

**IN-HOUSE SYMPOSIUM 2014**



**DEPARTMENT OF PHYSICS  
INDIAN INSTITUTE OF SCIENCE  
BANGALORE-560012**



## **FOREWORD**

As a periodic review of its activities, the Department of Physics has been organizing In-house Symposium on annual basis during recent years. This one-day symposium usually consists of oral presentations by faculty members, post-docs and students, and poster presentations by all those who would like to present their recent results. This year we have a total of 19 talks and 55 posters. I hope this package would be a reasonable representation of the ongoing research activities in the department. This event is also particularly useful to freshers (including senior undergraduates) to familiarize themselves with the current research activity in our Department in various branches of Physics.

I would like to thank Arindam Ghosh, Prabal Maiti, Prateek Sharma and Vijay Shenoy of our department who have shouldered the responsibility to organize this In-house Symposium. I urge all of you to actively participate in this important scientific activity. I hope you will all have an enjoyable and fruitful day.

**Prof. V. Venkataraman**

**Chairman**

**November 21, 2014**



## **Department of Physics, IISc Bangalore**

### **Inhouse Symposium 2014**

**November 21, 2014**

**Auditorium, New Physical Sciences Building**

### **Programme**

#### **Session I    9:00-10:30    Chair: Vijay B. Shenoy**

T01	9:00-9:15	P S Anilkumar <i>Spin polarized electron scattering: Investigation on the spin-orbit and exchange interactions in materials</i>
T02	9:15-9:30	D.Venkateswarlu <i>A Brillouin light scattering study of the resonant spin wave modes in permalloy nanowires network</i>
T03	9:30-9:45	Ranjan Modak <i>Conservation laws in one-dimensional disordered system</i>
T04	9:45-10:00	Manjari Gupta <i>Strong-coupling theory approach to describe an atomtronic josephson junction on an optical lattice</i>
T05	10:00-10:15	Srabani Kar <i>Probing carrier dynamics in graphene by using terahertz spectroscopy</i>
T06	10:15-10:30	Saurish Chakrabarty <i>Super-cooled liquids with randomly pinned particles</i>

#### **10:30-11:00    Tea**

#### **Session II    11:00-1:00    Chair: J K Basu**

T07	11:00-11:15	Rahul Pandit <i>Particles and Fields in Superfluid Turbulence</i>
T08	11:15-11:30	Akshay Bhatnagar <i>Universal Statistical Properties of Inertial-particle Trajectories in Three-dimensional, Homogeneous, Isotropic, Fluid Turbulence</i>
T09	11:30-11:45	Tarun Deep Saini <i>Excess central light as mass accumulation due to adiabatic growth of central supermassive black holes in galaxies with Sersic profiles</i>
T10	11:45-12:00	Upasana Das <i>Formulating highly super-Chandrasekhar white dwarfs in GRMHD framework</i>
T11	12:00-12:15	Sujit Nath

*Origin of nonlinearity and plausible turbulence by  
hydromagnetic transient growth dimming  
magnetorotational instability in accretion disks*

T12	12:15-12:30	Amit Kumar Majhi <i>Comparison of Activation Energy and Pore Dynamics in liquid and gel phases of electroporated lipid bilayers using MD simulations</i>
T13	12:30-12:45	Nallani Raghav <i>Molecular mechanism of water permeation in helium impermeable graphene and graphene oxide membrane</i>
T14	12:45-1:00	Sudip Chakrabarty <i>Polarizable Force Field Development for Ionic Liquids</i>
	<b>1:00-2:00</b>	<b>Lunch</b>

<b>Session III</b>	<b>2:00-4:30</b>	<b>Poster Session</b>
<b>Session IV</b>	<b>4:30-5:30</b>	<b>Chair: K Rajan</b>
T15	4:30-4:45	K. Ramesh <i>Pressure Dependence of Glass Transition in As<sub>2</sub>Te<sub>3</sub> Glass</i>
T16	4:45-5:00	Aditya N. Roy Choudhury <i><math>\mu</math> vs. B in GaAs : Role of Interface Traps</i>
T17	5:00-5:15	Semonti Bhattacharyya <i>Sensing Coulomb impurities with 1/f noise in 3D Topological Insulator</i>
T18	5:15-5:30	Hariharan N <i>Correlation between magnetic and dielectric properties in Tb<sub>0.5</sub>Sr<sub>0.5</sub>MnO<sub>3</sub> single crystal</i>
	<b>5:30-6:00</b>	<b>High Tea</b>
<b>Session V</b>	<b>6:00-7:15</b>	<b>Chair: V Venkataraman</b>
Anil Kumar Memorial Lecture	6:00-7:00	G Ravindra Kumar, TIFR <i>Science with Extreme Light</i>
	<b>7:00-7:30</b>	<b>Best Poster Award</b> <b>Viswamitra Memorial Prize</b> <b>Best write-up Award in PH300 (Seminar Course)</b>
	<b>7:30-8:30</b>	<b>Dinner</b>

## **Poster List 2014**

	<b><u>Poster No.</u></b>	<b><u>Presenter's Name</u></b>	<b><u>Title</u></b>
1	P01	Arnab Rai Choudhuri	A forth coming popular science book on the sunspot cycle
2	P02	Sudeep Kumar Ghosh	Few Body Physics in Synthetic Dimensions with SU(N) Interactions
3	P03	Subbarao Kanchi	Dendrimer interaction with lipid bilayer
4	P04	Rituparno Mandal	Complex Rheology of Nematic Fluid; Connection to Elastic Turbulence
5	P05	Nairita Pal	Droplet Dynamics in a Turbulent Flow
6	P06	Sayonee Ray	FFLO order in a 1D p-wave Superfluid: A Bosonization study
7	P07	Himanshu Joshi	DNA Nanotechnology: Scaffolding the bottom up Synthesis
8	P08	Adhip Agarwala	Kondo effect in synthetic non-Abelian gauge fields
9	P09	Saientan Bag	Molecular Dynamics and Charge Transport Simulation In Hexa-peri-Hexabenzocoronene/Oligothiophene Hybrid: An Electric-Field-Responsive Discotic Liquid-Crystalline Phase
10	P10	Soumen Kumar Bag	Ionic Hubbard Model Study using DMFT
11	P11	Suman Saurabh	LIQUID CRYSTALLINE ORDERING OF VERY SHORT DNA FRAGMENTS
12	P12	Pranab Jyoti Bhuyan	Active fluidization in dense glassy systems
13	P13	Gopal Hazra	Correlation between Decay Rate and Amplitude of Solar Cycles as Revealed from Observations and Dynamo Theory
14	P14	Sambuddha Sanyal	Fermions in synthetic non-abelian gauge field
15	P15	Deovrat Prasad	COOL CORE CYCLES: COLD GAS AND AGN FEEDBACK IN CLUSTER CORES
16	P16	Ashok Garai	DNA elasticity from short DNA to nucleosomal DNA
17	P17	Soumavo Ghosh	Suppression of gravitational Instabilities By Dominant Dark matter Halo in LSB galaxies
18	P18	M. A. Aamir	Anomalous Universal Conductance Fluctuations in Dual-Gated Bilayer Graphene
19	P19	Amogh Kinikar	Conductance properties of graphene nano-constrictions
20	P20	N. Naresh	Synthesis of Nitrogen rich nanostructured carbon nitride by chemical vapor deposition method
21	P21	Debayan Dey	Phylogenetic and structural analysis reveals the evolution of promiscuous DNA binding of

