professor in 1963. Dr. Wilson arrived at Cornell already famous for his mathematical prowess.

Wilson also was among the first in his field to use computer simulations and modeling as research tools. He was regarded as a "*supercomputing visionary*" who championed the National Science Foundation's establishment of academic supercomputing centres across the United States. In his later years at Ohio University, he worked on issues in educational reform up to the day he died. His "Physics by Inquiry" approach to teaching showed how one can tap into the natural love of learning exhibited by young children and thus change the education system in such a way as to sustain that love of learning throughout life.

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New members of PANE (Aug 2013 - Feb 2014)

We welcome the following persons who have become PANE members during last six months. The total members of PANE now stands above 230.

Dr Amar Saikia, Dispur College, Guwahati
Mr Ananta Rajbongshi, Nalbari College, Nabari
Mrs Anita Talukdar, Arya Vidyapeeth College, Guwahati
Ms Bhanu Das, Guwahati College, Guwahati
Mr Bijit Sinha, S S Academy Junior College, Guwahati
Dr Bimal K Sarma, Gauhati University
Dr Biren Das, Arya Vidyapeeth College, Guwahati
Prof B M Jyrwa, NEHU, Shillong
Prof Dhruba J Saikia, Cotton College State University, Guwahati
Mr Dipak Kumar Deka, Guwahati College, Guwahati
Dr Hemam Dinesh Singh, Sikkim University
Dr Imtiwati Jamir, Fazl Ali College, Mokokchung
Mr Jayanta Kr Bhagawati, S S Academy Junior College, Guwahati
Mrs Jhuma Biswas, Birjhora Mahavidyalaya, Bongaigaon
Dr Kangkan Sarmah, Mangaldai College, Mangaldai
Prof Mangal Chandra Mahato, NEHU, Shillong
Monzurul Kader Ahmed, Birjhora Mahavidyalaya, Bongaigaon
Mr Nabajit Dutta, Handique Girls College, Guwahati
Dr Nripendra Kumar Deka, Cotton College, Guwahati
Mr Partha Pratim Nath, Guwahati College, Guwahati
Prof P Nongkynrih, NEHU, Shillong
Mr Pradip Kumar Kalita, Guwahati College, Guwahati
Mr Priyangshu Rana Borthakur, The ICFAI University, Tripura
Dr Rajarshi Krishna Nath, Assam University, Silchar
Dr Ranjita Devi, Guwahati College, Guwahati
Dr Rulee Baruah, HRH The Prince of Wales Institute of Engineering and Technology, Jorhat
Dr S Brajamani Singh, Manipur University
Dr Saumyajit Sengupta, Don Bosco Sr Sec School, Guwahati
Dr Satyendra Nath Barman, B Barooah College, Guwahati
Dr Sudipta Nandy, Cotton College, Guwahati
Mr Tapan K Sarma, North Guwahati College, Guwahati
Prof Th Ranjit Singha, Assam University, Diphu Campus, Diphu
Mr Uday Sankar Senapati, Handique Girls' College, Guwahati

One-day discussion session on physics education at undergraduate level

The Physics Academy of North East (PANE) and Physical Society of Gauhati University (Department of Physics) jointly organized a meeting on '*Physics Education at Undergraduate Level*' on January 7, 2014 at Department of Physics, Gauhati University. The meeting was formally inaugurated by Dr Mridul Hazarika, Honourable Vice Chancellor of Gauhati University. The meeting has discussed in length and breadth the issues related to physics education at undergraduate level. The merits and demerits of semester and annual systems of examination were discussed in depth. Even though there were some differences of opinion on the merits of semester system, most of the resource persons were of the opinion that the semester system is a better model for examination and evaluation. It was opined that the need of the hour is to improve the existing semester system so that it becomes more useful and effective system of teaching and learning. The summary of the observations were:

- For smooth functioning of the semester system, colleges in general and teachers in particular should be provided with more responsibilities in assessing and evaluating a student. For speedy and error free examination and evaluation, formation of smaller zones may be a solution.
- The vacant posts at various departments in colleges must be filled up without delay
- The higher secondary section should be dissociated from the undergraduate colleges.
- The existing infrastructure facilities, particularly the laboratories and the number of class rooms must be improved.
- The syllabus should be designed in modular model. Present undergraduate physics syllabi are heavily burdened and disorderly arranged.
- Grading system should be thoroughly reviewed
- Under the semester system the need of declaration of results should be in time.

Several eminent academicians including Prof K M Pathak, Former Vice Chancellor of Tezpur University, Prof H L Duarah , Former Vice Chancellor of Gauhati University, and Prof K Pathak, Former Vice Chancellor of Dibrugarh University took part in the discussions. Among other dignitaries present were Prof Dilip Kumar Choudhury, Executive President of PANE, Prof Sourav Basu, Head of Deaprtment of Physics, IIT Guwahati, Prof N Nimai Singh of Manipur University, Dr B Borah, Principal of Pandu College, Dr Balen K Dev Choudhury, Principal of Pub Kamrup College, and Dr (Mrs) I Bordoloi, Principal of Handique Girls' College.

The meeting was convened by Prof Buddhadev Bhattacharjee, General Secretary of PANE.

article

Active Galactic Nuclei (AGN) a class of most prominent sources of TeV γ-rays

Umananda Dev Goswami

Active Galactic Nuclei (AGN) are a class of intriguing objects found at the heart of a galaxy, including our own galaxy, the Milky Way. Dr Umanada Dev Goswami writes about these objects and their highly energetic γ -ray emissions

Dr Goswami is an Assistant Professor in the Department of Physics of Dibrugarh University. He works on theoretical and experimental High Energy Physics, Astrophysics, and Cosmology.

Introduction

Active galaxies are one of the most strange and fascinating classes of objects of our Universe. All such galaxies contain an active central compact region, known as galactic nucleus, with a very high luminosity. It is estimated that $\sim 1\%$ of all galaxies have an active nucleus [1]. These Active Galactic Nuclei (AGN) consist of supermassive black holes of a few million to a few billion solar masses, which accrete matter and convert $\approx 10\%$ of the rest mass of the accreted matter into electromagnetic energy to provide the spectacular observational evidences for their existence [2, 3]. It should be noted that, although it is most likely that all galaxies contain one or more supermassive black holes, all of them may not be active [4]. Only about 10% of all AGN exhibit relativistic jets, powered by accretion onto a supermassive black hole [1]. The total power output of an AGN may range from $10^{40} - 10^{47}$ erg/s,which spreads across the entire electromagnetic spectrum ranging from radio waves to γ-rays [2, 3]. The current interest on AGN is mainly focused as a prominent class of TeV γ-ray emitters. TeV γ-rays are true reliable messenger of our relativistic Universe because they can be traced back to their sources. The study of TeV γ-ray sources is very important to solve many fundamental problems in physics, such as the source and acceleration mechanisms of high energy cosmic rays, existence of dark matter, and cosmic strings etc. [2]. In most of the cases, the power output of an AGN varies with respect to time which may ranges from years to minutes or even less. The high luminosity of AGN is the direct evidence of their high mass content as, to counter balance the huge radiation pressure, a high gravitational force is necessary for a stable configuration [3].

Unified model of AGN

Depending on observational characteristics, AGN can be classified in many different ways. However, there are three more important classes of AGN - Seyfert galaxies, quasars, and blazars [2, 3]. Since this classification is based on the observational characteristics, rather than proven inherent properties, there is a general belief that all AGN are almost same and can be described by a single model. Consequently, a widely accepted unified model of the various classes has been developed. The main idea behind this unified model is that, the central part of an AGN contains a supermassive black hole of mass $\sim 10^7 - 10^{10} M_\odot$. Around the hole, there is a thin accretion disk surrounded by a thick torus lying in the equatorial plane of the hole (see Fig.1). There are some additional features of the model as per requirement to explain the observational properties of different AGN [2]. Thus the observational characteristics

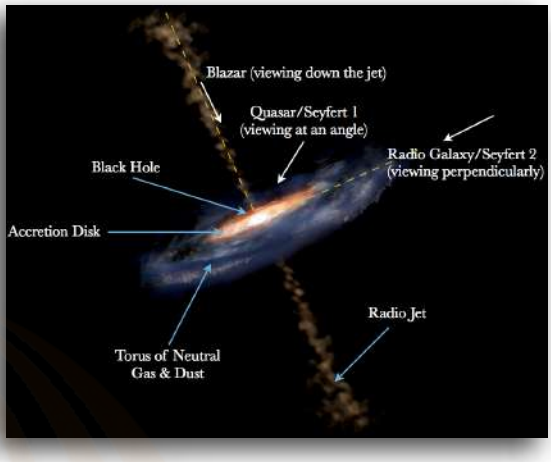

Fig.1. An artists impression of the unified model of AGN. Depending upon the viewing angle we observe different classes of AGN.

of an AGN are mainly attributed to their geometry, specially the angle between their rotation axes and the line of sight of the observer [1, 2]. This angle is large in cases of Seyfert galaxies and quasars, whereas it is acute for blazars. However, there is no evidence of high-energy γ-radiation from the Seyfert galaxies [2] and as far as TeV γ-rays are concerned, blazars are the most important AGN than the quasars, because in general, quasars are not prominent TeV γ-ray emitters [1]. Moreover, blazars are more compact compared to quasars.

