SYMPHY 2012

Physics Department In-House Symposium

March 31, 2012

Lecture Complex Hall 31

organized by

Research Scholars' Association of Physics

RSAP

Contents

Schedule

09:30 **Tea + Registration**

Session I

09:45 **Inauguration of SYMPHY 2012**

Time	Title	Speaker
10:00	The effect of surface modification on the electronic properties of ZnO nanoparticles by Tb	Archana Sharma
10:15	Strain-tunable band gap in graphene/h-BN heterobilayer	Harihar Behera
10:30	Triggered di-hadron correlations in ALICE at LHC @ 2.76TeV	Greeshma K M
10:45	Paramagnetic Meissner effect in a single crystal of 2H-NbSe2	Santosh Kumar

Session II

11:00 **Faculty talk:** Prof. Punit Parmananda: Using anticipation synchronization to predict geomagnetic storms: A preliminary feasibility exploration

Time	Title	Speaker
11:30	Giant number fluctuations in microbial ecologies	Dipjyoti Das
11:45	Continuous-wave broadband generation in a fiber laser	Aditi Ghosh
12:00	Cosmic ray muon flux on exoplanets around K/M stars	Souvik Dutta
12:15	Effect of annealing on the structural, micro-structural, magnetic, magnetocaloric and magneto-transport properties in $Ni^{46}Co^{4}Mn^{38}Sb^{12}$ melt spun ribbons	Roshnee Sahoo

12:30 – 14:00 **Lunch**

13:30 – 14:30 **Poster Session**

Session III

14:30 **Invited talk:** Prof. Sushil Mujumdar (TIFR): Coherent emission from disordered amplifying systems

Time	Title	Speaker
15:30	Development of localized surface plasmon based fiber optic sensors	Rani Dutta
15:45	Lifetimes measurements of excited nuclear states by Doppler shift attenuation method (DSAM)	Bhushan Kanagalekar
16:00	Novel coupling schemes for quorum sensing	Harpartap Singh
16:15	Signatures for a unified theory in the sky	Kuntal Kumar Ghosh

16:30 **Tea**

Session IV

17:00 **Faculty talk:** Prof. P. Ramadevi: String theory basics and current research

Time	Title	Speaker
17:30	“All in One” molecules for quantum dots, metal and metal oxide nanostructure formation: Gram scale synthesis and properties	Jeotikanta Mohapatra
17:45	On the nature of ground state of long acenes	Himanshu Chakraborty

List of posters:

Title	Presenter
Optical properties of GaN nanopillars fabricated using ICP-RIE technique	Hari Pratap Bhaskar
Excited states of Te-126 nucleus	Virendra Pasi
Cross-section measurements of complete and incomplete fusion reactions	Bhushan Bhujang
Size and shape controlled fabrication of magnetite nanoparticles and their magnetic properties	Arijit Mitra
Constituent quarks and multi-strange baryon production in heavy ion collision	Nirbhay Behera
Effect of buffer layer growth temperature on epitaxial GaN films deposited by magnetron sputtering	Pravanshu Mohanta
Magnetic, magnetocaloric and magnetotransport properties of R $Sn_{(1+x)}Ge_{(1-x)}$ compounds (R=Gd, Tb, Er; x=0.1)	Sachin Gupta
GO and RGO based FETs fabricated with Langmuir-Blodgett grown monolayers	Divakar Botcha

Invited Talk

Coherent emission from disordered amplifying systems

Prof. Sushil Mujumdar
Tata Institute of Fundamental Research

Optical wave propagation in disordered structures reveals a plethora of interesting mesoscopic phenomena realized by wave interference in multiply scattering systems. We give a brief overview of the activities pursued in our laboratory, pertaining to disordered systems with amplification. In particular, we stress on the emission of coherent intensity from such systems, and discuss the non-gaussian nature of the statistics of the emission intensity of the coherent modes. We further propose a method to control the frequency fluctuations of the system, and provide experimental support to the proposal.