## **Poster List 2014**

			histone like proteins HU and IHF
22	P22	Amit Roy	Carrier density and disorder dependent charge transport in poly (3,4-ethylenedioxythiophene) devices
23	P23	Arvind Kumar	Sol-Gel Spin Coated High- $\alpha$ TiO <sub>2</sub> Thin Films for CMOS applications
24	P24	Pumlian Munga	Unique Electrical switching in Cu-As-Se glasses
25	P25	Nupur Biswas	Interaction of quantum dots and protein with model cell membrane
26	P26	P. Lokeswara Rao	Structural Characterization of Co-crystals by Solid-State NMR
27	P27	Tanweer Ahmed	High detectivity in Photosensitive Graphene-hBN-MoS <sub>2</sub> multilayer heterostructures
28	P28	Sridevi. S	Sensitive detection of C- reactive protein using optical fiber Bragg gratings
29	P29	Satyendra Nath Gupta	Direct and Fowler-Nordheim tunneling in Siloxene Nanosheets and across grain boundaries in Silicon Nanocrystals
30	P30	Rakesh Manjappa	Refraction effects in optical ct of scattering gel dosimeters
31	P31	Kimberly Hsieh Sui Mee	Proximity Effect of Topological Insulators on the Electronic States of Graphene
32	P32	PBS Mahapatra	Gate controlled Seebeck effect in twisted bilayer graphene
33	P33	Tathagata Paul	Impact of annealing on transport and low frequency noise in ultrathin WSe <sub>2</sub> field effect transistors
34	P34	Harish Ravi	Electron Electric Dipole Moment Measurement Based on Chopped NMOR in Cs.
35	P35	Motiur Rahman Khan	Injection barrier induced deviations in space charge limited conduction in electrochemically prepared poly(3-methylthiophene) based devices
36	P36	Avradip Pradhan	Two Dimensional Electron Transport in Array of Te/Ag <sub>2</sub> Te Nanowire Composites
37	P37	M. Teena	Structural, electrical and optical characterization of InSe thin films
38	P38	S.M. Khare	COLOURED PDMS MICROPILLAR ARRAYS FOR DROSOPHILA LARVA FORCE MEASUREMENT
39	P39	Shwetha G. Bhat	Exchange Bias Studies on Single Ferrimagnetic Fe <sub>3</sub> O <sub>4</sub> Thin Films
40	P40	Saqib Shamim	Ultra-low noise atomically patterned nanostructures in Si
41	P41	Arnab Roy	Disorder induced critical phase transition in

## **Poster List 2014**

			NiFe magnetization reversal
42	P42	P. K. Bera	Yielding behaviour and Creep dynamics in a tumbling nematic of worm-like micelles
43	P43	R.Venkatesh	Synthesis of bamboo like structured carbon nitride nanotubes
44	P44	Ashoka Bali	Thermoelectric properties of Pb0.75-xMnxSn0.25Te alloys with variable manganese content
45	P45	Chandan Kumar	Fabrication of Graphene hBN heterostructures and 1/f noise set up
46	P46	Atul Prakash Abhale	Investigation of Lateral Photovoltaic Effect in lead Sulphide Colloidal Quantum Dots/Silicon heterojunction by light beam Induced Current Technique
47	P47	Sreekar Guddeti	Pulsed Laser Deposition of exchange-biased metallic spin valves
48	P48	Gyan Prakash	Tunable Ultrafast Carrier relaxation and plasmon coupling in Graphene-plasmonic hybrid structure
49	P49	Raju Chetty	Thermoelectric properties of Indium doped Cu2CdSnSe4
55	P50	Nafisa Begam	Large Drag reduction and Anomalous Hydrodynamic interactions of Soft Colloid in Polymer Melts
51	P51	Paritosh Karnatak	Noise in High-mobility Graphene Transistors: Contacts vs Bulk
52	P52	Paritosh Karnatak	Fermi-Edge Transmission Resonance in Graphene Driven by a Single Coulomb Impurity
53	P53	Mohana Krishna.R	Presentation title: Estimation of Magnetic Gradients using Photospheric and Chromospheric Magnetic Measurement
54	P54	GopiNath Daptary	Observation of transient superconductivity at LaAlO3-SrTiO3interface
55	P55	Vivekanandan Raman	Core-shell nanostructured Bismuth telluride/Cadmium telluride based composite for efficient photovoltaic cells

# **TALK ABSTRACTS**



## **Spin polarized electron scattering: Investigations on the spin-orbit and exchange interactions in materials**

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Understanding the magnetic interactions at the surfaces of thin films is a challenging task. Spin polarized electron scattering studies on these surfaces can give information about the spin-orbit and magnetic exchange interactions. Here, a beam of spin-polarized electrons are generated by shining circularly polarized light of appropriate wavelength on strained GaAs photocathode. These electrons are guided through electrostatic lenses towards the material under investigation and are scattered from the sample surface in a spin dependant fashion. Then the scattering asymmetry (between spin-up and spin-down electrons) as a function of the energy of the incoming electrons is obtained. This gives information about the spin-orbit and exchange interactions. This proves to be a vital technique as there is a growing interest in the scientific community to develop materials with high spin-orbit interaction for variety of applications. In this lecture, I will discuss the details of the experimental set-up, some case studies of how information about the spin-orbit interaction is extracted and some of the immediate future perspectives.

# A Brillouin light scattering study of the resonant spin wave modes in permalloy nanowires network

D.Venkateswarlu

*Spintronics and Thinfilm Magnetism Lab, Department of Physics,  
Indian Institute of Science, Bangalore, India-560012.*

Brillouin light scattering (BLS) technique has been carried out to study the properties of resonant spin wave modes in 20nm thick permalloy nanowires network (PNN), fabricated by a combination of standard lift-off technique followed by high resolution e-beam lithography.