TeV γ-rays emission from AGN

One of the most exciting discoveries during 90s is the detection of very-high energy γ-ray emission from extragalactic sources, i.e. from AGN. Very-high energy γ-rays fall within the range of ≥ 30 GeV to ≤ 100 TeV [2]. Markarian 421 (Mrk 421) is the first AGN, detected as a source of very-high energy γ-rays by the Whipple telescope in 1992 [5]. It is classified as a BL Lac object, a subclass of the blazar family of AGN with a redshift of $z = 0.031$. The flux measured from the Mrk 421 by the Whipple group during its detection time was 1.5×10^{-11} photons/cm^2/s above 500 GeV. This detection of Whipple was confirmed by HEGRA telescope in 1996 [6]. The HEGRA group measured a flux of $\approx 8 \times 10^{-12}$ photons/cm^2/s above 1 TeV.

Similarly, the second AGN is also detected by Whipple group in 1996, which is the Markarian 501 (Mrk 501), is also a nearby BL Lac AGN ($z = 0.034$) [7]. The flux of Mrk 501 was observed as $\approx 8 \times 10^{-12}$ photons/cm^2/s above 300 GeV. The confirmation of this source is again provided by HEGRA group with a observing flux of $\approx 2.3 \times 10^{-12}$ photons/cm^2/s above 1.5 TeV in

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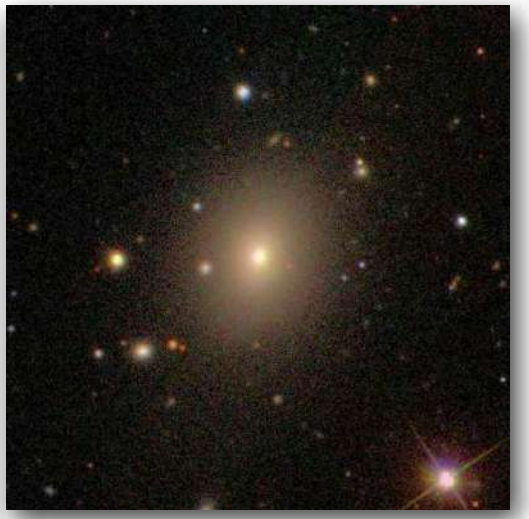

Fig.2. Images of Markarian 421 (left) and Markarian 501 (top).

1997 [8]. As of now about fifty AGN are detected as TeV γ-ray sources by different γ-ray telescopes, of which most of them are blazars at a redshift range of $z = 0.031 - 0.536$. Most recently, three quasars have been detected as sources of very high energy γ-rays [1, 2, 9]. The number of TeV γ-ray sources is expected to increase because of improvement in observational techniques [9].

There are two fundamentally different production processes of very-high energy γ-rays, viz. leptonic and hadronic processes. The main production processes of TeV γ-rays are inverse Compton scattering and decays of neutral pions produced in hadronic interactions. Hadronic processes are, however less favoured in many cases because the cooling times for such processes are long, which makes it difficult to explain the rapid variability. In the lower energy range, γ-rays are dominantly produced from leptons via synchrotron radiation processes [1, 2, 9].

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university news

Tripura University

✦Dr Arshad Hussain of Physics Department, Tripura University has visited Yamaguchi University and Osaka University, Japan during 20 November and 5 December, 2013 as a part of a collaborative science programme. Dr Hussain is the State Executive Member of PANE from Tripura.

✦Also Dr P K. Paul of the same department is visiting Prof T Matsumoto's lab at Department of Chemistry & Macromolecular Science, Osaka University.

✦Dr. Sekhar Chackraborty of Physics Department has joined as a Visiting Scientist in the Department of Materials Engineering, Ben-Gurion University of the Negev, Israel.Mr.

✦Trisanu Banik, a student of the same department has won the first Prize for oral presentation in National Space Science Symposium seminar 2014 (NSSS-2014) sponsored by ISRO at Dibrugarh University.

Gauhati University

✦Dr Buddhadev Bhattacharjee (4th from left in the photograph), a professor in the Physics Department signs an MOU with CERN Geneva at IIT, Mumbai on 27 April, 2013 for the ALICE Physics Collaboration (see photograph). Dr Bhattacharjee is the General Secretary of PANE.

✦Dr Madhurjya P Bora of Physics Department has visited University of York, York and Culham Laboratory, Oxford, UK from September to December, 2013 as a Commonwealth Academic Fellow.

obituary

Prof Subrata Chakraborty playing violin at the NC-HEPC 2013
13 Feb, 2013

Prof Subrata Chakraborty

As our members would recall, Prof Subrata Chakraborty of Visva-Bharati, Santiniketan, had passed away on 15 September, 2013. Prof Charaborty, a former student of Cotton college, was an active member of the PANE and was engaged in research in High Energy Physics till his last days. His sudden demise is a great loss to the Physics Community as a whole and has cast a pall of gloom among his students, colleagues, collaborators, near and dear ones, and other people who were associated with him.

We, at PANE, pay tribute to his contributions and fondly remember his association with this organisation. Following are some condolence messages, conveyed to PANE by his teacher, colleagues, friends, and students.

It's a great loss especially for the PANE community. I along with all my faculty send the deepest condolences to the family of Prof Subrata. May God give strength to his family to bear the loss. We all pray for the departed soul.
- R K Thapa and Faculty
School of Physical Sciences, Mizoram University

Its a great loss for the PANE in particular and to the NE Physics Community in general. I pray God to provide patience to his family to bear the sorrow and grief.
- R C Tiwari, Physics Department
Mizoram University

It is a great shock to learn of the sudden and untimely demise of Professor Subroto Chakraborty. I am still unable to reconcile myself with this harsh reality. Subroto was one of my dearest students working for a PhD in physics at Delhi University. He was also a great exponent of instrumental music - something which I did not approve much of at that time because of fear of possible interference with his Physics career. But, the fear was unfounded because Subroto was a highly conscientious worker who would never let his love for music interfere with his academic work. He was a great soul, whose untimely passing away is a great loss to both the academic and music worlds. May His soul rest in peace.
- A N Mitra, Emeritus professor
Department of Physics, Delhi University

It is indeed sadden to hear the dead of Prof Chakraborty. May his soul be in peace. - Gunadhor S Okram
UGC-DAE Consortium for Scientific Res., Indore

We have lost a person who dearly loved Cotton College.
- Paban Sahariah, Cotton College

His sudden and untimely demise created a never-filled vacuum. His speech was always very much encouraging and motivating to the young researchers like us. His parental approach to all the young researchers and the way of interaction is really unparalleled.
- Subrata Deb, Belonia College

His posture, balanced mind, easy approaching attitude etc, everything we will miss now. India has lost one of her worthy son. - B J Hazarika, Pandu College

Prof. Subrata Chakraborty's demise has come as a shocking news to all. Very sad indeed. Prayers for him. May his soul rest in peace. - Akbari Jahan, Gauhati Univ.

Shocked! The vacuum left behind shall never be filled!
- M R Sheikh Shamu

This is a very sad news, may his soul rest in peace
- Lalrosanga Renthlei

It is a great loss for scientific community, in particular for Physics Academy of North East. May his soul rest in peace. - Th Gomti Devi, NERIST

May his soul rest in peace - Lipi Goswami, GIMT

Really very sorry to learn about the sudden demise of Prof. Subrata Chakraborty. I pray to the Almighty for his eternal peace. - Suparna Bhattacharjee,GU

He was a great teacher who made you beleive that you were important and gave you the confidence everyday to believe in yourself. We can just hope that he has proceeded to another world to spread more sunshine there.
- K Sashikanta, GU

May his soul rest in peace.
- Namita Sarmah Bordoloi, Cotton College

I am very sorry to hear the sad demise of Prof. S.Chakraborty. May his soul rest in peace.
- Zoliana Bawitlung, Mizoram University

It is a great shock to hear Subrata's demise. He was like my dear young brother We shared so many ideas of physics, literature, music, and philosophy together in all these years, here at Guwahati, Delhi, and Santiniketan. Let his loving family members get strength to brave his untimely loss. - Dilip Choudhury, GU and PANE

It is indeed sad.
- V Madhurima, Central University of Tamil Nadu

Good people goes to heaven if God wishes to . . .
- Kushal Kalita, GU

I am really very sorry to hear this sad news. May his soul rest in peace - Alika Khare, IITG

May the Good Lord give enough strength to the bereaved family members for the Lost.
- Ng K Francis, Tezpur University

Prof Subrata Chakraborty was a avid connoisseur of music and was an accomplished violinist.

We had the opportunity to watch him playing violin during the National Conference on High Energy Physics and Cosmology in February, 2013 (see the above photograph).

Here is a 7-min video of Prof Chakraborty, playing *Mishra Bihu* on the violin. Click on the icon below to download this clip.

Courtesy
Physics Department, GU

.mov (546 MB) | .avi (62 MB)

Letters to PANE Newsletter

application of CORSIKA code to simulate VLF radio-emission from cosmic ray showers

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Received 31 December 2013. Accepted 21 January 2014 © PANE

Very Low Frequency (VLF < 1 MHz) Radio Emission by Transition Radiation (TR) mechanism is expected from very large Cosmic Ray showers that have the shower maximum near ground level. CORSIKA is a detailed Monte Carlo program to study the cosmic ray induced Extensive Air Showers (EAS) in the atmosphere. A simple geometrical model is developed for production of TR from cosmic ray EAS using charge excess distribution as calculated from CORSIKA Simulation. The model helps to establish the observed high field strength at lower frequency.