Faculty Talks

Using anticipation synchronization to predict geomagnetic storms: A preliminary feasibility exploration

Prof. Punit Parmananda

Synchronization and Chaos are frequently observed in nonlinear systems. Since these two phenomena are ubiquitous in nature they inevitably overlap (co-exist). In the present talk, different types of chaotic synchronizations under unidirectional coupling are introduced. Possible application of one of these synchronization phenomena to predict the occurrence of Geo-magnetic storms is entertained.

String theory basics and current research

Prof. P. Ramadevi

I will briefly discuss the basics of string theory and then indicate some of the interesting developments of relating quantum field theory in d dimensions to Einsteinian gravity in anti-de Sitter spacetime in d+1 dimensions. This is famously known as AdS-CFT correspondence or Maldacena's conjecture.

Student Presentations (Oral)

The effect of surface modification on the electronic properties of ZnO nanoparticles by Tb

Archana Sharma

Structural and optical properties of the Tb doped ZnO nanoparticles are systematically studied as a function of the Tb mole-fraction. Our study suggests that the Tb incorporates mostly on the surface and affects the optical properties of the ZnO nanoparticles by influencing the attachment of certain adsorbed groups, which are found to be responsible for the appearance of a broad green luminescence (GL) band in the photoluminescence spectra recorded for these nanoparticles. It has been found that the accumulation of Tb on the surface of the nanoparticles not only enhances the band edge UV luminescence by suppressing the GL under the vacuum condition but also increases the band gap energy by introducing a hydrostatic compressive strain in individual nanoparticles, which provides a unique opportunity to study the pressure dependence of the optical properties of nanoparticles without applying any external pressure. The hydrostatic compressive strain is explained in terms of the increase of the surface strain energy as a result of the Tb accumulation on the surface of the nanoparticles. The average value of the surface energy density for the particles has been estimated as a function of Tb mole-fraction. The pressure coefficient of the band gap, which is obtained from the variation of the band gap energy with the hydrostatic strain, has been found to decrease significantly with the particle size for the ZnO nanoparticles.

Strain-tunable band gap in graphene/h-BN heterobilayer

Harihar Behera

Graphene, a one-atom-thick planar crystal of carbon atoms in a 2D hexagonal lattice, is the presently attracting much attention due to its exotic mechanical, electronic, thermal, and optical properties promising novel applications. However, the absence of a spectral gap prevents it from being used in digital electronics which requires a gap to pinch off the current. Many studies in opening a band gap in graphene also exist with their peculiar advantages and disadvantages. However, using full-potential density functional calculations within local density approximation (LDA), we predict [1] that mechanically tunable band-gap and quasi-particle-effective-mass are realizable in graphene/hexagonal-BN hetero-bilayer (C/h-BN HBL) by application of in-plane homogeneous biaxial strain. While providing one of the possible reasons for the experimentally observed gap-less pristine-graphene-like electronic properties of C/h-BN HBL, which theoretically has a narrow band-gap, we suggest a schematic experiment for verification of our results which may find applications in nano-electromechanical systems (NEMS), nano opto-mechanical systems (NOMS) and other nano-devices based on C/h-BN HBL.

References:

[1] Harihar Behera and Gautam Mukhopadhyay, Strain-tunable band gap in graphene/h-BN hetero-bilayer, Journal of Physics and Chemistry of Solids, doi:10.1016/j.jpcs.2012.02.010

Triggered di-hadron correlations in ALICE at LHC @ 2.76TeV

Greeshma K M

QGP can be studied using many of its signatures, such as flow, jets, strangeness enhancement, J/psi suppression etc. My work is to study the QGP using the triggered dihadron correlations, which is a powerful tool in the low pT regime, where background calculation makes the analysis tough. The first part of the research is a study of the TPC (Time Projection Chamber) using dihadron correlations, and in future will try to do the Fourier Decomposition to study higher harmonics.

Paramagnetic Meissner effect in a single crystal of 2H-NbSe2

Santosh Kumar

A variety of novel behaviors like positive magnetization, oscillatory magnetization response and asymmetry in M(T) curves for positive and negative fields have recently been reported in the temperature dependence of field cooled cool-down magnetization M(T) curves in some superconductors. These new results validate the notion of multi-quanta vortex states and their gradual crossover to an ordered Abrikosov's flux line lattice with the decreasing temperature.These observations motivated us to investigate another low Tc (~7.14K) superconducting compound 2H-NbSe2, very widely investigated for peak effect phenomenon. The results of magnetization measurements in two different orientations H || c and H || ab plane revealed positive magnetization (Paramagnetic Meissner effect) and intersection of M(T) curves below Tc. Moreover, the isothermal MH scans revealed positive magnetization on field cooling which confirms the fingerprints of multi-quanta vortex states in the domain of surface surface superconductivity. We reckon these observations arise due to the nucleation of surface superconductivity at third critical field Hc3.

