SATYENDRA NATH BOSE NATIONAL CENTRE FOR BASIC SCIENCES

Newsletter

Vol. 9, Issue 2

Editorial

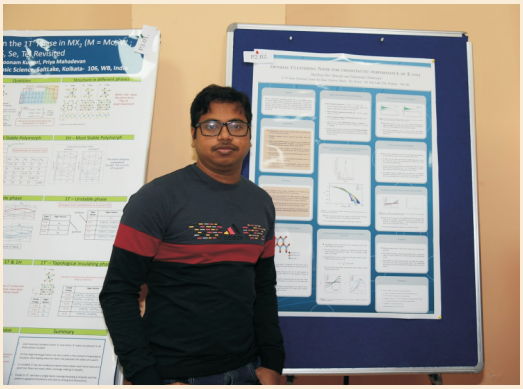
We are very happy to publish the online issue of the Newsletter amid Covid-19 pandemic, thanks to the great efforts made by the Newsletter support staff and members; we also sincerely thank all the contributors, who have promptly sent their articles. The issue covers academic and non-academic events in the first half of the present year. We wish you all to keep healthy, stay safe and be successful in your future endeavors.

All the best!

Professor Satyendra Nath Bose wih a loving child

News and Events (Academic)

Bose Fest 2020



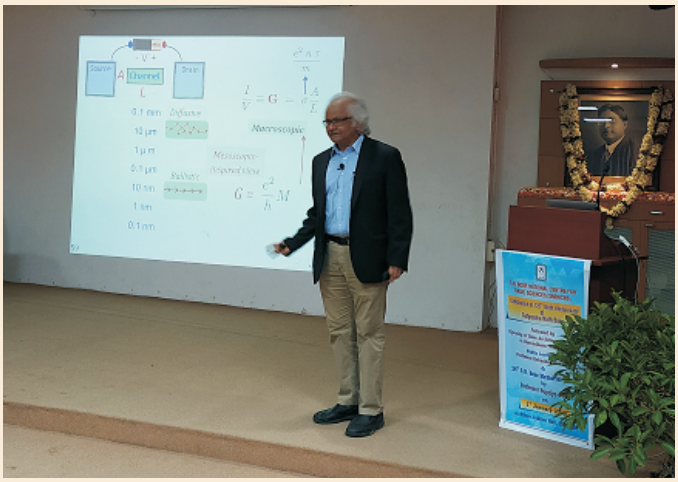
The in-house symposium Bose Fest was organized during 24 - 25 January, 2020. The students and postdocs working at the centre presented their research work in the form of oral contributions and poster presentations. The main spirit of this event is to encourage the academic members of the center to know about each other's research and engage in fruitful scientific exchange. For the students who are at the early stage of their PhD, BoseFest offers a flavor of how an actual scientific conference unfolds. These young students who still do not have experience of presenting in a conference, get to see how to communicate the most important results of one's research to an audience of varied backgrounds in the span of 10 - 15 minutes time. A high level of attendance and participation from the students is crucial for the success of BoseFest. We hope in future years the students' participation improves and more and more students are seen actively engaging in scientific discussions during the oral contributions and poster sessions of BoseFest.

Apart from the scientific sessions, there were other activities like photo exhibition, cultural program where the academic and non-academic members of the center participated enthusiastically. An alumni session was also organized where many alumni members of the center joined and shared stories and anecdotes from their PhD days.

Organizers: Sakauntala Chatterjee and Thirupathaiah Setti.

Colloquium / Named Lectures

S. N. Bose Memorial Lecture



The 24th S. N. Bose Memorial Lecture was delivered at the Centre by Professor Supriyo Datta, Thomas Duncan Distinguished Professor of Electrical and Computer Engineering, Purdue University, USA, on 1st January 2020, the 127th Birth Anniversary of Satyendra Nath Bose. The title of the talk : Mesoscopic Physics: A New Perspective on Transport.

G. N. Ramachandran Lecture

The 5th G. N. Ramachandran Lecture by Professor Daan Frenkel, FRS, Department of Chemistry, University of Cambridge, United Kingdom on 12th February 2020 at Silver Jubilee hall. The Lecture title: Counting the Uncountable: Entropy, Granular Entropy and Information.