Introduction

The extensive air shower (EAS) is a cascade of secondary charged particles initiated when a high energy ($> 10^{14}$ eV) primary particle interacts with an atmospheric nucleus. It is now well established that the electromagnetic component of an EAS produces radio waves over a wide frequency band from VLF (< 1 MHz) to VHF (up to GHz). The measurement of radio pulses from air showers has a number of advantages – higher duty cycle, lower cost, and better direction estimate at high primary energies.

The possibility of emission of radio wave by negative charge excess of secondary cosmic ray particles in the atmosphere was first pointed out by Askaryan [1] in 1962. In 1965, Jelley [2] detected 44 MHz radio pulse associated with EAS and in 1966, Kahn & Lerche [3] proposed geomagnetic charge separation mechanism for radio emission at higher frequencies. The Gauhati University Cosmic Ray (GUCR) [4,5] group detected radio waves associated with EAS at several frequencies and measured correlation between different pairs, above and below the cutoff frequency (~ 75 MHz) predicted by Askaryan's coherence mechanism. It was proved that the mechanisms responsible for LF and HF radio emissions are different and that the radio field strength increases at low frequency. The high field strength ($\sim 500\,\mu$V m^{-1} MHz^{-1}) at LF, reported by GUCR group was in good agreement with earlier measurement of Hough [6] et. al. In 1985, Nishimura [7] proposed transition radiation (TR) mechanism to explain high field strength at low frequency (LF). Falcke [8] proposed LOFAR (Low Frequency Array) using digital interferometry and consequently the LOPES (LOFAR Prototype Station) experiment [9] was developed. Today's theoretical works mostly involve simulation, viz., REAS3 [10] and MGMR [11] suitable for high frequency, above 10 MHz.

However, no adequate model exists for LF emission. We have developed a model based on TR mechanism using charge excess of EAS particles at ground level as predicted by Monte Carlo simulation code CORSIKA (COsmic Ray SImulation for KAscade) [12] and could explain higher field strength at lower frequency.

Transitional radiation model

The existence of transition radiation was first suggested by Frank & Ginzburg (1946) [13] being emitted when a uniformly moving charged particle traverses the boundary, separating two media of different dielectric properties.

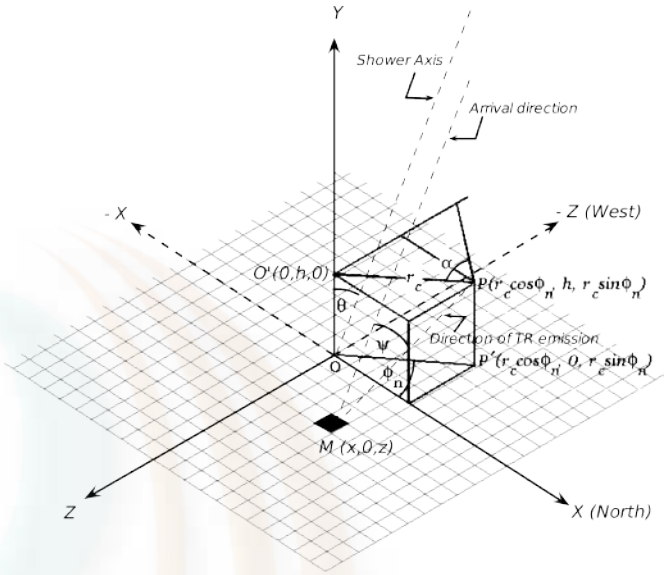

Fig.1. Schematic diagram of the coordinate system used.

We apply TR theory to develop a prototype model for radio emission following Dooher's [14] approach of resolving field vectors into Fourier components with respect to time. A FORTRAN program is written to calculate the arrival time of the transition radiation at the position of the loop antenna, from different elements of the shower front, after striking ground, and the corresponding induced field strength, using charge excess derived from CORSIKA simulation.

Simulation method

CORSIKA code my be used to generate an EAS initiated by photons, protons, nuclei, and many other particles. It recognizes more than 50 elementary particles and gives type, energy, momentum, location, direction, and arrival times of all secondary particles that are created in an air shower and pass through selected observation level. Full simulation was performed using the CORSIKA-6980 code, assuming proton with primary energy 10^{17} and 10^{18} eV. Observation level is fixed at ground. The particle output file from CORSIKA is first decoded with available FORTRAN code. The whole ground area (assumed plane) is divided into elements of area 10 m $\times$ 10 m (Fig.1). FORTRAN programs are used to calculate the negative charge excess and their average arrival time for each element. Another code evaluates the total electric field at the observation point due to kth element on the ground and the corresponding arrival time, to get the TR pulse profile. This information is further transformed to the frequency domain by using DSP method in MATLAB to get the amplitude spectrum and power spectral density estimate.

Results and discussions

Simulation results show about two to three orders of magnitude higher field strengths at VLF compared with higher frequencies and compared with earlier experimental [15] and theoretical results (Fig.2). The TR field strength is found to increase with decrease of frequency.

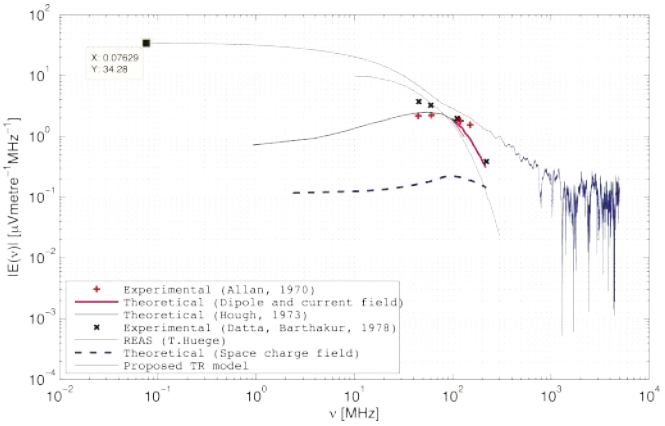

Fig.2. Amplitude spectra showing comparison of present model with REAS and other theoretical as well as experimental observations at 10^{17} eV . Both the TR and REAS spectrum is for 20 m in the north direction of shower centre from a 10^{17} eV proton induced vertical air shower.

Simulation results show about two to three orders of magnitude higher field strengths at VLF compared with higher frequencies and compared with earlier experimental [15] and theoretical results (Fig.2). The TR field strength is found to increase with decrease of frequency. Whereas the other models are incapable of extending towards the LF/VLF side, the proposed TR model seems to contribute much higher field strength to the emission process in this region. With this particular configuration, the TR model shows a lower cut off frequency of about 76 kHz.

In future, using an array of antenna system, it may be possible to estimate the core location, primary energy and mass composition from measurement of radio frequency and field strength.

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role of Zinc and Copper in human stone formation

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Received 3 January 2014. Accepted 28 January 2014 © PANE

Applicability of X-ray spectrometry namely PIXE technique for the elemental analysis in biological and medical fields has been increasing day by day for their quick, reliable, and multi-elemental detection capability. The concentration of the most common elements in the stones formed inside the human body viz. Ca, Fe, Cu, Zn, and Sr were determined and Karl Pearson's coefficient of correlation was determined among the elements where Fe has a positive correlation with the remaining four elements. Other elements also show a positive correlation with certain remaining elements. The roles of some elements out of the five elements were discussed through factor analysis using principal component extraction method where Zn and Cu play more important role as first factor, subsequently, Ca and Sr as second role in the formation of stone.

Introduction

Stone disease is a major problem in many parts of the world. Solid deposits like urinary stones and gallstones formed in human bodies are of sufficient interest to many scientists as it is one of the panic diseases to the mankind. This disease has been known from antiquity and quite prevalent to man as well as animal. Manipur is a north-eastern state of India which borders Myanmar on one side and can be said to fall in the broad belt area of stone disease covering south east, north east, middle east Asia [1]. The state having an area of 22,356 sq km stretches from latitude 23.80° to 25.68° N.

Geographically, It can be divided into two regions — (*i*) valley – just at the heart of the state covering 10% of the total area and (*ii*) hills – surrounding the valley. The population residing in plains consists of Hindus and Muslims and those residing in the hills are Tribals. The prevalence of stone disease was minimal among Tribals [2]. This may be due to different drinking and food habits.

PIXE is one of the most powerful techniques to detect the elements present in an unknown sample as the characteristic X-rays coming out from the different elements in the sample give the definite signatures of them. It has a great potential in trace analysis for its multi-elemental detection capability for a small sample. PIXE analysis trend was started in 1970 by Johansson and co-workers [3]. Many workers studied biological samples using this technique [4-6]. The main application of this technique is investigation of major, minor, and trace elements in the tissues as deficiency and accumulation of the said elements may lead to many diseases and disorders. Some of the trace elements known to be essential are Cr, As, Co, Cu, F, I, Fe, Mn, Mo, Ni, Se, Si, Sn, V, Zn, and other essential major elements are C, H, O, N, S, Ca, P, K, Na, Cl, and Mg totalling to twenty six essential elements [7]. In addition to these elements, toxic elements like Hg and Pb are acquired by the body as environmental contaminants. These toxic elements are known to be very harmful even at extremely low concentrations. Due to the increasing importance of the need to determine the role of essential and toxic trace elements in human health and disease, it has become important to investigate the trace elemental levels for the research and diagnostic purpose in medicines.

Table.1. Concentration of elements in human stones (ppm).