Giant number fluctuations in microbial ecologies

Dipjyoti Das

Statistical fluctuations in population sizes of microbes may be quite large depending on the nature of their underlying stochastic dynamics. For example the variance of the population size of a microbe undergoing a pure birth process with unlimited resources is proportional to the square of its mean. We refer to such large fluctuations, with the variance growing faster than the mean, as Giant Number Fluctuations (GNF). Luria and Delbruck showed that spontaneous mutation processes in microbial populations exhibit GNF. We explore whether GNF can arise in other microbial ecologies. We study certain simple ecologies evolving via stochastic dynamics, namely (i) bi-directional mutations, (ii) a particular limit of infection of bacteria by bacteriophage and (iii) two simple models of Horizontal Gene Transfer (HGT). For the case of bi-directional mutation, we show analytically exactly that the GNF relationship holds at large times. For the ecology of bacteria undergoing Lysis or Lysogeny under viral infection, we show that if the viral population can be experimentally manipulated to stay quasi-stationary, the ecology behaves essentially like the one-way mutation process associated with GNF of the lysogen. Finally, we show that even the process of HGT may map to the mutation process at large times, and thereby exhibits GNF.

Continuous-wave broadband generation in a fiber laser

Aditi Ghosh

Optical fibers offer long interaction lengths and small core area to the propagating fields, making the nonlinear effects pertinent in their usage. In the presence of sufficiently high powers, the nonlinear process of four-wave mixing (and thus spectral broadening) is manifested in fibers owing to the non-zero third-order susceptibility in the silica fiber. This process can be utilized for designing broadband sources which find applications in optical communications, biomedical imaging and any wavelength-dependent testing of optical components. In the present work, continuous-wave broadband generation is obtained in a fiber laser with the help of low-dispersion specialty fibers, at pump powers as low as 250 mW. This broadband output can be used to obtain several coherent wavelengths. The time-dependent tests on these individual outputs confirm their stability in wavelength and power. The studies on combination of specialty fibers provide insights into the role of the individual fibers towards the broadband generation.

Cosmic ray muon flux on exoplanets around K/M stars

Souvik Dutta

Extrasolar Earth-like planets in close-in habitable zones around M-stars are weakly protected against galactic cosmic rays (GCRs), leading to a strongly increased particle flux to the top of the planetary atmosphere. Determining the precise effects of reduction of Planetary Magnetic Moments due to Tidal Locking and other parameters, thereby determining Muon Flux on them, might lead to important clues about the existence of life on them, K/M stars being the prime candidates.

Effect of annealing on the structural, micro-structural, magnetic, magneto caloric and magneto-transport properties in $Ni^{46}Co^{4}Mn^{38}Sb^{12}$ melt spun ribbons

Roshnee Sahoo

The effects of annealing on the structural, microstructural, magnetic, magneto caloric and magnetotransport properties of $Ni^{46}Co^{4}Mn^{38}Sb^{12}$ alloy ribbons have been investigated. It was observed that the room temperature structure changes from partially ordered B2 to fully ordered L21 phase upon annealing. At low temperature both as spun and annealed ribbon exhibit 5M modulated martensitic structure. Significant changes in the martensitic transition and the magnetic properties have been observed after annealing. The martensitic transition has shifted to lower temperature by 29 K and the austenite phase was stabilized at room temperature. A significant increase in the magnetization value was observed in the austenite phase as well as in the martensite phase after annealing. Strong magneto-structural coupling resulted in large MCE and MR in the annealed ribbon as compared to the as-spun ribbon. The increase in the FM ordering, a decrease in coercivity and an enhancement of MCE and MR values arise due to the structural/microstructural change brought about by annealing.