Bose Colloquia

1. Professor Sriram Ramaswamy, Department of Physics, Indian Institute of Science, Bengaluru, delivered a lecture on 10th January 2020. The title of the lecture : A Journey Through Active Matter.
2. Professor Vikram Tripathi, Tata Institute of Fundamental Research (Mumbai), delivered a lecture on 21st February 2020. Title of the lecture : Electronic instabilities in a 'flat' topological band: the case of tin telluride.

Conferences/Workshops/Lectures

ACTSM-2020

A two-days mini-school in computational physical sciences titled “Advanced Computational Techniques in Soft Matter (ACTSM-2020)” was held during 14-15 February, 2020 at the Centre. Convener: Jaydeb Chakrabarti and Co-convener: Suman Chakrabarty.

ICONSAT-2020

International Conference on Nano Science & Technology (ICONSAT-2020) held at Biswa Bangla Convention Centre, New Town, Kolkata during 05 - 07 March, 2020. Chairperson : Samit K. Ray, Director, SNBNCBS, Jt. Convener: Anjan Barman and Samir Kumar Pal.

National Science Day 2020

National Science Day 2020 was observed on 28th February 2020, at Silver Jubilee Hall. A Popular Scientific Lecture was delivered by Professor Sudipta Sengupta (Bhatnagar Awardee), Department of Geological Sciences Jadavpur University on the topic "Breaking barriers : journey of a woman geologist". Another lecture delivered by Dr. Suprakash Roy; Editor in Chief, Science and Culture; Indian Science News Association on the topic : Bibha Chowdhuri: A Jewell Unearthed.

Nearly 60 College Students attended the programme which also includes Visit to “Bose Archive” and the Laboratories of the Centre.

Outreach activities of the Centre

105th Indian Science Congress at Bengaluru

The Centre participated in the recent Indian Science Congress at Bengaluru from 3rd-7th January 2020. Four students from different department showcased the activities of the Centre at ISC.

‘Acharya Satyendranath Basu Bijnan O Projukti Mela’ and ‘Science & Cultural Fair’

Students of the Centre also participated at Science Fair namely Acharya Satyendranath Basu Bijnan 'O' Projukti Mela at Hedua Park, Kolkata & Science & Cultural Fair 2020 at Belgharia.

Vidyasagar Satyendra Nath Bose National Workshop

The 11th Vidyasagar Satyendra Nath Bose National Workshop on “Physics of Novel Functional Materials” (PNFM-2020) was held during 8th -10th Jaunary 2020; supported by the TPSC Grant of the Centre. Almost more than 200 participants including under-graduate and post-graduate students, research scholars, college and university teachers attended the program.

Research Highlights

Nonmagnetic Spin Filtering in a Single Molecular Junction

Atindra Nath Pal

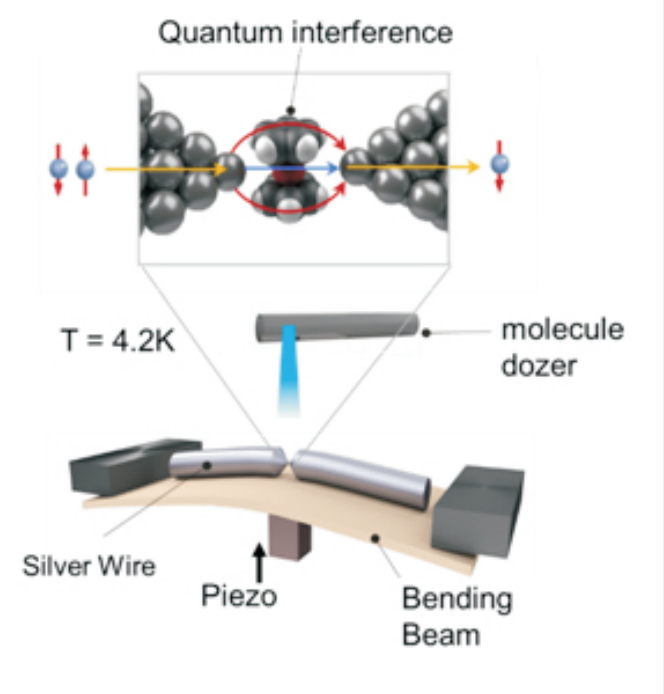


Figure: *Schematic of the Mechanically controllable Break junction (MCBJ) set up (bottom). Spin filtering due to spin dependent quantum interference in different molecular orbitals is depicted schematically (top).*