Sample	Elements					Sample	Elements				
	Ca	Fe	Cu	Zn	Sr		Ca	Fe	Cu	Zn	Sr
1	17400	5.0	0.0	11.0	3.0	**10**	114866.0	872.5	26.2	87.2	72.8
2	26000.0	0.0	0.0	8.0	8.0	**11**	387336.3	472.3	0.0	219.0	362.6
3	27000.0	11.0	0.0	24.4	1.0	**12**	369703.4	957.6	8.3	76.1	114.1
4	77000.0	25.0	0.0	10.5	1.2	**13**	143770.3	547.3	37.1	56.9	56.8
5	7000.0	8.0	0.0	75.0	3.5	**14**	341722.0	567.0	0.0	150.8	307.2
6	28000.0	2.0	0.0	29.0	21.0	**15**	356478.8	844.8	0.0	77.7	85.1
7	16700.0	8.0	5.0	56.0	0.8	**16**	166448.6	379.1	9.9	87.5	50.5
8	19000.0	10.0	18.0	22.0	1.7	**17**	7169.1	463.1	11.0	16.7	73.3
9	684.4	335.7	3.6	14.4	0.0						

Table.2. Correlation matrix.

Elements	Ca	Fe	Cu	Zn	Sr
Ca	1.0	0.526	-0.191	-0.177	0.807
Fe		1.0	0.521	0.519	0.347
Cu			1.0	0.999	-0.156
Zn				1.0	-0.138
Sr					1.0

Table.3. Varimax rotated factors : Principal component extraction.

Sample	Factor Loadings		Community
	F_1	F_2	h_i^2
Ca	-0.0735	0.963	0.932
Fe	0.674	0.603	0.818
Cu	0.980	-0.124	0.977
Zn	0.979	-0.111	0.970
Sr	-0.0948	0.903	0.824
Variance	2.389	2.131	4.52
% of variance	47.786	42.627	90.4

Experimental method

The stones, removed from different patients were collected from Regional Institute of Medical Sciences, Imphal and washed with distilled water to remove possible blood constituents and dried in room temperature. Eight samples were analysed at Centre for Characterisation of Compositional materials (CCCM), Hyderabad and another nine samples were also analysed at Institute of Physics (IOP), Bhubaneswar with same technique. An amount of 0.4 gm of the powder sample was mixed with pure graphite powder in the ratio 9 : 1 and pressed into pellets of 13 mm in diameter with a pressure of 30 kN/m^2. Protons of 2.5 MeV energy and a beam size of 3 mm in diameter from the Tandetron accelerator at CCCM was used for irradiation of the samples in the scattering chamber having a pressure of 5×10^{-5} mbar. A polyethylene sheet of thickness 300 μm was used to attenuate the prominent low energy peaks as well as the bremsstrahlung background and a beam current of 2 nA was used for it. A planar p-type Ge detector (Euresis Messures Type EGX 100-01, cooled at liquid nitrogen temperature, 77K) with full width half maximum (FWHM) of 155 eV at 5.9 keV was used to detect the characteristic X-rays from the sample and a multi-channel analyser was used for recording the spectrum. The concentration of an element in the unknown sample is directly proportional to area under the peak of the said element. This peak area can be determined by the Multi Channel Aanalyser (MCA) fitted to the Computer.

The elemental concentrations were calculated with the GUPIX 99 interactive software and coal fly ash (NIST) was used as external standard. Further, a 3 MeV collimated proton beam of diameter 2 mm obtained from the 3 MV Tandem Pelletron accelerator at IOP was used to irradiate the targets under vacuum condition (10^{-6} torr) inside the PIXE chamber [8]. Si(Li) detector cooled at liquid nitrogen temperature with FWHM 180 eV at 5.9 keV was used to detect the characteristic X-rays from the samples. The spectrum was recorded by a PC based MCA in 2K channel mode. The concentrations of the elements were determined using the GUPIX-96 software [9]. Pure single material as well as animal bone standard [10] and Pd standard [11] were also reported for the analysis of stones by earlier workers.

Results and discussions

A typical spectrum of one stone is shown in Fig.1. The characteristic X-ray peaks of Ca K$_\alpha$, Ca K$_\beta$, Fe K$_\alpha$, Zn K$_\alpha$, Zn K$_\beta$, and Sr K$_\alpha$ were observed from the corresponding X-ray energy signifying the presence of calcium, iron, zinc, and strontium in the particular stone (Sample 1). This process is known as qualitative analysis. For quantitative analysis, the area under the peak is taken for each element as the concentration of a particular element is directly proportional to its corresponding area. The elemental concentrations of the five elements of the stones are shown in Table.1.

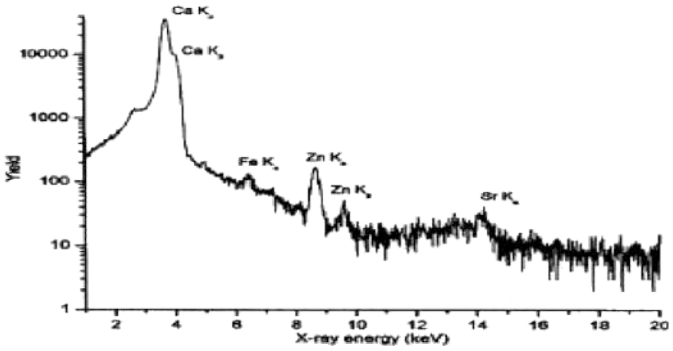

Fig.1. A typical PIXE spectrum of kidney stone (Sample 1).

As evident from the table, the concentration of the elements was different for different stones. Ca was found to be the major constituent element in the stones and it was common in all types of stone followed by Fe, Cu, Zn, and Sr in trace levels. The correlation matrix of the elements is given in Table.2. There is a positive coefficient of correlation of Fe with all the remaining four elements. This may further support the idea that Fe is scattered in stones as impurities or intergrowths inside the constituents of the stone [12]. There is a strong positive correlation between Ca and Sr; Cu and Zn. From the table, it is seen that there is a good inter-elemental relationship among different constituent elements in the stone.

Factor analysis, a multivariate statistical technique, was initially developed as a tool in the social sciences but has proven quite effective in scientific analysis also. The technique is used for data reduction and for deciphering patterns within large sets of data. This technique aims to transform the observed variables to a set of variables, which are uncorrelated and arranged in decreasing order of importance.

The factor analysis by using principal component extraction method was carried out in order to access the importance various elements in the composition of stones. Factor analysis aims at obtaining the prominent interpretable factors hidden in data set that explains as much of the total variability. The loadings on first two factors F_1 and F_2 that explain 90.4 percent of the total variability are shown in Table.3. As evident from the table, the loadings of Cu and Zn on F_1 are very high whereas the loadings of Ca and Sr on F_2 are high. The loading of Fe is almost equal for both factors. The variance explained for F_1 and F_2 are found as 2.389 and 2.131 which are 47.786 and 42.627 percent respectively. The communality column shows the part of the variance of each variable explained by the common factors.

Despite several efforts to elucidate the formation of stones, it largely remains unsolved. However this may be caused due to genetic, nutritional, and environmental factors. The change in Zn status reflects the probability of immune response inhibition which might lead to the progression of disease concerned [13]. Further, Cu might have taken important role as it has a high positive correlation coefficient with zinc.

Nevertheless, stone formation begins by nucleation of a crystal nidus from a supersaturated urinary environment, followed by transformation of the nidus into a stone through crystal growth, epitaxial growth, and crystal aggregation [14]. The basic factor responsible for renal stone formation is - changing composition of urine. In addition to it temperature, pH have influential role in the stone formation. The organic matters provide binding matrix for crytalloids and helps in increasing the volume of the stone. The growth of crystal takes place in suitable orientation, thereby forming different shapes of stones.

Conclusions

Human stones are analysed by PIXE technique and the concentrations of the elements in the stones are determined in ppm level. The predominant element was found to be calcium. Out of the elements, Zn and Cu play more important role as compared to remaining elements like Ca, Fe, and Sr. PIXE technique cannot investigate the compounds responsible for the formation of stone although it can determine the elemental concentration.

Acknowledgement

The author would like to thank the staffs and authority of IOP, Bhubaneswar and CCCM, Hyderabad for extending facility for the analysis of the stones.

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PANE Conference 2014

The PANE Biennial Conference 2014 will be held in North Eastern Regional Institute of Science and Technology (NERIST, www.nerist.ac.in), Nirjuli, Arunachal Pradesh from November 3 to 5, 2014, as per news released by Prof P R Alapati, State Executive Member of PANE from Arunachal Pradesh. As per information, the organisers are taking care that the PANE Conference will be well separated from the forthcoming DAE-HEP Symposium coming up in December 8 to 12, 2014 at IIT, Guwahati. Dr Todo Carlo (from NERIST) and his team are now working on the conference poster and the first announcement is supposed to be released soon.

News by Dr Pijush Kanti Dhar
Publicity Secretary, PNAE

study of electronic and optical properties of BiSe and BiTe using density functional theory

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Received 11 January 2014. Accepted 6 February 2014

The electronic structures for BiSe and BiTe have been investigated by first principles full potential-linearized augmented plane wave (FP-LAPW) method with Generalized Gradient Approximation (GGA). The calculated density of states (DOS) and band structures show semiconducting behaviour of BiSe and BiTe with a narrow direct energy band gaps of 0.2 eV and 0.7 eV, respectively. The real and imaginary parts of dielectric constants ε_1 and ε_2 are also calculated to understand the bulk crystal optical properties of BiSe and BiTe.