Development of localized surface plasmon based fiber optic sensors

Rani Dutta

In recent years, a lot of attention has been paid to the development of sensors for various applications. Due to the contributions made from different disciplines of science and engineering, new mechanisms and technologies have been emerged to develop sensors with high figure of merit. However, for practical applications, it is essential to have simple and flexible methodology which can be incorporated easily to make user friendly, portable and sustainable prototype devices for the detection. Optical and spectroscopic detection techniques have been exploited immensely in this regard. Now-a-days, the detection of bio- and explosive molecules is of great interest due to its various applications in civil, defense, forensic, humanitarian and military use. Since the detection and identification are the major important criteria, extremely high sensitivity and selectivity are essential for this trace detection. Major effort is being made to develop optical sensor devices to increase the sensitivity with specificity. The noble metal nano-particles are proved to be good sensing agents since its localized surface plasmon resonance (LSPR) are sensitive to its environment. Localized surface plasmons are the collective oscillations of the surface electrons of metal nano-particles those can be optically excited. The LSPR frequency is very much susceptible to the dielectric constant of its environment and this phenomenon has been cleverly utilized to develop very sensitive LSPR based chemical and biosensors. However, it is also reported that the spectrum of this LSPR resonance gets broadened and shifted due to the interactions between the nano-particles. This eventually decreases the sensitivity of the optical detection mechanism. Thus, it is important to know the optimal nano-particle distance for the development of this kind of sensors. This prompted us to pay systematic attention to these interactions and consequences in the development of nano-particles LSPR based optical sensors. Here, we report our observations on collective LSPR of silver nano-particles immobilized on the fiber optic core surface using evanescent wave absorption technique. The motivation of this study is to understand the spectral shift and broadening mechanisms due to the interactions between the nano-particles and bring about a simple model to improve the sensitivity of this class of LSPR based optical sensors.

Lifetimes measurements of excited nuclear states by Doppler shift attenuation method (DSAM).

Bhushan Kanagalekar

The lifetimes of excited states of a nucleus are of the order of femtosecond to nanosecond. The lifetime of an excited state gives an idea of the transition probability. The lifetimes of successive E2 transitions in a rotational band gives the quadrapole deformation of the nucleus. Lifetimes of states are determined using Doppler shift attenuation method (DSAM) (femtosecond to picosecond) and recoil distance method (RDM) (picosecond to nanosecond). In my talk, I will describe how to describe how lifetimes are determined using the DSAM method.

Novel coupling schemes for quorum sensing

Harpartap Singh

Previous research has shown that global coupling can lead to quorum sensing. However, no general framework for local interactions resulting in quorum sensing has been developed yet. Here, we present novel global and local coupling scenarios which yield quorum sensing type transitions. In our proposed global coupling, N (population) appears explicitly in the denominator of the interaction term. This is different from the previous works wherein N appears (directly or indirectly) in the numerator of their global interaction resulting in an increase of the coupling strength as the population is augmented. Using both these coupling schemes, we have studied a system of weakly coupled electrochemical oscillators and found that above a critical number of oscillators, global oscillations are induced in the system. In the reverse case, the loss of oscillations is investigated to demonstrate quorum sensing. The global coupling part has been verified experimentally using an array of Chua circuits.

Signatures for a unified theory in the sky

Kuntal Kumar Ghosh

Impact of domain walls on cosmological power spectrum and thereby exploring the early universe.

"All in One" molecules for quantum dots, metal and metal oxide nanostructure formation: Gram scale synthesis and properties

Jeotikanta Mohapatra

A general, reproducible and solventless technique has been developed for the fabrication of highly quality quantum dots, metal/metal oxide nanostructure by utilizing single organic molecules. The rationalized synthesis strategy of a broad range of nanostructure, such as CdS, CdSe, ZnS, ZnO, CdO, SnO^2, Fe^3O^4, Ag and Au, by thermolysis of the single molecules for the first time demonstrated. The influence of the different reaction parameters (precursor concentration, growth temperature and residence time) on the size and the physical and chemical properties of the nanoparticles were studied.