The field of spintronicsis predominantly based on spin-polarized currents, in which the current is governed by one electronic spin type. For example, key spintronic phenomena, as magnetoresistance and spin transfer torque, could not be activated without such currents. Typically, spin-polarized currents are injected from magnetic materials, although materials with high spin-orbit coupling and spin-splitting by magnetic fields are used as well. We show that spin-polarized currents can be generated at the single molecule level without such means. Our experiments were performed in a mechanically controllable break junction setup (MCBJ) placed in a liquid helium cryostat, schematically shown in the above figure. Using shot noise measurements, we detect spin-polarized currents in molecular junctions based on silver electrodes bridged by a vanadocene molecule with a total spin of 3/2. Interestingly, some of the measured Ag/vanadocene junctions reveal nearly ideal

ballistic transport close one quantum of spin-polarizedconductance, thanks to an almost fully open spin-polarized transmission channel. The experimental findings are reproduced by transport calculations, revealing a mechanism based on spin-dependent quantum interference that yields very efficient spin filtering. Our findings pave the way for using quantum interference at the single molecule scale for spintronic manipulations in structures based on individual molecules, molecular layers, or larger molecular structures, where quantum interference takes place in their molecular repeated unit.

Reference:

1. Pal A. N., Li D., Sarkar S., Chakrabarti S., Vilan A., Kronik L., Smogunov A. & Tal O. (2019) Nature Communications. 10, 5565.

A Thermodynamic View of Dynamic Allostery: Quest for a Universal Mechanism

Suman Chakrabarty

Allostery is a fascinating molecular process through which distant parts of a large biomolecule (e.g. protein) can communicate with each other. Ligand molecules (e.g. drug) binding to an allosteric site of protein can both positively and negatively regulate a distant functional site. Such feedback mechanism plays a vital role in regulation of a myriad biochemical processes including metabolism (enzymes), cooperative oxygen uptake (hemoglobin) and signal transduction (GPCRs). Classic view of allostery involves long range conformational changes in proteins triggered by local energetic perturbation created by the ligand binding. But in the last couple of decades, several examples have been found where the distal dynamics of the protein may be modulated without significant changes in the average protein structure. Even intrinsically disordered proteins (IDPs) have been found to participate in allosteric response. Thus a new description of allostery has started to emerge that must invoke the population shift in a conformational ensemble and dynamics of the proteins instead of a static structural view.[1]

"Dynamic allostery" has been traditionally associated with purely entropic effect since there is no change in the overall protein structure. Our earlier work in a PDZ domain protein, a classic example of dynamic allostery, has established that ligand binding can lead to re-distribution of the electrostatic energy in terms of rearrangement of hydrogen bonded network involving the protein side-chains.[2] Thus, even though the total average energy of the system may not change significantly, the internal redistribution of energy in terms of population shift in specific interactions may lead to the long range response known as "dynamic allostery".

Recently we have revisited this enigma called "dynamic allostery" in order to explore how the underlying signaling network might respond to different kinds of perturbation.[3] Traditionally allostery has been studied in the context of ligand binding, point mutations and post-translational modifications. We have explored the effect of a relatively simple change in the protonation state (upon change in the solution pH) of two specific histidine residues in the PDZ3 protein. Here we demonstrate for the first time the evidences of dynamic allostery triggered by change in protonation state. Similar to the ligand binding induced allostery, here also we find long range re-wiring of the hydrogen bonded network leading to redistribution of the electrostatic interactions.