Introduction

Today semiconductors can be grown with various compositions ranging from monoatomic layer to nano-scale islands, rows, arrays, in the art of quantum technologies and numbers of conceivable new electronic devices are manufactured [1]. Narrow gap semiconductors BiSe and BiTe are classic room temperature thermoelectric materials [2]. Their excellent thermoelectric performance has been attributed to the details of the near-gap electronic structure combined with low lattice thermal conductivity. BiSe and BiTe are the chalcogenides of transition metal having applications in the field of opto-electronic devices like photodiodes, solar cells, LED, and semiconductor lasers. They have NaCl structures at room temperature with Wyckoff positions as Bi $(0,0,0)$ and Se & Te $(0.5,0.5,0.5)$ [3]. In this report, we would like to present a systematic study of DOS, energy band structures, and optical absorption [4, 5] of BiSe and BiTe using FP-LAPW method.

Computational methods

First principles FP-LAPW [6] method based on density functional theory (DFT) [7, 8] is used for calculations of DOS, band structure, and dielectric constants of BiSe and BiTe. For exchange -correlation, we have used GGA [9]. In the FP-LAPW procedure, wave functions, charge density, and potential are expanded in spherical harmonics within non overlapping atomic spheres of radius $R_{\rm mt}$ and in the remaining space of the unit cell plane waves are considered. The maximum multi-polarity l for the waves inside the atomic spheres was confined within $l_{\rm max} = 10$. The wave functions in the interstitial region were expanded in plane waves with a cut-off up to $K_{\rm max} = 2.5\,\text{a.}u.^{-1}$ (where $K_{\rm max}$ is the maximum value of the wave vector $\boldsymbol{K} = \boldsymbol{k}+\boldsymbol{G}$). The equillibrium lattice constants were optimized using the experimental values of $a = 5.59\,\mathring{A}$ for BiSe and $a = 6.47\,\mathring{A}$ for BiTe [3]. The bond lengths calculated from lattice parameters are found to be $2.95\,\mathring{A}$ between Bi and Se, and $4.57\,\mathring{A}$ between Bi and Te. The calculation was accomplished by using the WIEN2K code [10]. BiSe and BiTe are the chalcogenides with space group Fm3m (number 225). The muffin-tin radii are set to $R_{\rm mt} = 2.4\,\text{a.}u.$ for Bi, $2.3\,\text{a.}u.\,for Se, and 2.4\,\text{a.u.}$ for Te. A mesh of 1000 k-points was used after doing k-optimization. The calculated lattice constants found by volume optimization are $a = 5.9492\,\mathring{A}$ for BiSe and $a = 6.3928\,\mathring{A}$ for BiTe which are shown in Figs.1 (a and b).

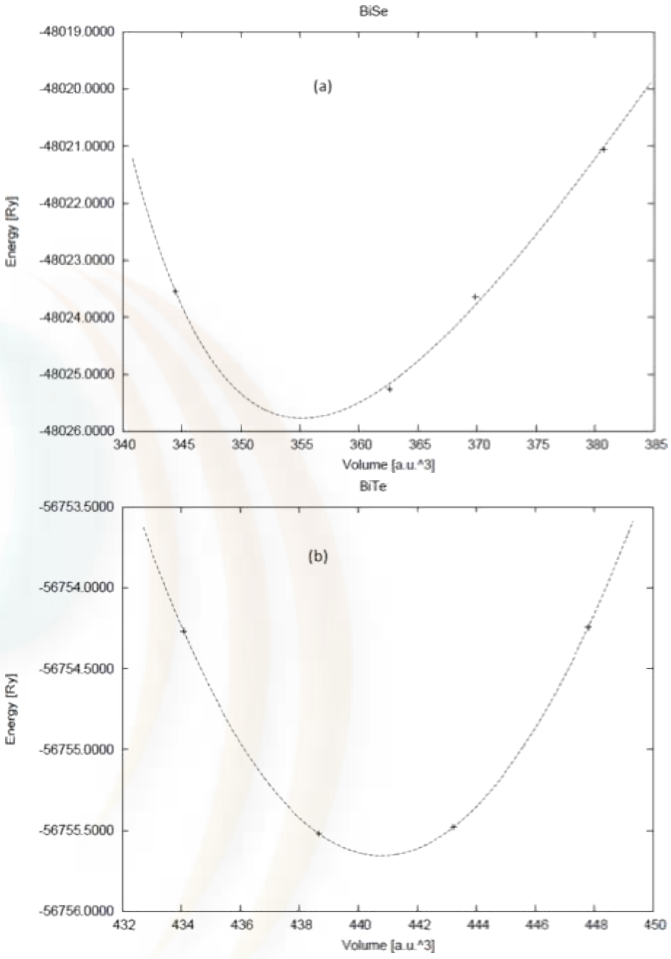

Fig.1. Volume optimization for BiSe and BiTe.

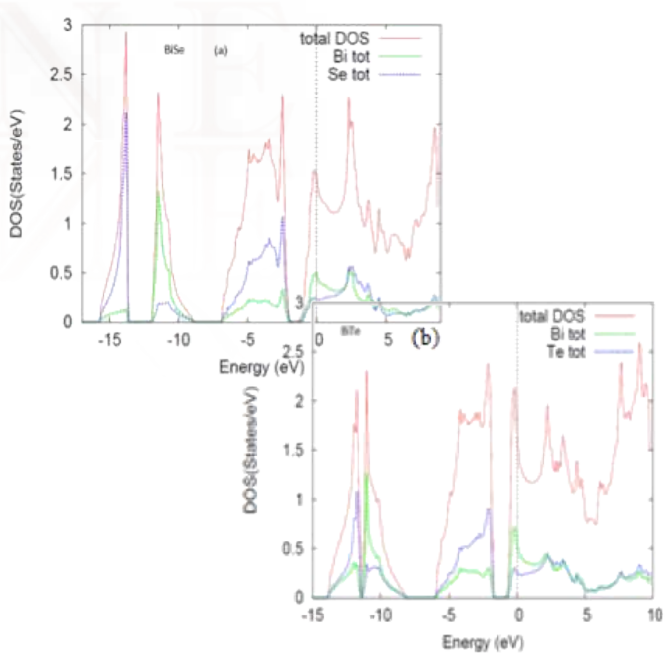

Fig.2. Total DOS for BiSe and BiTe.

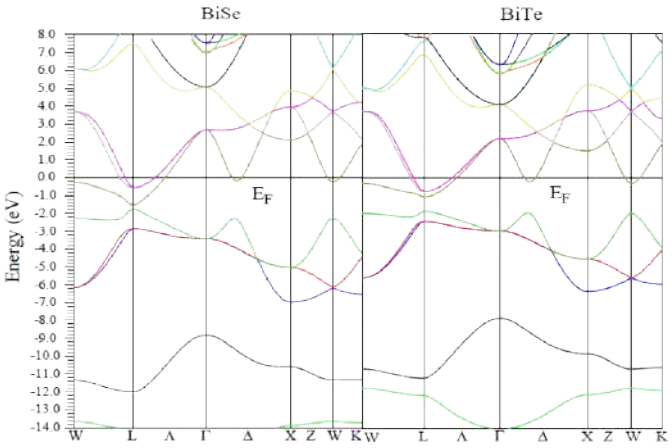

Fig.3. Band structures of BiSe and BiTe.

Results and discussions

The total DOS plots of BiSe and BiTe are shown in Fig.2. From Fig.2(a) we found that the contribution to total DOS are from Bi-6p and Se-4p electron states . In the core region, 6p states of Bi shows sharp peak at -11.0 eV. In the valence region, we have observed, Se-4p states contributing to total DOS. In the valence region, we have observed, Te-5p states contributing to total DOS.

From the band structure plots (Fig.3), we observe a direct band gap of the order of 0.2 eV and 0.7 eV in BiSe and BiTe respectively below E_F at high symmetry point L. The band structure plots were also found with higher number of bands at the regions where peaks of the DOS were observed. In Figs.4(a) and 5(a), we have presented the calculated imaginary parts of the total dielectric function ε_2 as a function of energy. Optical spectra have been analysed for the energy range $0-14$ eV. Our calculated dielectric function has displayed basically two main peaks and they are positioned around 0.7 eV in BiSe and 0.4 eV in BiTe. The peaks are sharp peaks with maximum around the Fermi level. These are followed by some small structures. The peaks reproduced in our calculation are the general form of the spectra. The trend in ε_2 may be linked to the trends observed in the DOS and band structures. Our band-resolved optical calculations show that the transition between highest lying valance band (HVB) and lowest lying conduction band (LCB) account for almost all structures in the optical spectra at energies below 10 eV. Optical transitions between bands that are parallel or nearly so in an appreciable part of the BZ tend to result in peaks in the optical spectrum. The real parts of the total dielectric function ε_1, presented in Figs.4(b) and 5(b), are obtained from the imaginary parts by the Kramers-Kronig relation [11] leading to the features consistent with ε_2. In this study, we have found similar type of results in both the chalcogenides.

Conclusions

In conclusion, we have observed a strong hybridization between Bi-6p and Se-4p states in BiSe and between Bi-6p and Te-5p states in BiTe near and at the Fermi level (E_F). The band structure plots were also compared with the DOS results and a direct band gap of the order of 0.2 eV and 0.7 eV in BiSe and BiTe were found suggesting that these are semiconductors with low energy gaps. However, the band gaps when checked with experimental values (optical band gap = 0.35 eV and thermal band gap = 0.37 eV of BiSe and band gap = 0.165 eV of BiTe) [12,13] seem to have differences. We propose to check this discrepancies with mBJ potential inclusion. Furthermore, we have found that transitions between highest lying valence band and lowest lying conduction band are responsible for most of the optical absorption in this system.