On the nature of ground state of long acenes

Himanshu Chakraborty

Several years back Angliker et al. [Chem. Phys. Lett. 87, 208 (1982)] predicted nonacene to be the first linear acene with triplet state 1^{3}B_{2u} to be the ground state instead of the singlet 1^{1}A_{g} state. However, contrary to that prediction, in a recent experimental work Tönshoff and Bettinger [Angew. Chem., Int. Ed. 49, 4125 (2010)] demonstrated that nonacene has a singlet ground state. Motivated by this experimental finding, we decided to perform a systematic theoretical investigation of the triplet states of polyacenes, with an emphasis on singlet-triplet splitting, starting from naphthalene, all the way up to decacene. Methodology adopted in our work is based upon Pariser-Parr-Pople model (PPP) Hamiltonian, along with large-scale multi-reference singles-doubles configuration interaction (MRSDCI) approach. Furthermore, we also calculate the absorption spectra of these acenes from their 1^{3}B_{2u} states, and find them to be significantly different as compared to those from the 1^{1}A_{g} states. Thus, linear optical absorption experiments performed on oriented samples of acenes, in conjunction with our results, can be used to determine the spin multiplicity of their ground states. We also analyze the nature of many-particle wave functions of the important states.

Student Presentations (Poster)

Optical properties of GaN nanopillars fabricated using ICP-RIE technique

Hari Pratap Bhasker

Gallium nitride (GaN) nanopillars are fabricated by Inductively Coupled Plasma Reactive Ion etching (ICPRIE) technique without any prior lithographic processing. Nanopillars are found to be highly c-axis oriented with density as high as $\approx 10^{10}$ cm^{-2}. The average tip diameter of the nanopillars for the hydride vapor phase epitaxial (HVPE) grown samples is found to be 22 nm, while for the MBE grown sample, nanopillars are found to be even narrower (tip diameter as small as 5 nm). Photo luminescence (PL) of nanopillars shows distinctly different optical properties as compared to bulk.

Excited states of Te-126 nucleus

Virendra Pasi

Our main interest in ^{126}Te lies in studying the phenomenon of K-isomerism. Many nuclei in the mass region ~130 *e. g.* ^{138}Gd, ^{136}Sm, ^{134}Nd, ^{132}Ce, ^{130}Ba, ^{128}Xe have been found to have K-isomers. The nucleus ^{126}Te is expected to have g-soft behavior and may exhibit K-isomerism as predicted by Xu *et al*. [1]. In the literature, only few energy states are known in ^{126}Te [2]. Our plan was to build the level scheme first and then look for the isomer, if there is any. Here we present our experimental result on the excited states of ^{126}Te.

[1] F.R.Xu *et al.,* Phys. Rev. C 59, 731(1999).

[2] C.T. Zhang *et al.,* Nuclear Physics A 628 386 (1998).

Cross-section measurements of complete and incomplete fusion reactions

Bhushan Bhujang

Cross-sections of complete and incomplete fusion channels are obtained from the measured gamma ray intensity in offline measurement. The reactions used are 11B+124Sn, 10B+124Sn and 11B+122Sn in the beam energy range of 56-78 MeV. 10B, 11B obtained from Pelletron accelerator bombarded 2mg/cm^2 thick targets. CF channel cross-sections were successfully reproduced by PACE results and reproducing incomplete fusion cross-sections by suitable model is in progress.

Size and shape controlled fabrication of magnetite nanoparticles and their magnetic properties

Arijit Mitra

A general, reproducible and solventless thermolysis technique has been developed for the fabrication of monodispersed Fe^3O^4 nanospheres and nanocubes of controllable sizes 2-36 nm by using oleic acid and oleylamine as a reducing as well as surface functionalized agent. The shape of as-prepared Fe^3O^4 nanoparticle is readily interchanged from sphere to cube morphology through a control of growth rate. The magnetization for the same volume cubic morphology is slightly less form spherical nanoparticles. We believe this might be due to shape anisotropy. Interestingly, 18 nm Fe^3O^4 nanoparticles exhibit blocking temperature above 300 K, suggesting ferromagnetism with a remnant magnetization (MR) of 21 emu/g and coercivity (HC) of 200 Oe. For cube shape Fe^3O^4 nanoparticles, a sharp feature appeared for the field cooled (FC) and zero field cooled (ZFC) magnetization curve at 110-120 K, corresponding to the signature of the Verwey transition temperature (TV).