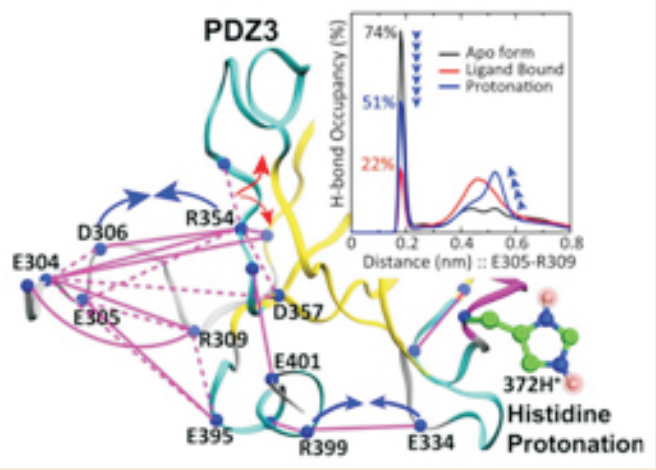


Figure: *A schematic diagram of the propagation of energetic perturbation from the protonation site (H372) to distal termini regions and associated population shift in hydrogen bond distribution (inset) (J. Phys. Chem. Lett. 2020,* ***11****,90269031)*

Surprisingly, the same set of polar/charged residues that constitute the hydrogen bonding network to propagate the signal seems to be

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involved irrespective of the nature of the perturbation. This observation leads us to speculate that these signaling proteins might have evolved in a way to sustain an inherent signaling network that may respond to different types of energetic perturbation. Thus, there could be an universal response system embedded where the polar/charged residues are the hubs of the network, the edges are specific interactions (e.g. hydrogen bonds) and depending on the specific nature of the external perturbation a specific region/path of this network might get activated. This idea of the possibility of a universal response network will be explored further in other signaling proteins including GPCRs and Rhodopsins.

References:

(1) Motlagh, H. N.; Wrabl, J. O.; Li, J.; Hilser, V. J. The Ensemble Nature of Allostery. *Nature***2014**, *508* (7496),331339. https://doi.org/10.1038/nature13001.

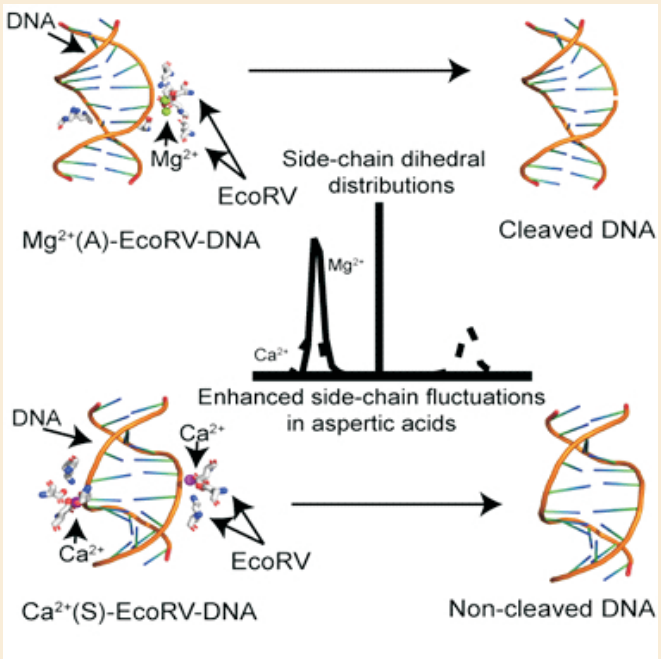
(2) Kumawat, A.; Chakrabarty, S. Hidden Electrostatic Basis of Dynamic Allostery in a PDZ Domain. *Proc. Natl. Acad. Sci.***2017**, 110. https://doi.org/10.1073/pnas.1705311114.

(3) Kumawat, A.; Chakrabarty, S. Protonation-Induced Dynamic Allostery in PDZ Domain: Evidence of Perturbation-Independent Universal Response Network. *J. Phys. Chem. Lett.* **2020**, 90269031.https://doi.org/10.1021/acs.jpclett.0c02885.