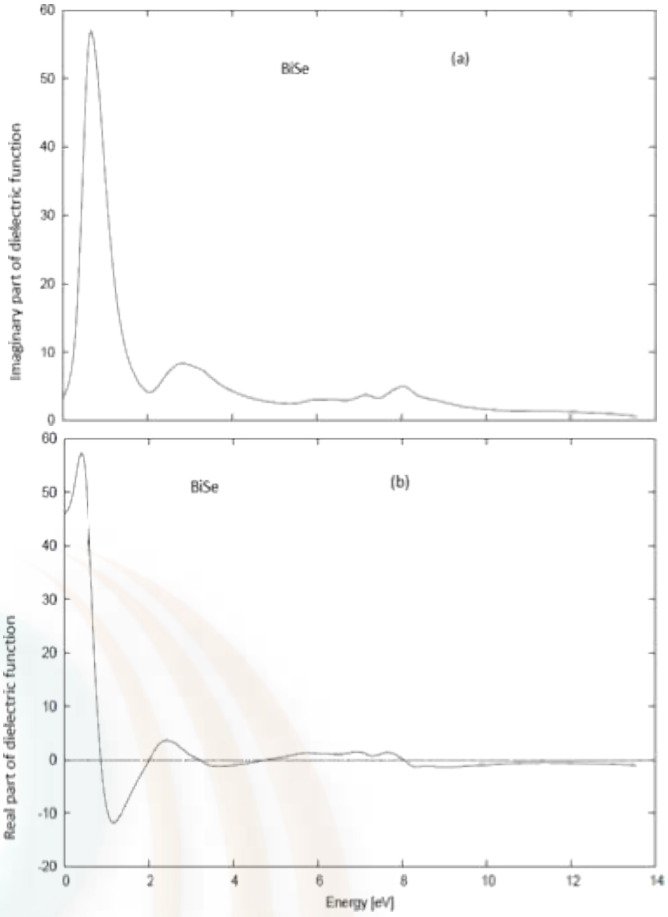

Fig. 4. Dielectric constants of BiSe.

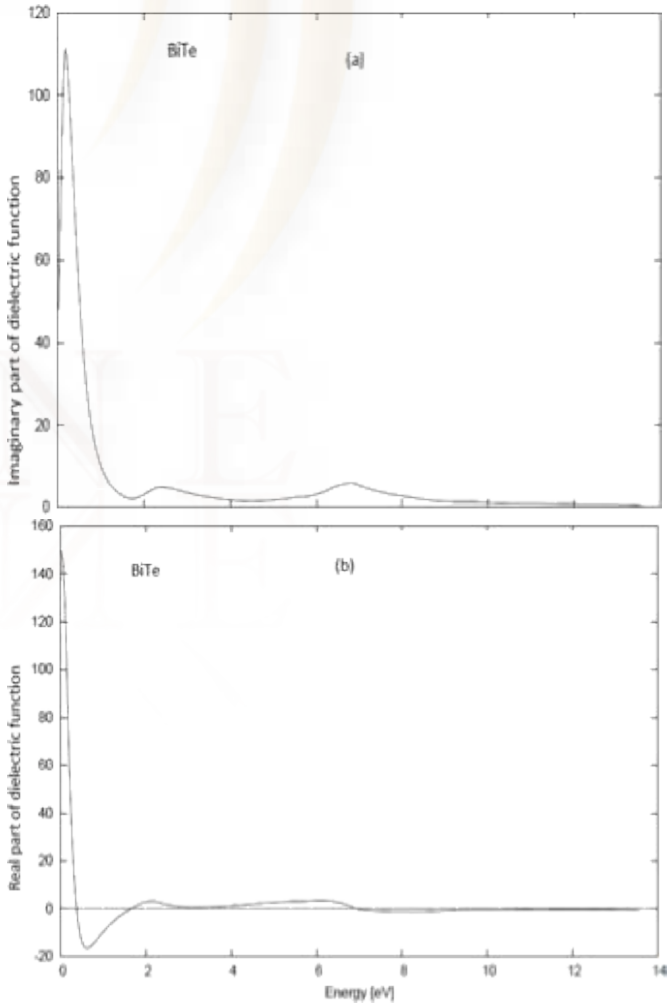

Fig. 5. Dielectric constants of BiTe.

Acknowledgement
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article

Noise
boon or bane?

Shantu Saikia

Shantu Saikia of St Anthony's College (Shillong) is writing about few exciting possibilities of noise, an otherwise unwanted phenomena.

The Ratchet Effect is one such possibility being utilised at microscopic level.

Dr Saikia is a PANE executive member from the Department of Physics of St Anthony's.

Introduction

"*We live in a very noisy environment*". The term noise (or fluctuations) here refers to the minute and random variations in temperature to which any physical or biological system at a finite temperature is subjected to. These fluctuations have their origin in the coupling of the system to the external environment and so are present in almost all systems. With this perception of noise, we are very safe to make the above statement.

Conventionally, noise has always been an undesirable element in any system as it was always thought to have a destructive role. Thrust was to devise ways and means to minimise the amount and effect of noise creeping into systems. However, a finite amount of noise always remained. Therefore, efforts started to discover and hence to model systems where these random fluctuations could play a constructive role. As a result, over the past three decades, many pioneering works have revealed the constructive role of noise in different systems.

In the macroscopic domain, the effect of noise or fluctuations in the system dynamics is negligible, as the energy associated with these random fluctuations is negligible compared to the mean energy of the system. However as we go down to the microscopic domain, the energy scales of these fluctuations become comparable to the mean energy scales of the system and they start playing a non-negligible and at times a dominant role in determining the nature of the system dynamics. The discovery of 'Brownian motion' by British botanist Robert Brown (1773-1858) in 1827 and its subsequent analysis, highlighted the role these random fluctuations can play in the microscopic regime.

As of now many systems have been discovered whose dynamics is governed by non-equilibrium fluctuations. Several noise-induced or noise-assisted non-equilibrium phenomena have been discovered in physical and biological systems. For example, thermal ratchets (also called Molecular motors or Brownian motors), stochastic resonance

Fig.1. Reproduction of Umberto Boccioni's (1882-1916) painting, "The Noise of the Street Enters the House".

(SR), resonant activation, noise induced stability of states, noise-induced transitions and phase transitions, reaction rate theory, driven diffusive systems, etc., are few of these systems and processes.

Ratchet effect

Ratchet effect is a non-equilibrium phenomenon in which particles moving in a periodic potential attains a net unidirectional motion in the presence of random fluctuations without the application of any obvious external bias. This model system of particles moving in a periodic potential have many analogue in physical and biological systems, for example ad-atoms moving on the surface of a crystal, motion of vortices in a superconductor, motion of motor proteins along microtublules etc.

In this phenomenon, the particles utilise the energy of the random fluctuations constructively do useful work. Primary motivation for the study of ratchets was to understand the operation of biological motors or molecular machines occurring in nature. For example, to give a physical explanation of the motion of the motor proteins along microtubules. The motor proteins (actin, kinesin, and dyenin) transport organelles (cargo)

for intracellular transport (kinesin and dyenin) and for muscle contraction (actin). They use energy generated from the hydrolysis of ATP to ADP. The dimensions of these molecular engines are in the nanometer range. Also, the operation of these systems deal with minute amounts of energy. At these dimensions and energy scales, the behaviour of these systems is influenced by fluctuations far away from equilibrium, as the energy of these fluctuations become comparable to the energy scales of the system. This leads to many observable and significant deviations from the system's average behaviour. However the molecular motors, in spite of operating in a very noisy environment, have high efficiencies, converting almost 20-90 percent of the energy to mechanical work and dissipating the rest into the environment.

Though the primary motivation for studying ratchet effect was to understand the underlying mechanism for the operation of molecular motors, the realm of noise assisted transport mechanism has gone far beyond the biological domain. The ability of the molecular motors to utilise non- equilibrium fluctuations for the generation of useful work and their high efficiencies has aroused the interest of the scientific community in small systems of molecular dimensions. The very presence of these naturally occurring molecular motors points to the possibility of fabricating artificial nano-devices for various technological applications. During the past few decades, significant strides have been made in designing artificial Brownian motors with successful experimental demonstrations and technological applications. Inspired by naturally occurring ion pumps in biological systems which transport ions through nanopores in membranes against concentration gradients, artificial nanopores have been fabricated in polymer films and silicon materials. Nanofluidic diodes have been prepared which can rectify ion currents similar to a semiconductor diode rectifying electron current . Advanced high resolution particle separation techniques are being developed. For example, mesoscopic particles can be selectively filtered through asymmetric bottle-neck like pores pierced in silicon membranes. This is possible due to the sensitive dependence of the transport direction on the particle size. Ratchet devices that control the motion of magnetic flux quanta in superconductors were predicted. This is possible by allowing these fluxons to move along asymmetric channels. Subsequently, the findings were experimentally verified. These devices find applications in superconductivity. These are but only a few of many potential applications of devices based on ratchet effect.