The achievement of very narrow nanowires of widths (periods) about 70nm (250nm) results into a strong spin wave confinement in different PNN regions. This is even evident from the non-dispersive character ( $\omega(k)$  is constant) of the spin waves unlike the usual antidot structures with larger nanowire width. Due to the versatility and high sensitivity of the BLS technique, we could observe several spin wave modes in the frequency range from 2 to 20GHz. The in-plane angular dependence of the spin mode frequency on the applied magnetic field direction showed a four-fold anisotropy with maxima and minima along the [10],[01] and [11],[1,-1] PNN lattice directions, respectively. The frequency dependence on the applied magnetic field strength shows different behavior depending on the direction of the field. When the field is applied at  $0^0$  of the PNN, all the detected modes exhibit a monotonic frequency behavior while at  $45^0$  the two lowest frequency modes become soft at a given critical field and exhibit a finite frequency gap. Micromagnetic simulations are used to extract the mode frequency and spatial profiles to the modes detected in the BLS experiments. The frequency dependence of different modes has been also analytically reproduced by using the Kittel formula where the demagnetization factors have derived by the PNN shape anisotropy.

## Conservation laws in one-dimensional disordered system

Ranjan Modak<sup>1</sup> and Subroto Mukerjee<sup>1,2</sup>

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<sup>2</sup> Centre for Quantum Information and Quantum Computing,  
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We have constructed an infinite number of conserved charges for non-interacting disordered model by treating on-site potential as a zeroth order Hamiltonian and hopping as a perturbation. As a result, these conserved charges can be expressed as an infinite order power series of hopping whereas number operator at per site can be treated as zeroth order conserved charge. For a particular form of long range hopping model (type-I), we see a truncation in the power series at the linear order in hopping. Using a particular convergence criteria, we have shown the distinction between localized phases (power series converges) and delocalized phases (power series diverges) in Andre-Aubry model.

# Strong-coupling theory approach to describe an atomtronic josephson junction on an optical lattice

Manjari Gupta\* and H. R. Krishnamurthy†

*Center For Condensed Matter Theory, Department of Physics, Indian Institute of Science, Bangalore 560012, India*

J. K. Freericks‡

*Department of Physics, Georgetown University, Washington, D.C. 20057, USA*

(Dated: November 14, 2014)

We examine the behavior of a bose superfluid on an optical lattice in the presence of an annular trap and a barrier across the annular region which acts as a Josephson junction. As the superfluid is rotated it moves with a supercurrent until it develops phase slips which generate vortices. We use a finite temperature strong-coupling ( $t/U$ ) expansion about the mean-field solution of the Bose Hubbard model, as described in our earlier paper Ref. [1], to characterize the device. Although our formalism is in equilibrium, it allows us to study the superfluid current flow and the generation of phase slips. This theory should aid in the further development of atomtronic circuits ([2–4]). In addition, we show how even more complex Josephson junction structures spontaneously arise if the filling is increased to generate Mott regions within the system.

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- [1] M. Gupta, H. R. Krishnamurthy and J. K. Freericks, Phys. Rev. A **88**, 053636 (2013).
  - [2] B. T. Seaman, M. Krämer, D. Z. Anderson, M. J. Holland Phys. Rev. A **75**, 023615 (2007).
  - [3] R. A. Pepino, J. Cooper, D. Z. Anderson and M. J. Holland, Phys. Rev. Lett. **103**, 140405 (2009).
  - [4] Stephen Eckel, Jeffrey G. Lee, Fred Jendrzejewski, Noel Murray, Charles W. Clark, Christopher J. Lobb, William D. Phillips, Mark Edwards and Gretchen K. Campbell, Nature **506**, 200-203 (2014).

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**“For Oral Presentation”**

# **Probing carrier dynamics in graphene by using terahertz spectroscopy**

S. Kar<sup>1,2</sup>, D. R. Mohapatra<sup>1</sup>, S. Jayanti<sup>3</sup>, E. Freysz<sup>4</sup>, and A. K. Sood<sup>1,2</sup>

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## **Abstract**

We have studied the change of terahertz conductivity ( $\Delta\sigma$ ) of photoexcited carriers (excitation wavelength is 800 nm) in as prepared monolayer graphene (AG) (unintentionally hole doped with Fermi energy  $E_F$  at  $\sim -180$  meV) and nitrogen doped graphene (NDG) (with  $E_F \sim -10$  meV) and thermally annealed doped graphene (TAG). The window of terahertz range is 0.5-2.5 THz. Throughout this terahertz window we observe negative  $\Delta\sigma$  in AG and positive  $\Delta\sigma$  in NDG. To understand –ve  $\Delta\sigma$ , we have adopted the recently proposed secondary hot carrier generation process due to Coulomb interaction of photoexcited carriers with the existing carriers. Near the Dirac point the intraband scattering dominates over secondary hot carrier generation and  $\Delta\sigma$  turns into positive in NDG. We can quantitatively estimate the amplitude and sign of  $\Delta\sigma$  by varying  $E_F$  and momentum relaxation time. Furthermore, the cooling of hot carriers after photoexcitation is analyzed using a supercollision model which involves a defect mediated collision of the hot carriers with the acoustic phonons, thus giving an estimate of the deformation potential varying from 15 - 28 eV.

# Super-cooled liquids with randomly pinned particles

Saurish Chakrabarty<sup>1</sup>, Smarajit Karmakar<sup>2</sup>, and Chandan Dasgupta<sup>1</sup>

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*21 Brundavan Colony, Narisingi, Hyderabad, India*

We present a study of super-cooled liquids in the presence of quenched disorder using molecular dynamics simulations. The quenched disorder is introduced by pinning a randomly chosen fraction of atoms in a super-cooled liquid at equilibrium. We obtain the phase diagram of two model systems in the temperature – pinning fraction plane. For both these systems, we observe that the temperature window between mode-coupling transition temperature  $T_C$  and the Kauzmann temperature  $T_K$  widens as we increase the pinning fraction  $\rho_{pin}$ . This result does not agree with an earlier prediction (based on mean-field and renormalization group calculations on certain spin systems) which says that these two temperatures approach each other as the  $\rho_{pin}$  is increased. We also observe a considerable change in the kinetic fragility of the super-cooled liquid on introduction of the random pinning and believe that this plays a role in giving us the phase diagram we get.

## Particles and Fields in Superfluid Turbulence

Rahul Pandit, Centre for Condensed-Matter Theory, Department of Physics,  
Indian Institute of Science, Bengaluru 560 012, India

I give an overview of our recent studies of the interactions of particles with fields in superfluid turbulence. The particles we use are active: not only are they advected by the flow but they also act back on it. Our simulations of such particles interacting with the field in the two-dimensional Gross-Pitaevskii equation yield new insights into how such particles interact with vortices and how they collide with each other. In particular, we find a continuous transition from inelastic to elastic collisions as we change the range of the repulsive interaction between particles.