Microscopic Insight to Specificity of Metal Ion Cofactor in DNA Cleavage by Restriction Endonuclease EcoRV

Jaydeb Chakrabarti

Restriction endonucleases protectbacterial cells against bacteriophage infection by cleaving the incoming foreign DNA into fragments. In presence of Mg^{2+} ions, EcoRV is able to cleave the DNA but not in presence of Ca^{2+}, although the protein binds to DNA in presence of both metal ions as explained in the figure. We make an attempt to understand this difference using conformational thermodynamics. We calculate the changes in conformational free energy and entropy of conformational degrees of freedom, like DNA base pair steps and dihedral angles of protein residues in Mg^{2+}(A)-EcoRV-DNA complex compared to Ca^{2+}(S)-EcoRV-DNA complex using all-atom Molecular Dynamics (MD) trajectories of the complexes. We find that despite conformational stability and order in both complexes, the individual degrees of freedom behave differently in the presence of two different metal ions. The base pairs in cleavage region are highly disordered in Ca^{2+}(S)-EcoRV-DNA compared to Mg^{2+}(A)-EcoRV-DNA. One of the acidic residues ASP90, co-ordinating to the metal ion in the vicinity of the cleavage site, is conformationally destabilized and disordered, while basic residue LYS92 gets conformational stability and order in Ca^{2+}(S) bound complex than in Mg^{2+}(A) bound complex. The enhanced fluctuations (see the figure) hinder placement of the metal ion in the vicinity of the scissile phosphate of DNA. Similar loss of conformational stability and order in the cleavage region is observed by the replacement of the metal ion. Considering the placement of the metal ion near scissile phosphate as requirement for cleavage action, our results suggest that the changes in conformational stability and order of the base pair steps and the protein residues lead to cofactor sensitivity of the enzyme. Our method based on fluctuations of microscopic conformational variables can be applied to understand enzyme activities in other protein-DNA systems.



Ref.: Mandal SC, Maganti L, Mondal M, Chakrabarti J. Microscopic insight to specificity of metal ion cofactor in DNA cleavage by restriction endonuclease EcoRV. Biopolymers. 2020;e23396.

Scientific Stories

Manipulating Ferromagnetism in Femtosecond Timescale

Santanu Pan and Anjan Barman

Extracting the fundamental physics behind every physical phenomenon is the foundation stone for its futuristic technological applications. However, probing the underlying physics becomes a challenge when it occurs in extreme dimensions either in space (nanometre) or time (nanosecond). From the textbook physics we know that the magnetic moments, inside a ferromagnetic material, are aligned in a particular direction when subjected to an external magnetic field. Therefore, one can manipulate these moments by tuning the field magnitude and orientation, which is a slow process. In 1996, Bigot *et al*. demonstrated a new fascinating avenue of manipulating the magnetic moments within few hundreds of femtoseconds (10^{-15} secs). They showed that by shining a femtosecond laser pulse on a ferromagnetic material one can decrease its magnetic moment in the ultrafast timescale which is named as 'ultrafast demagnetization'. Since then it has become the heart of magnetism research and a wide range of theoretical as well as experimental investigations have been brought into the picture to explain this unusual ultrafast modification in the magnetic moments. Most of the results claim a direct interaction between the laser pulse and the material.

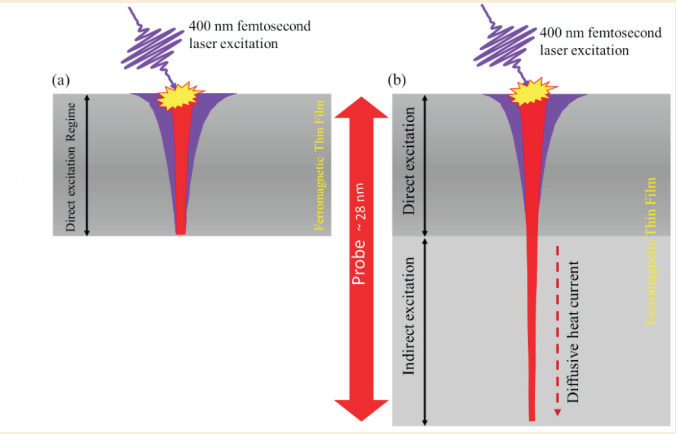


Figure 1. *(a) Thinner ferromagnetic multi-layered film excited by 400 nm femtosecond pulsed laser which directly interact with the whole sample volume resulting only in direct interaction mechanism. (b) Thicker ferromagnetic multi-layered film where the excitation laser pulse cannot* penetrate down to the *bottom of the sample. The laser-induced ultrafast heat current generated in the upper layers diffuse down and causes an indirect excitation of demagnetization mechanism. Violet (400 nm) and red (800 nm) colors represent the depth profile of the exciting and probing laser pulse.*