Any system in contact with a constant temperature bath is subjected to random thermal fluctuations. But the second law of thermodynamics forbids the utilisation of these fluctuations by the system to generate useful work as long as the system is in thermodynamic equilibrium. If that was possible, it would be like having a perpetuum mobile of the second kind, which will be able to extract thermal energy from a single temperature bath and convert it into mechanical energy. Hence rectification of the fluctuations is impossible in equilibrium. This is supported by the principle of detailed balance which states that at equilibrium, the rate of occurrence of any transition in a system equals the corresponding rate of occurrence of the reverse transition. Rectification is possible only when the system is driven away from thermodynamic equilibrium. Earlier, efforts were made to conceptualise a model to illustrate the phenomenon of ratchet effect. Richard Feynman in a thought experiment popularly known as the 'ratchet and pawl' experiment, was able to design a model which could utilise the random motion of Brownian particles to generate directed motion, by breaking the symmetry of the system. The system also had to be driven away from equilibrium. The *ratchet and pawl* was subsequently experimentally verified. Its subsequent analysis contributed a lot to the theoretical formulation of the physics of ratchets and ratchet effect.

For ratchet effect to be realised, a system has to satisfy the following general conditions: (*i*) There should be an underlying spatially periodic potential in the system, (*ii*) The symmetry of the system has to be broken, (*iii*) All the forces and gradients present in the system has to average out to zero when averaged over time, space or ensembles, (*iv*) The system has to be driven permanently out of thermodynamic equilibrium, and (*v*) Random forces (of thermal, non-thermal, or even deterministic origin) should play a prominent role. There are different ways in which the above mentioned general conditions can be met. Based on these, different ratchet models have been proposed. For example, rocking ratchets, flashing ratchets, inhomogeneous ratchets etc. In all of these models, there is a complex interplay of thermal noise, nonlinearity, asymmetry, and unbiased driving which can lead to a rectification of noise resulting in a net motion of particles. In recent years, an enormous amount of work has been devoted to the detailed theoretical exploration of all these numerous models. Moreover, an appreciable and growing number of experimental studies and biological and technological applications have been established such as microscopic particle separation. Of late, the field of deterministic ratchets has also drawn substantial interest of the scientific community. In these systems, net current results, without the presence of any external bias or asymmetric fluctuations. In these ratchets, the deterministically induced chaos mimics the role of thermal noise.

To conclude, the presence of an optimal amount of noise in certain systems can play a constructive role giving rise to many counterintuitive phenomena; ratchet effect being one of them. Noise thus becomes a boon rather than a bane for such systems.

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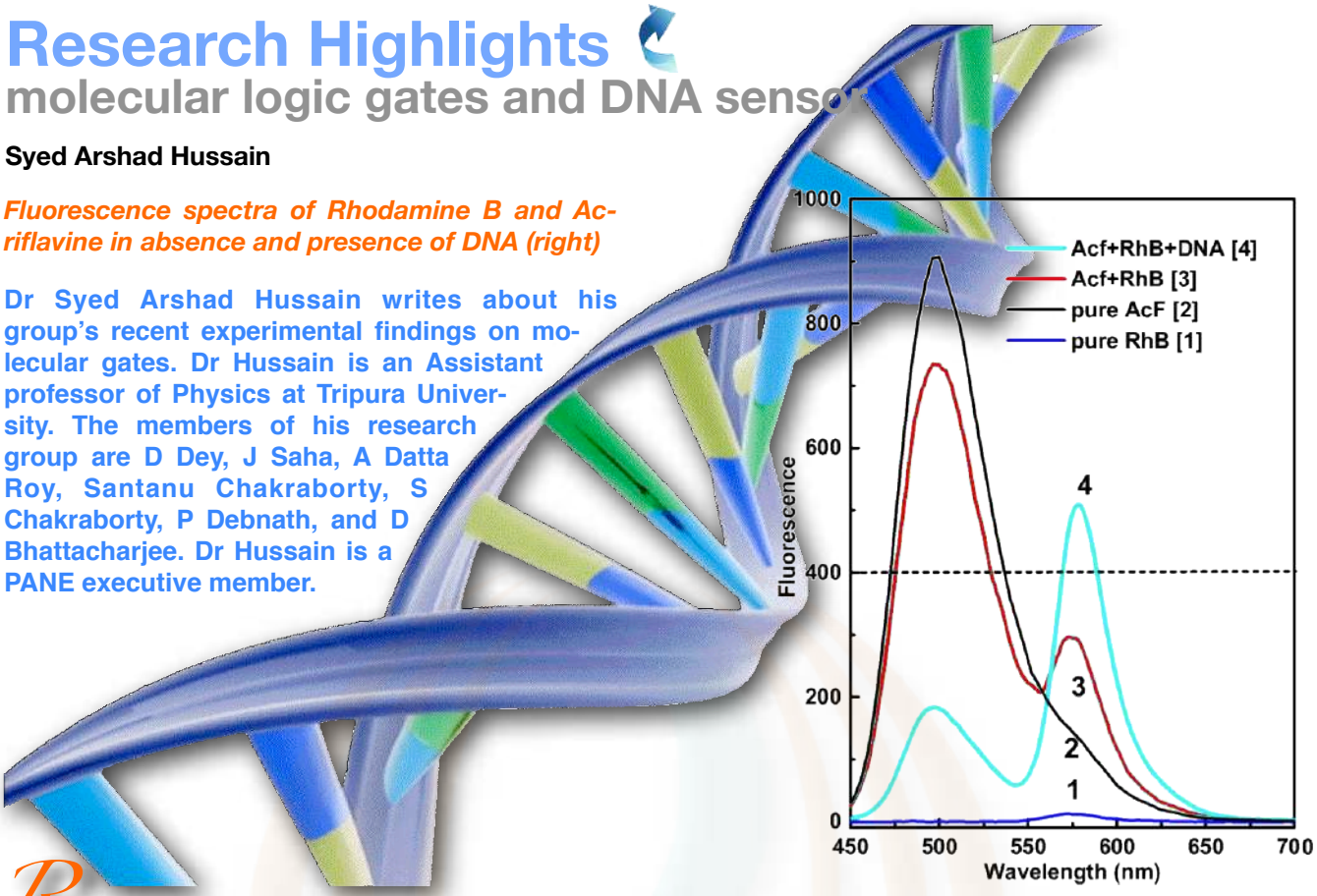
Research Highlights

molecular logic gates and DNA sensor

Syed Arshad Hussain

Fluorescence spectra of Rhodamine B and Acriflavine in absence and presence of DNA (right)

Dr Syed Arshad Hussain writes about his group's recent experimental findings on molecular gates. Dr Hussain is an Assistant professor of Physics at Tripura University. The members of his research group are D Dey, J Saha, A Datta Roy, Santanu Chakraborty, S Chakraborty, P Debnath, and D Bhattacharjee. Dr Hussain is a PANE executive member.



Research on molecular logic gate was initialized by the recognition of the pioneering work of de Silva using the beguiling idea that molecules can manipulate and process information using logic, as do electronic computers and human brains. A remarkable progress has been made since then in the development of molecular logic gates. The change in fluorescence characteristics of a dye due to the introduction of some external agent can be considered to be analogous to the digital responses in electronic logic gates. Molecules can undergo changes in ground or exited state due to the interference of some external chemical or biological materials.

In our experiment, we use Acriflavine (Acf) and Rhodamine B (RhB), which are laser dyes with ultrapure Milli-Q water (resistivity 18.2 MΩ-cm), as solvent. Sheared Salmon Sperm DNA having a size of nearly about 2000 bp with approximate GC content 41.2% was used as received. The purity of DNA was checked by UV-Visible absorption and fluorescence spectroscopy. The excitation wavelength (λ_{ex} = 420 nm)was selected to excite the Acf molecules directly and to minimize the direct excitation of the RhB molecules. With this excitation Acf shows prominent fluorescence and RhB shows negligible fluorescence. However for Acf-RhB mixed solution fluorescence spectrum, the RhB fluorescence intensity increases even with this excitation wavelength (420 nm), as well as Acf fluorescence decreases compared to their pure counterpart. This is due to the transfer of energy from Acf to RhB. It is interesting to observe that in presence of DNA, the RhB fluorescence intensity increases and the Acf fluorescence intensity decreases further, compared to that in absence of DNA. This indicates that presence of DNA influence the extent of energy transfer between these dyes. Based on the fluorescence spectra the FRET efficiency have been calculated using the following equation $E = 1 - F_{DA}/F_D$, where F_{DA} is the relative fluorescence intensity of the donor in the presence of acceptor and F_D is the fluorescence intensity of the donor in the absence of the acceptor.

It has been observed that the FRET efficiency of the dye pair increases from 20% (absence of DNA) to 79.1% (presence of DNA). These data support the increase in energy transfer between Acf and RhB in presence of DNA. We would like to mention in this context that FRET process is distance dependent. In presence of DNA, the cationic dyes Acf and RhB are adsorbed onto negatively charged phosphate backbone of DNA. This causes closer approach between them and resulting an increase in FRET efficiency.

Based on the spectral characteristics, we have designed the logic gate. We consider the fluorescence intensity of 500 nm band during FRET between Acf and RhB, as the output signal and presence of DNA as input. Fluorescence intensity of 400 units has been chosen as the reference level. In the absence of DNA (input = 0), fluorescence intensity at 500 nm band is greater than the reference level (output = 1). In presence of DNA (input = 1) the 500 nm fluorescence band intensity is less than the reference level (output = 0). Thus an effective NOT gate can be developed which can sense the presence of DNA in aqueous solution having concentration as low as 1 μg/ml. Thus by observing the fluorescence intensity of 500 nm band it is possible to detect the presence of DNA.