This work has been done with Vishwanath Shukla (IISc) and Marc-Etienne Brachet (ENS, Paris).

# Universal Statistical Properties of Inertial-particle Trajectories in Three-dimensional, Homogeneous, Isotropic, Fluid Turbulence

Akshay Bhatnagar,<sup>1,\*</sup> Anupam Gupta,<sup>2,†</sup> Dhrubaditya Mitra,<sup>3,‡</sup> Prasad Perlekar,<sup>4,§</sup> and Rahul Pandit<sup>1,¶</sup>

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Inertial particles, advected by turbulent fluid flows, show rich dynamics that are of great interest, not only because of potential applications in geophysical, atmospheric, astrophysical, and industrial processes, but also because they pose challenging questions of fundamental importance in the fluid dynamics and nonequilibrium statistical mechanics of such flows. We uncover universal statistical properties of the trajectories of heavy inertial particles in three-dimensional, statistically steady, homogeneous, and isotropic turbulent flows by extensive direct numerical simulations. We show that the probability distribution functions PDF  $P(\phi)$ , of the angle  $\phi$  between the Eulerian velocity  $\mathbf{u}$  and the particle velocity  $\mathbf{v}$ , at this point and time, shows a power-law region in which  $P(\phi) \sim \phi^{-\gamma}$ , with a new universal exponent  $\gamma \simeq 4$ . Furthermore, the (PDFs) of the trajectory curvature  $\kappa$  and modulus  $\theta$  of the torsion  $\vartheta$  have power-law tails that scale, respectively, as  $P(\kappa) \sim \kappa^{-h_\kappa}$ , as  $\kappa \rightarrow \infty$ , and  $P(\theta) \sim \theta^{-h_\theta}$ , as  $\theta \rightarrow \infty$ , with exponents  $h_\kappa \simeq 2.5$  and  $h_\theta \simeq 3$  that are universal to the extent that they do not depend on the Stokes number  $St$  (given our error bars). We also show that  $\gamma$ ,  $h_\kappa$  and  $h_\theta$  can be obtained by using simple stochastic models. We characterize the complexity of heavy-particle trajectories by the number  $N_I(t, St)$  of points (up until time  $t$ ) at which  $\vartheta$  changes sign. We show that  $n_I(St) \equiv \lim_{t \rightarrow \infty} \frac{N_I(t, St)}{t} \sim St^{-\Delta}$ , with  $\Delta \simeq 0.4$  a universal exponent.

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## **Excess central light as mass accumulation due to adiabatic growth of central supermassive black holes in galaxies with Sersic profiles**

Tarun Deep Saini

Deep observations of the inner regions of elliptical discs show that they are very well fitted by the Sersic profile. However, the fitting leaves out some excess light at the centre that has a cuspy density profile. These galaxies are believed to harbour supermassive black holes at their centres that grow in time due to accretion of matter. I will show that the slow growth of the black hole perturbs the distribution function of stars in a manner that can be computed by considering adiabatic invariants of the Keplerian problem; and yields cuspy excess mass in accordance with the observations. I will show that a relation can be obtained between the fractional excess light and the mass of the black hole, which can be used to estimate the mass of the black hole.

# Formulating highly super-Chandrasekhar white dwarfs in GRMHD framework

Upasana Das and Banibrata Mukhopadhyay

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November 17, 2014

## Abstract

Type Ia supernovae (SNeIa) are believed to be triggered in white dwarfs having mass close to the Chandrasekhar limit of 1.44 solar mass. However, observations of several peculiar, highly over-luminous SNeIa do not conform to this traditional explanation. These SNeIa, e.g. SN 2003fg, SN 2006gz, SN 2007if, SN 2009dc, seem to invoke the explosions of super-Chandrasekhar white dwarfs having mass 2.1-2.8 solar mass. In our venture to obtain a fundamental basis behind the formation of such super-Chandrasekhar white dwarfs, we have exploited the enormous potential of magnetic fields, which can affect the structure and properties of the underlying white dwarf in a variety of ways. We have progressed from a simplistic to more rigorous and self-consistent models in the following sequence - spherically symmetric Newtonian model with a constant central magnetic field; spherically symmetric general relativistic model with varying magnetic field and finally, a model including the self-consistent departure from spherical symmetry obtained from extensive general relativistic magnetohydrodynamic (GRMHD) numerical analysis. Here we particularly present the results of the GRMHD formulation, whereby we have constructed stable equilibrium models of strongly magnetized, static, white dwarfs. Interestingly, we find that significantly super-Chandrasekhar white dwarfs, with mass 1.7-3.4 solar mass, are obtained for many possible field configurations, namely, poloidal, toroidal and mixed. Further, due to the inclusion of deformation in the white dwarfs caused by a strong magnetic field, super-Chandrasekhar white dwarfs are obtained for relatively lower magnetic field strengths compared to that in the simplistic model, as speculated in our earlier work.

# Origin of nonlinearity and plausible turbulence by hydromagnetic transient growth dimming magnetorotational instability in accretion disks

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November 18, 2014

## Abstract

We investigate the evolution of hydromagnetic perturbations in a small section of accretion disks. It is known that molecular viscosity is negligible in accretion disks. Hence, it has been argued that a mechanism, known as Magnetorotational Instability (MRI), is responsible for transporting matter in the presence of weak magnetic field. Now the question arises, whether other hydromagnetic effects, e.g. transient growth (TG), can play important role to bring nonlinearity in the system, even at weak magnetic fields. Otherwise, whether MRI or TG, which is primarily responsible to reveal nonlinearity to make the flow turbulent? Our results prove explicitly that the flows with high Reynolds number ( $R_e$ ), which is the case of realistic astrophysical accretion disks, exhibit nonlinearity by TG of perturbation modes faster than that by modes producing MRI. For a fixed wavevector, MRI dominates over transient effects, only at low  $R_e$ , lower than its value expected to be in astrophysical accretion disks, and low magnetic fields. This seriously questions (overall) suasiveness of MRI in astrophysical accretion disks.

## Abstract

# COMPARISON OF ACTIVATION ENERGY AND PORE DYNAMICS IN LIQUID AND GEL PHASES OF ELECTROPORATED LIPID BILAYERS USING TEMPERATURE DEPENDENT MD SIMULATIONS

Amit Kumar Majhi<sup>1</sup>, Subbarao Kanchi<sup>1</sup>, Venki Venkataraman<sup>1</sup>, Ganapathy Ayappa<sup>2</sup>, Prabal Maiti<sup>1</sup>

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<sup>2</sup>Department of Chemical Engineering, Indian Institute of Science, Bangalore, India.