Constituent quarks and multi-strange baryon production in heavy ion collision

Nirbhay Behera

Heavy Ion Collision experiment aims to investigate the QCD matter at very high energy density and temperature, to explore the QCD phase diagram and to explore the possibility of formation of Quark-Gluon Plasma in the laboratory. In the mid rapidity region, strangeness enhancement is believed to be one of the potential signatures of QGP formation. Multi-strange baryons are formed and decouple from the system very early in time. The study of multi-strange baryons could probe the QCD matter in a definite fashion. In a complete geometrical approach using overlap model, we try to show how the strangeness enhancement scales with quark participants rather than nucleon participant, which is an indication of formation of a partonic phase in heavy ion collisions.

Effect of buffer layer growth temperature on epitaxial GaN films deposited by magnetron sputtering

Pravanshu Mohanta

Epitaxial GaN films were deposited by reactive sputtering of a GaAs target in 100% nitrogen at 700 ^oC on ZnO buffer layers grown at different substrate temperatures over sapphire substrates. High resolution X-ray diffraction measurements and the corresponding analysis show that the growth temperature of buffer layers significantly affects the micro-structural parameters of GaN epilayer, such as lateral coherence length, tilt and twist, while the vertical coherence length remains unaffected. The optimum substrate temperature for buffer layer growth has been found to be 300 ^oC. High epitaxial quality GaN film grown on such a buffer layer exhibited micro strain of $1.8x10^{-4}$ along with screw and edge type dislocation densities of $7.87x10^9$ and $8.41x10^{10}$, respectively.

Magnetic, magnetocaloric and magnetotransport properties of R $Sn_{(1+x)}Ge_{(1-x)}$ compounds (R=Gd, Tb, Er; x=0.1)

Sachin Gupta

We have studied the magnetic, magnetocaloric and magnetotransport properties of the system $RSn_{(1+x)}Ge_{(1-x)}$ (R=Gd,Tb,Er; x=0.1) by means of magnetization, heat capacity and resistivity measurements. It has been found that all the compounds crystallize in the orthorhombic crystal structure described by the centrosymmetric space group Cmcm(No. 63). The magnetic susceptibility and heat capacity data suggest that all the compounds in this series are antiferromagnetic at low temperatures. Large negative values of θp in case of $GdSn_{1.1}Ge_{0.9}$ and $TbSn_{1.1}Ge_{0.9}$ indicate that strong antiferromagnetic interactions are involved, which is also reflected by the magnetization isotherms data. On the other hand $ErSn_{1.1}Ge_{0.9}$ shows weak antiferromagnetic interactions. In case of $TbSn_{1.1}Ge_{0.9}$, the coefficient of electronic heat capacity and Debye temperature are found to be γ =99.8 mJ/mol-K^2 and θ_D=101K respectively. Among these three compounds, $ErSn_{1.1}Ge_{0.9}$ shows considerable magnetocaloric effect (MCE). The MCE has been measured both in terms of isothermal entropy change and adiabatic temperature change. These values are found to be 9.5 J/kg K and 3.2 K respectively for ΔH=50 kOe. The resistivity data show all the compounds show positive and small value of MR. Resistivity data of $TbSn_{1.1}Ge_{0.9}$ show the anomalous behavior below TN, suggesting the formation of superzone gaps in the conduction electron energy bands.

GO and RGO based FETs fabricated with Langmuir-Blodgett grown monolayers

Divakar Botcha

Graphene oxide (GO) monolayers were transferred onto SiO_2/Si substrates by Langmuir-Blodgett (LB) technique and were converted to reduced graphene oxide (RGO) by exposure to hydrazine vapors followed by various durations of heat treatment at 400 °C in Ar atmosphere. Bottom gated FETs were fabricated with LB grown monolayers before and after reduction and were electrically characterized. The conductivity of RGO monolayers has been found to be in the range of 3 to 5 Scm^{-1}. The RGO devices showed p-type behavior with a hole mobility of 0.07cm^2/Vs and I_{on}/I_{off} ratio of 2.