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article

Relativity on fifty years of relativistic astrophysics

Sanjeev Kalita

The year 1963 marked the entry of relativistic theory of gravity into the regime of astrophysics. Since the foundation of general relativity, the theory used to be a playground for mathematical physicists, with no support from realistic objects in the Universe. However, nature did oblige to relativists (Narlikar, 2010) in 1963 when the potential application of relativistic gravity was physically realized. The discovery of quasar by Marteen Schmidt (1963) and rotating black hole geometry by Roy Kerr (1963) was the beginning of a new branch known as 'Relativistic Astrophysics'. It basically deals with cosmic objects and phenomena where general relativity plays role.

Quasars are compact looking objects which are huge radiators, being 100 to 1000 times brighter than the brightest galaxies, lying at cosmological redshifts and each emitting from a region as small as the solar system containing a mass as large as 1 million to 10 billion Suns. Hoyle and Fowler (1963) proposed existence of supermassive stars having strong gravitational field and being responsible for quasar energy output. It indicated an environment where relativistic gravity is fully applicable. This heralded the beginning of Relativistic Astrophysics with the first international conference at Texas University. The biennial series is called Texas Symposium, the latest of which was over by December, 2013. Advent of extragalactic optical and radio astronomy has shown that quasars are supermassive black holes in the violent process of mass accretion and jet emission. Quasars are used to test cosmological models. Their high redshift provides cosmologists the clue about large scale structure formation and the expansion rate of the Universe. Quasar spectra are used to determine intergalactic hydrogen reservoir left over from the decoupling era. They 'speak' in many wavelength languages (Berry, 1967) ranging from radio to ultraviolet. Their structure and distribution have been proved to be useful tool for testing theory of gravity. For example, recent discovery of a Large Quasar Group (Clowes, 2012), has challenged the prevalent geometry of the Universe. Today they constitute a major research area in high energy astrophysics.

The idea of a rotating black hole metric is amazing. The Kerr solution which is an axisymmetric metric of vacuum Einstein's field equations, is the most aesthetic solution ever found. Still, it resembles the realistic phenomena. All compact objects have enormous rotation which has definitive role to play in their emissivity. Active galactic nuclei (AGN), pulsars are all rotating relativistic structures. Mechanism of energy extraction from the rotating black hole constitutes interesting area of research in the field. The gravitational redshift of light emitted from matter near to the horizon of a black hole is sensitive to the rotation. Development of X-ray astronomy in 1970s helps astronomers to study such radiations emitted by accretion disks near the black holes. This has been a useful tool for testing general relativity.

Gravitational interaction has given astrophysicists useful information about the universal matter composition. Since the discovery of gravitational lensing (Walsh, Carswell, & Waymann, 1979), it has been used to probe deeper into space and time. Hubble Deep Field survey (1995 onward) determined distances up to more than 10 billion light years, by using gravitational lensing. Since the lensing process is independent of the nature and physical state of the deflecting mass, the phenomenon has been a robust tool for understanding how dark matter and dark energy work.

One major advance in Relativistic Astrophysics is the discovery of binary pulsar by J. Taylor and R. Hulse (1975). Known as Hulse-Taylor pulsar, this is a laboratory for general relativity. Their close orbits were used to have accurate test of the phenomenon of orbital precession. Today binary pulsars are conceived as sources of gravitational radiations. Young physicists of the country, in collaboration with USA interferometric detectors like LISA and LIGO are in attempt to provide strong evidence of the gravitational waves from astrophysical sources. This is one of the frontiers of Relativistic Astrophysics where we will be able to test gravity up to a scale as small as 10^{-26} m or so.

Exotic of all objects is the Gamma Ray Burst (GRB) which is the most energetic explosion after the Big Bang. Detected in 1967, GRBs are cosmological sources having optical as well as X-ray after glows, and hence associated with collapse of extraordinarily massive stars like the one with 100 Suns. Being still in doubt, theorists want to propose models with neutron star mergers or black hole mergers. They have pushed the gamma ray astronomy to the frontier. Today, they are being used to test models of quantum gravity (Mitrofanov, 2003; Carroll, 2003; Jacobson, Liberati & Mattingly, 2003) where GRB photons suffer from vacuum dispersion due to quantum gravitational fluctuation. It has brought quantum gravity to the framework of Relativistic Astrophysics.

By the time binary pulsars or GRBs were found, cosmology was pushed to the horizon with the discovery of Cosmic Microwave Background (CMB). In 1990s, the COBE satellite proved the accuracy of simple relativistic model of the universe. Inflationary cosmology compelled particle theorists to look into the cosmological issues critically. String theory, multiverse, brane cosmology etc. are few examples of this interface. The last and the confronting revolution in Relativistic Astrophysics is the discovery of an accelerating universe which has challenged both quantum field theory and general relativity. New theories of gravity are being carefully scrutinized. The large scale clustering of galaxies at different redshifts

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has been strong probe to test competing ideas of gravity. Since 2003, WMAP satellite has been of tremendous help in proving the idea like inflation, dark matter and dark energy. The recent PLANCK mission is expected to give further precise information about the evolution of the universe since the emission of the first light.

The latest Texas symposium has discussed these issues in the single framework of Relativistic Astrophysics. Coming half a century may have in its disposal many exotic ideas which may change the way we look into the nature of the Universe. Many challenging problems are lying to be solved. New mathematics and extraordinarily precise data may uncover a 'New Universe' for our generation.

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news

UGC sponsored workshop at S S College, Hailakandi

On 21st January, 2014, the Department of Physics and Chemistry of S S College, Hailakandi, jointly organised a 7-day workshop on "*Recent Trends of Research and its Applications in Physical Sciences*", under the aegis of UGC, NERO, in association with Assam Science Society, Hailakandi. Dr Bhibhas Deb, The director, College Development Council of Assam University was the Chief Guest. Mr Samsher Singh, Deputy Commissioner of Hailakandi District, formally inaugurated the workshop. Among the other dignitaries present were, Prof B K Dhar, President, General Body of S S College and Prof Debadutta Chakraborty, Coordinator, IQAC. Dr A K Das, Principal of the college presided over the inaugural session. Dr Rupam Sen, the Organizing Secretary presented the welcome address. A total of thirty nine participants from different parts of the country participated in this workshop. In the first technical session, Prof C R Bhattacharjee from Department of Chemistry, Assam University, delivered his views and ideas on *smart materials*. Subsequently Dr Atri Deshamukhya, Dr. Senorita Devi, Dr H S Das (all from Department of Physics, Assam University), Dr Sudip Choudhury, Dr Sk Jasim Uddin, and Prof S B Paul (all from Department of Chemistry, Assam University) acted as resource persons in the workshop. The valedictory program was presided over by Dr A K Das, Principal of the College. Apart from him Prof B K Dhar, President, Assam Science Society, Hailakandi Branch and Prof S B Paul also graced the occasion. Dr Apratim Nag of G C College, Silchar gave his opinion regarding the different aspects of this seminar. The vote of thanks was offered by Smt Sukanya Choudhury, Department of Chemistry of S S College.

News and photograph by Dr Rupam Sen
PANE member from S S College

editorial

Education Policy
how to make it meaningless

Madhurjya P Bora

Very recently, I had the opportunity to be present as a subject expert in certain interview committees for appointing Assistant Professors and promoting existing faculty members, at various leading colleges in Assam. And it had taken some time for me to realise that I am merely made a part of a mock interview process and my presence at these *so called interviews* is actually making them more dubious than ever! As many of us are becoming aware that these days, the interviews at colleges in Assam are nothing but a bookkeeping job where all one does is to check and verify the mark sheets and various certificates which can very well be done away with making the interview unnecessary, courtesy the new education policy of our government! Nobody in the interview board is supposed to ask the prospective candidate, a single question related to the subject concerned. In one particular case, the scenario is particularly singular - the case of promoting an Assistant Professor to the level of an Associate Professor (which is supposed to be through a very rigorous assessment of one's academic achievements of which an academic interview is an integral part, and so we thought!), where the only criteria to be fulfilled by the candidate is to complete three years of continuous service! These are the terms dictated by the Directorate of Higher Education of Assam. Now our readers can understand what are the motivations behind these new policy for promoting education and how much progress can we make in this way.

There are many other examples of these kinds of forced unethical practices like fixing a pass percentage in school boards even before the examination is held! We can also question the aftermath of these kinds of policy with respect to such a basic and integral faculty as education.

Needless to say, why the education scenario as a whole, in our country is crumbling. Take the case of an upper level student of a high school. Next three to four years of her life will be agonisingly difficult, especially in case of a science student, when she has to cram up to 12 - 13 hours a day, attending scores of tutorial classes, preparing herself to be a part of certain elite institutions, where cramming rules the roost. Imagine, the most productive years of a teenager are wasted this way, where she should have been taking a keen and deeper interests in the subjects which helps her understand the concepts better.

The whole policy toward education is extremely short sighted and geared up in creating certain pockets of excellence, much in the same way, the British used to do with us in the pre-independence era, rather than elevating the whole society with a wholesome education. Our education policy at the moment can be compared to a magic diet or a magic potion which can be used to achieve instant gratification such as a dream figure or a dream colour, instantly and all of us know that in the long run, all these fail.

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newsletter vol 2 no 2