The molecular level understanding of electroporation has been studied by few research groups [1, 2, 3] over the last decades. We have performed molecular dynamics simulation (MDS) of electroporation at different temperatures to find activation energy as well as pore dynamics in the gel and liquid phases of POPC and DPPC lipid bilayers.

The MDS of bilayers were performed using NAMD, the Particle mesh Ewald (PME) method, the all-atom CHARMM force field and an integrated time-step of 2 fs.

The bilayers were composed of 256 lipids which were solvated with TIP3 water molecules with a low KCl concentration. The MD simulations were performed in temperature range from 250 K to 350 K with varying electric fields (0.02 to 1 V/nm).

A plot of pore initiation rate as a function of inverse temperature showed Arrhenius type behaviour. The activation energy was determined to be 25.5 and 21.5 kJ/mol for the liquid phase of POPC and DPPC lipids respectively for an electric field of 0.3 V/nm, and reduces at higher fields. The activation energy in the gel phase of POPC increases to 28.8 kJ/mol at the same field. The pore closing time after the field is switched off was found to be longer in the gel phase than in the liquid phase.

Remarkably, pores of radii  $\sim$ 0.7 nm in the gel phase of POPC did not close even after 50ns, whereas they close completely within 10ns in the liquid phase.

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# **Molecular mechanism of water permeation in helium impermeable graphene and graphene oxide membrane**

Nallani Raghav and Prabal K Maiti

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The layers of graphene oxide (GO) are found to be good for permeation of water but not for helium (Science 2012 335 (6067): 442-444) suggesting that the GO layers are dynamic in the formation of permeation route depending on the environment they are in. From the free energy calculations of the reduced and oxidized parts of the sheet, and water trapped between them, we see that oxidized parts help open up a GO membrane and reduced parts help in permeation of the water. For helium the free energy calculations show that neither the oxidized parts nor the reduced parts open up.

# Polarizable Force Field Development for Ionic Liquids

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**Abstract:** We have developed a many-body polarizable force field for ionic liquids, a potential solvent for an increasing number of applications<sup>1</sup>. The description of the electrostatic interactions for this model requires a contribution from polarizable atomic multipole. The multipole moments through the quadrupole are assigned on each atomic center, based on a Distributed Multipole Analysis (DMA)<sup>2</sup> derived from large basic set molecular orbital calculations on isolated ions. The vdW parameters of the hydrogen atoms on the heterocyclic ring are adjusted to agree with the ab initio optimized geometries of isolated ion pairs. Classical MD simulations are performed for a wide range of temperatures to validate our many-body polarizable force field. The liquid density, heat of vaporization, and ion self-diffusion coefficient are found in a good agreement with available experimental data<sup>3</sup>.

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# **Pressure Dependence of Glass Transition in As<sub>2</sub>Te<sub>3</sub> Glass**

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## **ABSTRACT**

Amorphous solids prepared from their melt state exhibit glass transition phenomenon upon heating. Viscosity, specific heat and thermal expansion coefficient of the amorphous solids show rapid changes at the glass transition temperature ( $T_g$ ). Generally, application of high pressure increases the  $T_g$  and this increase (a positive  $dT_g/dP$ ) has been understood adequately with Free Volume and Entropy models which are purely thermodynamic in origin. In this study, electrical resistivity of semiconducting As<sub>2</sub>Te<sub>3</sub> glass at high pressures as a function of temperature has been measured in a Bridgman anvil apparatus.  $T_g$  estimated from the slope change in the resistivity – temperature plot shows a negative  $dT_g/dP$  (-2.99 °C/kbar) in the pressure range 1 bar to 9 kbar is generally uncommon in liquids. When the sign of the thermal expansion coefficient is negative,  $dT_g/dP = \Delta k/\Delta\alpha$  will be less than zero which can result in a negative  $dT_g/dP$ . In general, chalcogenides rich in tellurium show negative thermal expansion coefficient (NTE) in the supercooled and stable liquid states. An electronic model proposed by deNeufville and Rockstad finds a linear relation between  $T_g$  and the optical band gap ( $E_g$ ) for covalent semiconducting glasses when they are grouped according to their average coordination number. The electrical band gap ( $\Delta E$ ) of As<sub>2</sub>Te<sub>3</sub> glass decreases with pressure, thus a negative  $dT_g/dP$  is expected. In this sense, As<sub>2</sub>Te<sub>3</sub> is a unique glass where its variation of  $T_g$  with pressure can be understood by both electronic and thermodynamic models.

## **$\mu$ vs. B in GaAs : Role of Interface Traps**

Aditya N. Roy Choudhury and V. Venkataraman

We had experimentally observed the magnetic field (B) dependence of the electron chemical potential ( $\mu$ ) in n-type GaAs at room temperature. The diamagnetic conduction electron cloud induces a Landau Gap in a high magnetic field ( $\sim 7$  Tesla) which, in turn, makes the  $\mu$  dependent on B. Experimentally, this signal (which is of the order of  $\sim 100 \mu\text{V}$ ) appears as a voltage across a GaAs MOS capacitor when kept in a pulsed field. This experiment is known to detect *only* the itinerant contribution to the net magnetization in the semiconductor, especially in the non-degenerate limit where most other magnetization measurements cease to work owing to a very low carrier concentration.

We compare the measured signals with the theoretically estimated ones for 3 different dopings of GaAs ( $N_D \sim 1 \times 10^{17}/\text{cc}$ ,  $5 \times 10^{16}/\text{cc}$  and  $5 \times 10^{15}/\text{cc}$ ). The signals are observed to be 80% - 60% of what was theoretically estimated and we attribute this discrepancy to the traps that are present in the GaAs-oxide interface.

We develop a theory of MOS Energy Band Diagram in a high magnetic field and show that such interface traps can indeed lessen our signal.

In addition to this, while doing such calculations, we see, to our surprise, that the MOS capacitance theoretically calculated with an AC voltage produced by a time-varying magnetic field ( $C_B$ ) is quite different than the MOS capacitance measured with a simple AC voltage source outside any magnet ( $C_E$ ). In fact the presence of interface traps was seen to lie at the heart of this difference as we could theoretically show that  $C_B$  and  $C_E$  become exactly equal when no interface traps are present.