Opposing the existing concept, a new microscopically different theoretical proposal followed by several experimental observations demonstrated that an indirect interaction between the laser pulse and the ferromagnetic material via laser excited hot electrons or heat current can also cause this ultrafast magnetic quenching. This raises intense debate on the prevalent mechanism in femtosecond timescale. Our recent research demonstrates that both direct and indirect interactions can coexist and play crucial role, where the indirect excitation originates from laser induced heat current which diffuses inside the ferromagnetic material. It is further observed that though the resultant decrease in magnetic moments arises from a cumulative effect of both the interaction mechanisms, it is non-trivial to isolate their individual contributions. However, we have experimentally demonstrated that one can easily transit from one regime to the other by manipulating few external parameters such as the laser excitation power, physical dimension of the material, laser wavelength etc. Apart from resolving the role of the excitation process in such ultrafast timescale, this work put a step ahead for developing ultrafast magnetic storage and memory devices.

Reference:

Controlled coexcitation of direct and indirect ultrafast demagnetization in Co/Pd multilayers with large perpendicular magnetic anisotropy, Santanu Pan, Olav Hellwig, and Anjan Barman, Physical Review B **98**, 214436 (2018).

Limits of Applicability of Riemannian Geometry

Sunandan Gangopadhyay

The current theories of physics, namely, the special and general theory of relativity, quantum mechanics and the quantum theory of fields have been formulated on the fabric of a continuous cloth has. By continuous spacetime, we mean a point in

spacetime described by four coordinates (ct, x, y, z) that can take values varying continuously. The question that may arise immediately to the inquisitive mind is whether the concept of a continuous spacetime is always valid. It is important to realize that asking this question is in itself a giant leap from our common sense. Common sense would tell us that spacetime around us must be continuous because a discrete structure of spacetime would mean that there are regions (if at all they can be called as regions) where there is no spacetime at all.

But our common sense or intuition is well known to work well at length scales larger than some standard of length. A natural standard of length (spatial distance) would be the depth of a swimming pool, for instance, a metre. What about moving to smaller and smaller length scales and entering the quantum world. Our current understanding of the quantum domain is counter intuitive. Can we be really sure that on a "small scale", time and space do not become quite different from our present notion? Spacetime may well become fragmentized at very small length scales. Such a remarkable idea or question about the structure of spacetime is not novel at all. In fact, it was raised by Riemann himself in 1854, and thereafter, it has been discussed repeatedly. However, this extremely important question about the limits of applicability of Riemannian geometry is still far from being answered. To understand the problem in a simple way, let us imagine looking at a piece of cloth from some distance apart. What we shall observe is a continuous fabric of cloth from a distance of say two feet from the cloth. However, as we move nearer and nearer to the cloth, we shall start observing the threads with which the clothhas been woven. In fact, we shall observe regions where there are no threads of the cloth at all, and the very notion of a continuos fabric of cloth breaks down. A similar situation is expected to happen also in the case of spacetime at energies close to the Planck energy, which in turn implies length scales close to the Planck length.

In the recent years, this problem about the status of Riemannian geometry at very small length scales has been one of the major concerns of theoretical high energy physicists. The reason for this concern lies in the search of a unified physical theory which would incorporate all the fundamental interactions. It turns out that as we move to the regime of increasingly high energies, and therefore, to closer collisions between various particles, the scale of unexplored space regions becomes smaller. Our present understanding indicates that the usual space relations down to the distance of the order of 10^{-15} cm goes through in the usual Riemannian way and their applications do not lead to inconsistencies. As we keep on increasing the energy of collision of particles further, the distance probed would be smaller and smaller, and it is highly plausible that there exists a fundamental length scale $l_p = \sqrt{\frac{G\hbar}{c^3}} = 10^{-33}$ cm. This fundamental length is known as the Planck length. If a fundamental length scale does exist, it would definitely tell theoretical physicists and mathematicians to reformulate our standard conception of a continuous spacetime fabric. It would also mean that Einstein's theory of general relativity, which is essentially a dynamical theory of spacetime formulated on the foundations of Riemannian geometry would possibly break down at distances close to the Planck length. In technical terms one would say that Einstein's theory of gravity has to be quantized. In reality, it would be a daunting task to write down a theory of gravity at length scales close to the Planck length, if the very notion of a continuous fabric of spacetime breaks down at such length scales. Such a theory, if at all can be formulated, would need to pass certain tests, for example, it would need to predict something new which has not been observed earlier, and also need to yield some signatures of a discrete space-time in the low energy limit which can be tested experimentally. Efforts to formulate such a quantum Einstein gravity theory have been going on for the last six decades and the truth is still far from reality. One of the major hindrances in developing a quantized version of gravity is that Einstein's theory of gravitation although beautiful in structure mathematically, is non-linear in nature. Despite these obstacles, one can be sure that there is indeed some new physics which we are not aware of, at distances close to the Planck length.