# Sensing Coulomb impurities with 1/f noise in 3D Topological Insulator

Semonti Bhattacharyya, Mitali Banerjee, Hariharan N., Suja Elizabeth, Arindam Ghosh

Dept. Of Physics, IISc, Bangalore

Non-trivial Surface-states of a 3D topological insulator (TI) form a unique two dimension electron gas that combine Dirac-like dispersion and a natural protection against backscattering of electrons (or holes) by non-magnetic disorder. The resulting electrical transport reveal several intriguing properties ranging from bipolar field effect transistor action, weak antilocalization in quantum transport, to recent discovery of quantum anomalous Hall effect. Many of these phenomena depend crucially of the nature of disorder and its screening by the Dirac Fermions at the topological insulator surface. Here we have carried out a detailed and systematic study of low-frequency 1/f noise in the electrical resistivity of  $\text{Bi}_{1.6}\text{Sb}_{0.4}\text{Te}_{1.7}\text{Se}_{1.3}$  single crystals, to explore the dominant source of scattering of surface electrons as a function of TI thickness, gate voltage and temperature. We have measured a number of exfoliated TI-based field effect devices with the thickness of the TI channel varying from 10 nm to 110 nm, which allows us to monitor the relative contributions of the surface and bulk regions to both transport and noise. Our results reveal that while trapped coulomb impurities at the substrate-TI interface gives rise to dominating scattering mechanism for thin (10 nm) TI, charged crystal disorder forms an additional scattering mechanism in thick TI (110 nm) channels. We have observed an unexpected maximum in noise in thick TI devices at  $T \sim 25\text{K}$  which indicates by scattering of the surface states by a cooperative charge dynamics in the bulk of the TI, possibly associated with the Selenium vacancies. Our experiment demonstrates, for the first time, an unexpected impact of the bulk charge distribution on the surface state transport in Tis that could be crucial to the implementation of these materials in electronic applications.

# **Correlation between magnetic and dielectric properties in $\text{Tb}_{0.5}\text{Sr}_{0.5}\text{MnO}_3$ single crystal**

Hariharan N, Sanathkumar R, H. L. Bhat and Suja Elizabeth

Single crystals of terbium strontium manganite,  $\text{Tb}_{0.5}\text{Sr}_{0.5}\text{MnO}_3$  were grown by optical float zone technique and their magnetic, dielectric and thermal studies were carried out. Temperature dependent magnetization measurements (ZFC/FC) at different fields show strong irreversibility below the magnetic anomaly around 44 K, which is designated as the spin-glass transition. Isothermal magnetization measurements did not show saturation even at 5 K and 14 T field. AC magnetization studies confirm glassy magnetic response below 44 K. Real ( $\epsilon_1$ ) and imaginary parts ( $\epsilon_2$ ) of the dielectric constant display large frequency dispersion. Two relaxation regions, each with different activation energies are clearly evident, one above and the other below the spin-glass transition temperature. Activation energy in the spin-glass regime is found to be lower than that in the paramagnetic region. The calculated activation energy ( $E_a$ ) relates to the electron hopping between  $\text{Mn}^{3+}$  and  $\text{Mn}^{4+}$  ions as the possible origin of dielectric dispersion. The bulk capacitance and resistivity derived from the impedance measurements reveal an anomaly around the magnetic spin-glass temperature. These are suggestive of magneto-dielectric coupling in the system.. Electrical transport data between 60-300 K shows an insulating behavior.

# Science with Extreme Light

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High intensity, ultrashort light pulses can excite matter to high temperature *at* high density. This feature of ultrashort pulses provides a great opportunity for doing experiments in the lab that help us understand the behaviour of matter pushed to extreme conditions. Research in this area bridges diverse areas - from astrophysics to accelerator physics and from condensed matter physics to biology.

This talk will introduce the subject and dwell on two basic themes - one dealing with how light couples to such plasmas and another that deals with the consequence of such coupling, namely the production and behaviour of 'hot' electrons (ranging up to MeV). I will present some results of experiments performed at TIFR – creation of gigantic magnetic fields, ultrafast plasma dynamics, passage of relativistic particles through dense, hot matter and interesting consequences in terms of electron and ion acceleration, ultrafast hard x-ray emission, laser fusion, laboratory astrophysics etc.

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# **POSTER ABSTRACTS**



# A forthcoming popular science book on the sunspot cycle

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**Abstract:** My popular science book *Nature's Third Cycle: A Story of Sunspots* will be published by Oxford University Press in January 2015. This book gives an introduction to the phenomenology of the sunspot cycle along with a non-technical presentation of dynamo theory, which provides the basis for theoretically understanding this cycle. The poster shall give some information about this book.

Title: Few Body Physics in Synthetic Dimensions with SU(N) Interactions

Authors: Sudeep Kumar Ghosh, Umesh Kumar Yadav and Vijay B. Shenoy

Cold atomic systems with SU(N) symmetric interactions have been of recent experimental and theoretical interest. Motivated by this, we study few body physics in such systems which also realize synthetic dimensions (Celi et al., PRL 112, 043001) within the cold atom setting by coupling the atomic hyperfine states via light. Choosing the light appropriately also provides ability to control magnetic flux in the plaquettes of the synthetic lattice. Using a combination of exact diagonalization and analytical methods, we uncover the novel physics that emerges in the interplay of non-local interactions in synthetic dimensions and the magnetic flux. Attractive SU(N) interactions, in absence of flux, obtains a sequence of multi-particle ``baryonic'' bound states. We show how the presence of flux stabilizes a different sequence of baryonic states, presenting a detailed few body phase diagram. We also discuss consequences of our findings to the many body setting, pointing out the novel phases that can be realized in these systems. These results will be of interest to both experimentalists (suggesting systems with novel physics), as well as theorists for exploring the novel phases realized.

# Dendrimer interaction with lipid bilayer

Subbarao Kanchi<sup>a,b</sup>, K.G.Ayappa<sup>b</sup>, J.K.Basu<sup>a</sup> and Prabal K. Maiti<sup>a</sup>

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Poly(propyl ether imine) (PETIM) are a new class of dendrimers, known to be less toxic in nature. Lower cytotoxicity makes PETIM dendrimers an ideal candidate for drug<sup>1,2</sup> and non-viral gene delivery vehicles<sup>3</sup>. However, not much is known about the nature of the interaction of the dendrimer with lipid bilayer. We performed fully atomistic molecular dynamics (MD) simulations of five oxygen core (G3 and G4) PETIM dendrimers and DMPC lipid bilayer complex systems to understand microscopic structure of the interaction mechanism. In case of G3, all five dendrimers are aggregated and forms a single cluster in water just above the upper leaflet of the bilayer. In contrast for G4 PETIM dendrimer, one dendrimer penetrates into the hydrophobic core of lipid bilayer and remaining four dendrimers aggregate to form cluster above the upper leaflet. The lipid bilayer becomes thin and tail disorderness increases locally in vicinity of dendrimer cluster. The cluster on the bilayer creates an asymmetry in the lipid density distributions. In case of G4, ordered domain formation is observed in the lipid bilayer and the penetrated dendrimer becomes denser and radius of gyration becomes less compared to dendrimers in water<sup>4</sup>. Potential mean force calculations are performed to explain the dendrimer penetration into the lipid bilayer using umbrella sampling technique. In this study, we also report the mass density profiles, lipid tail order parameters, lipid tilt angles, radius of gyration and radial density distribution of dendrimers.