On the experimental side, the search for the fundamental length is going on in the Large Hadron Collider at CERN, by studying collisions between particles at ever increasing energies and ultra-precise measurements of various physical properties at low energies. A disagreement between the experimental results and predictions of a quantum electrodynamics or chromodynamics type theory would indicate possible violations of the present concepts of spacetime and the requirement of introducing the fundamental length.

Artificial, Nanomedicine for Comprehensive Treatment of Several Diseases

Samir K Pal

Our group at S. N. Bose National Centre has developed a safe and cost effective nanomedicine that promises accurate treatment of a number of diseases. The medicine combines nanoparticles extracted from manganese salt with citrus extract, like from lemon. Both the ingredients are non-toxic, rather essential for the wellbeing of our body. Specifically manganese is a trace element, which our body needs in small amount for the normal functioning of our brain, nervous system and enzymes. It is thus considered an essential nutrient and can be found in seed, and whole grains as well as smaller amount in legumes, beans, nuts, leafy green vegetables & tea. On the other hand citrate salts from citrus extract (which contains potassium and sodium) belong to a class of drugs to make our urine less acidic. This effect helps the kidneys to get rid of uric acid, thereby helping to prevent gout, kidney stones and other metabolic problems (acidosis) caused by kidney diseases.

A crucial combination of manganese and citrate employing tricks of nanotechnology produces the nanomedicine in our laboratory. The artificially made nanomedicine is found to be important to maintain "redox" balance in our body's tissues- these are types of reactions in cells that add or remove oxygen, and are essential for many processes such as generating energy in cells. The redox reactions can also create harmful products to our cells called reactive oxygen species (ROS) which can instantly oxidize lipids (fat), proteins and nucleic acids accelerating our aging process. However, it has to be noted that our immune cells naturally produce ROS or generate oxidative stress to kill virus/bacteria and infected cells in our body. Thus controlled-increase of ROS or oxidative stress aids our immune cells to perform their natural functions more efficiently.

The developed nanomedicine is shown to have intelligence to decrease and/or increase oxidative stress (ROS) in our body depending on the situation and cures several diseases. Our findings have been published in international journals. In October last year a comprehensive review entitled "Role of Nanomedicine in Redox Mediated Healing at Molecular Level" of all the development has been published (DOI:*https://doi.org/10.1515/bmc-2019-0019*). The concept got immediate attention of international experts in the field and referred as *"a new front in redox medicine, the emerging field of ROS-based nanomedicine, involving nanomaterials with ROS-regulating properties, holds promise for optimized therapeutic efficacies"* in a recent Nature journal (DOI *https://doi.org/10.1038/s41580-020-0230-3)* in March in this year. The efficacy of the developed nanomedicine in balancing oxidative stress (ROS) in mice is tested recently. In a controlled experiment, we have injected lead (Pb) ions to the mice to create higher oxidative stress (ROS) and lever damage. The liver disease due to lead toxicity is very common in humans due to increase in pollution and use of Pb-containing cosmetic paints including lipsticks. In the experiment we found the nanomedicine reduces oxidative stress of the mammal due to lead-exposure and also helps to remove the toxic ions from the liver (popularly known as chelation therapy in medicine) reversing the damage of the organ. Recently ChemMedChem (Volume15, Issue5,March 5, 2020Pages 391-391 DOI *https://doi.org/10.1002/ cmdc.202000098)*, which is one of leading journals for drug discovery from Wiley publication house has highlighted our work in the front cover (as shown in the artwork).