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# Complex Rheology of Nematic Fluid; Connection to Elastic Turbulence

Rituparno Mandal,\* Debarshini Chakraborti,† and Chandan Dasgupta‡

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We numerically analyse the full non-linear hydrodynamic equations of a sheared nematic fluid under shear stress and strain rate controlled situations incorporating spatial heterogeneity in the gradient direction. For a certain range of imposed stress and strain rates, this extended dynamical system shows signatures of *spatio-temporal chaos* and *transient shear banding*. In chaotic regime the power spectra of the order parameter stress and the total injected power shows power law behavior and the total injected power shows a non-gaussian, skewed probability distribution, which bear striking resemblance to *elastic turbulence* phenomena observed in polymer solutions. The scaling behavior is independent of the choice of shear rate/stress controlled method.

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# Droplet Dynamics in a Turbulent Flow

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<sup>2</sup>*TIFR-H*

(Dated: October 31, 2014)

The acceleration of a droplet along its trajectory is measured from the data obtained from a two-dimensional direct numerical simulation of a system containing a droplet moving inside a turbulent fluid. The phase-field method is used to formulate the equations governing the system. A pseudo-spectral scheme is adopted to solve the equations numerically in two dimensions. The tracking of the droplet center of mass is done in a purely Eulerian framework. We discuss how the simulations can capture the droplet advection along the flow and the droplet deformation. After a more detailed calculation, we find a multifractal behaviour in the Weber number time series of the droplet. We also extract the exponent of the auto-correlation function of the phase field of the system and show how it is related to the droplet behaviour in the fluid.

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# FFLO order in a 1D p-wave Superfluid: A Bosonization study

Vijay B.Shenoy, Subroto Mukerjee and Sayonee Ray

November 18, 2014

## **Abstract**

We study a one dimensional system of spinless fermions with an attractive interaction subject to a boost (which can be applied with artificial gauge fields in cold atomic systems). In the absence of a boost, the fermions pair up yielding a p-wave or TS superfluid. We describe the system with a boost by an appropriate sine Gordon model and using bosonization, show that there is a critical value of the boost above which charge density wave order supplants superfluidity. We obtain an analytical expression for this critical boost as a function on the parameters of the model. Ongoing work involves performing a similar calculation for a microscopic lattice model within the framework of BCS theory.

# DNA Nanotechnology: Scaffolding the bottom up Synthesis

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## Abstract

DNA nanotechnology has applications ranging from cellular physics to diagnosis and therapeutics. Various nanostructures have been synthesized exploiting the molecular self-assembly of DNA molecules. We have constructed and characterized atomistic models of DNA nanotubes<sup>1</sup>, DNA icosahedra<sup>2</sup> and lipid-DNA complexes<sup>3</sup>. We attempt to address the thermodynamic stability and mechanical strengths of these nano-motifs using all atom molecular dynamics (MD) simulation. The structural analysis of our simulation data shows that these structures are indeed stable and well behaved. The steered MD simulation reflects ~ 4 times greater rigidity of DNA nanotubes compared to dS-DNA in terms of stretch moduli<sup>4</sup>. Our several nanosecond long MD simulations provide useful insights about DNA nanostructures and help to design them for practical applications.

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# Kondo effect in synthetic non-Abelian gauge fields

Adhip Agarwala\* and Vijay B. Shenoy†

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(Dated: November 18, 2014)

## Abstract

We study Kondo effect in a system where an impurity resides in a bath of non-interacting spin- $\frac{1}{2}$  fermions in  $3D$  space in presence of uniform non-Abelian gauge field. The gauge field generates a Rashba type spin-orbit ( $SO$ ) interaction in the bath which is in general described by three coupling parameters  $(\lambda_x, \lambda_y, \lambda_z)$ . Here we consider a special high symmetry configuration where  $(\lambda_x = \lambda_y = \lambda_z = (\lambda/\sqrt{3}))$  called the “spherical” gauge field. We study this problem by various techniques including Hartree Fock mean field and variational approaches. For small values of  $\lambda$  (below a critical value)  $SO$  coupling has a beneficial effect on the Kondo effect, reducing the critical interaction ( $U_c$ ) at the impurity required to form a local moment and the concomitant singlet state with the conduction band. On the other hand, at large  $\lambda$  one finds a novel state with a moment which is  $2/3$  of a full moment, given  $U_c$  exceeds a value  $\propto \lambda^{4/3}$ .

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# Molecular Dynamics and Charge Transport Simulation In Hexa-peri-Hexabenzocoronene/Oligothiophene Hybrid: An Electric-Field-Responsive Discotic Liquid-Crystalline Phase

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**Abstract**—Using atomistic molecular dynamics simulation we study the discotic columnar liquid crystalline phases formed by Hexa-peri-Hexabenzocoronene/oligothiophene Hybrid which was recently synthesized by Nan Hu et al.<sup>[1]</sup> and reported to have electric field responsive behavior. Nanoscale ordering of the molecules in this phase are characterized. Correlations (positional and orientational) between the molecules both along and perpendicular to the director are quantified. Several distribution functions are calculated to understand the various equilibrium properties of the nanophase. We also simulate the transport of charge through this phase and report the numerical value of charge carrier mobility along the direction of director of this liquid crystal.

## REFERENCE

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# Ionic Hubbard Model Study using DMFT

Soumen Kumar Bag

November 18, 2014

## Abstract

A detailed study of phase transitions in the ionic Hubbard model(IHM) at half filling is presented. Within the dynamical mean field approximation(DMFT) in paramagnetic Ionic Hubbard Model a series of transitions from the band insulator via a metallic state to a MottHubbard insulating phase is found at intermediate values of the one-body potential  $\Delta$  with increasing the Coulomb interaction  $U$ . Also I have studied Antiferromagnetic IHM, we show that at low temperature increasing  $U$  leads to a first order transition at a finite value  $U_{AF}$  between a paramagnetic band insulator and an antiferromagnetic Mott insulator. Magnetic phase diagram of Ionic Hubbard Model in temperature( $T$ ), staggered potential( $\Delta$ ) and Hubbard interaction( $U$ ) space is explored.