Enhancement of oxidative stress by the nanomedicine in animal tissue is also commendable and finds application in curing diseases including neonatal jaundice. In recent past we have shown that the added oxidative stress upon administration of the

nanomedicine can break down bilirubin (the toxic molecule causing jaundice) providing a cure for hyperbilirubinemia (jaundice). In a trial *(https://doi.org/10.2217/nnm.15.83)* on mice we found the nanomedicine safe and its swift, precisely bringing down bilirubin level within two and half hours. This ability of controlled enhancement of oxidative stress (ROS) in mammals paves new potential for the application of the nanomedicine in controlling virus infection including COVID-19. Recently, local administration of hydrogen peroxide, which is in a class of ROS, is recommended to be a way of surviving COVID-19 *(https://www.livetradingnews. com/surviving-the-coronavirus-disease-how-hydrogen-peroxide-works-172241.html).* The excess ROS was achieved by applying the hydrogen peroxide chemical in respiratory track through a nebulizer is advised in order to inactivate COVID-19 by breaking down the viral structure. As direct application of hydrogen peroxide create several complications including direct oxidation of normal body cells, replacement of the chemical by our nanomedicine would be beneficial. Our animal trial for the "redox" healing of several diseases is completed. We are now looking for sponsors so that we can start clinical trials on humans.

Visitor, Associates and Students' Programme

Short term visitors

1. Prof. Henry Witek, Dept. of Applied Chemistry, National Chiao Tung University, visited the Centre during 30th January 2020 to 14th February 2020. Host Faculty: Professor Debashish Mukherjee.

2. Dr. Sreeraj T. P. , NIT, Calicut, visited the Centre during 3rd February to 9th February 2020. Host Faculty: Manu Mathur.

2. Dr. Santabrata Das, IIT, Guwahati, visited the Centre during 10th March to 12th March 2020. Host Faculty: Soumen Mondal.

Advanced Postdoctoral Manpower Programme (APMP)

Total PDRAs (Centre funded) on roll - 15

Total RAs (Extramural funded) on roll - 1

Total SRAs (CSIR funded) on roll - 2

Joining of PDRAs:

1. Mr. Basant Roondhe, Designation: RA I (Adhoc) TUE-CMS; Department : CMP&MS; Mentor: Tanusri Saha Dasgupta; Date of joining: 3rd February 2020
2. Dr. Priyanka Garg Designation: PDRA I (Centre Funding; Department : CMP&MS; Mentor: Priya Mahadevan; Date of joining: 5th February 2020
3. Dr. Joy Prakash Das, Designation: PDRA I (Centre Funding); Department : CMP&MS; Mentor: Manoranjan Kumar; Date of joining:20th February 2020

Ph.D. Awarded/submitted

Ph.D. degree awarded to students during January -June 2020

1. Souvanik Talukdar, Thesis Title: Surface Modified Transition Metal Oxide based Magnetic Nanostructures for Intrinsic Fluorescence, Catalytic Properties and Drug Delivery. Supervisor: Kalyan Mandal
2. Soumi Roy Chowdhury, Thesis Title: Studies on Superconducting Pairing Mechanism in Low Dimensional Materials. Supervisor: Ranjan Chaudhury

Ph.D. thesis submitted during January - June 2020

1. Abhishek Bagchi, Thesis Title: Development of Microactuator Systems Basrd On The Photoinduced Microactuation Effect Found In Ferromagnetic Shape Memory Alloys. Supervisor: Pratip Kumar Mukhopadhyay

News and Events (Administrative)

Organized Hindi Workshop on "K*aralay Mein Hindi ka Prayog*" talk given by Shri L. K. Singh, Hindi Teacher, Hindi Teaching Scheme, Rajbhasha Bibhag, Nizam Palace, held on 21.02.2020 at the Centre.

Editorial Board: Saumen Adhikari, Jaydeb Chakrabarti, Sanjoy Choudhury, Ramkrishna Das, Gurudas Ghosh, Manoranjan Kumar, Rajib Kumar Mitra, Punyabrata Pradhan

For any comments, suggestions and input, please mail to: *punyabrata.pradhan@bose.res.in*

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S N Bose National Centre for Basic Sciences
Block-JD, Sector-III, Salt Lake,
Kolkata - 700 106