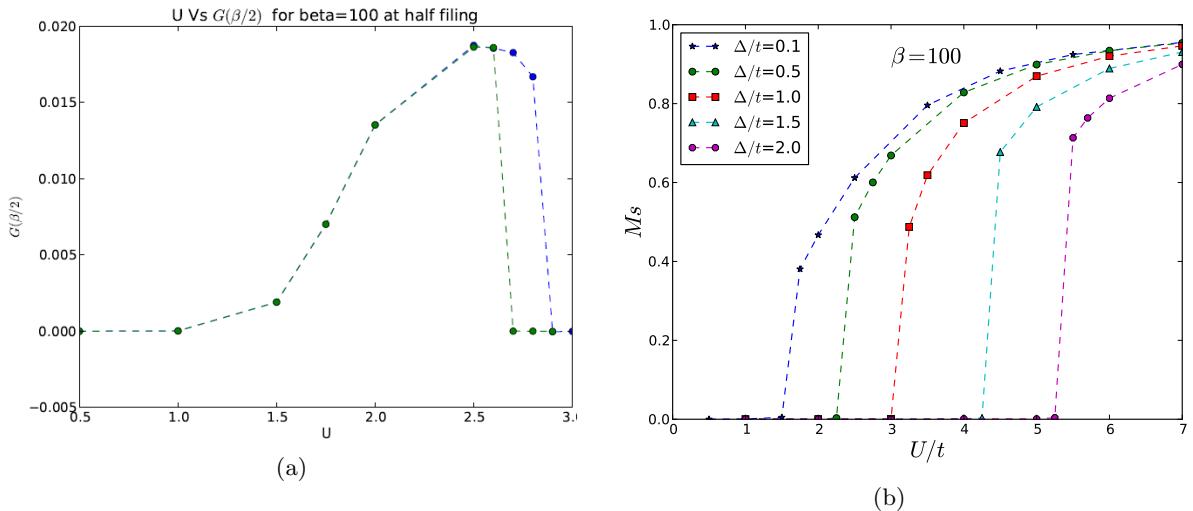


Figure 1: (a)zero frequency spectral function is proportional to  $G(\beta/2)$ . Figure shows that for  $\Delta=0.5$  there is paramagnetic band Insulator to metal smooth transition then a discontinuous transition to Mott insulator with  $U$ . Line are connected with green circle for increasing  $U$  and blue circles for decreasing  $U$ . (b)staggered magnetization  $M_s$  vs  $U$  for various  $\Delta$  values. The onset of  $M_s = (M_A - M_B)/2$  marks a first order transition from a BI to an AFI at  $U_{AF}$  for half filled IHM at  $\beta=100$ .

## **POSTER ABSTRACT**

# **LIQUID CRYSTALLINE ORDERING OF VERY SHORT DNA FRAGMENTS**

**Suman Saurabh, Prabal K. Maiti, Yves Lansac**

**Short DNA fragments between 6- to 20- bp long have been shown to exhibit various liquid crystalline phases in experiments. These observations are in complete violation of the molecular shape anisotropy that analytical theories demand for liquid crystalline ordering. It has been hypothesized that the liquid crystalline ordering is possible as a result of formation of long columns of DNA that stick to each other due to end-to-end stacking, giving rise to poly-molecular units which satisfy the shape anisotropy criteria necessary for ordering. We perform molecular dynamics simulations to probe the thermodynamic feasibility of this process, measured by the strength of end-to-end attraction between DNA fragments and demonstrate nematic ordering in a system of short 4-bp long DNA molecules.**

# Active fluidization in dense glassy systems

Pranab Jyoti Bhuyan,\* Rituparno Mandal,† and Chandan Dasgupta‡

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Dense soft glasses show strong collective caging behavior at sufficiently low temperatures. Using molecular dynamics simulations of a model glass former, we show that the incorporation of activity or self-propulsion,  $f_0$ , can induce cage breaking and fluidization, resulting in a disappearance of the glassy phase beyond a critical  $f_0$ . The diffusion coefficient crosses over from being strongly to weakly temperature dependent as  $f_0$  is increased. In addition, we demonstrate that activity induces a crossover from a fragile to a strong glass and a tendency for clustering of active particles. Our results are of direct relevance to the collective dynamics of dense active colloidal glasses and to recent experiments on tagged particle diffusion in living cells.

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# Correlation between Decay Rate and Amplitude of Solar Cycles as Revealed from Observations and Dynamo Theory

Gopal Hazra, Bidya Binay Karak, Dipankar Banerjee  
and  
Arnab Rai Choudhuri

November 19, 2014

## Abstract

Using different proxies of solar activity, we have studied the following features of solar cycle. (i) A linear correlation between the amplitude of cycle and its decay rate, (ii) a linear correlation between the amplitude of cycle  $n$  and the decay rate of cycle  $(n - 1)$ , and (iii) an anti-correlation between the amplitude of cycle  $n$  and the period of cycle  $(n - 1)$ . Features (ii) and (iii) are very useful because they provide precursors for future cycles. We have reproduced these features using a flux transport dynamo model with stochastic fluctuations in the Babcock-Leighton  $\alpha$  effect and in the meridional circulation. Only when we introduce fluctuations in meridional circulation, we are able to reproduce different observed features of solar cycle. We discuss the possible reasons for these correlations.

Title: Fermions in synthetic non-abelian gauge field

Authors: Sambuddha Sanyal and Vijay Shenoy

We are investigating a possible competition between superconducting and CDW order in a weakly interacting system of fermions in the presence of a synthetic non-abelian gauge potential. We found interesting singularities and non-analytic behavior in a system of free fermions in presence of an SU(2) non-abelian gauge field. On the other hand when the gauge field is of SU(3) type the Fermi surface shows a topological transition with increasing magnitude of the gauge interaction. Our goal is to understand how these non-interacting features effect the physics of interacting system.

# Title :- COOL CORE CYCLES: COLD GAS AND AGN FEEDBACK IN CLUSTER CORES

Author:- Deovrat Prasad, Prateek Sharma

## **Abstract:-**

Using high-resolution 2D and 3D simulations, we study the evolution of cool cluster cores heated by collimated bipolar active galactic nuclei (AGN) jets. We study the interplay between the cooling of the intracluster medium (ICM) and mechanical energy injection due to jets. Condensation of cold gas, and the consequent enhanced accretion, is required for AGN feedback to balance radiative cooling in cool cluster cores. A feedback efficiency as small as  $5 \times 10^{-5}$  is sufficient to reduce the cooling/accretion rate by a factor of 10 compared to a pure cooling flow. We find thermal cycles in cool cluster cores: condensation of cold gas when the ratio of the cooling-time to the free-fall time ( $t_{\text{cool}} / t_{\text{ff}}$ ) is 10 leads to a sudden enhancement in the accretion rate; a large accretion rate causes strong jets and overheating of the hot ICM such that  $t_{\text{cool}} / t_{\text{ff}} > 10$ ; further condensation of cold gas is suppressed and the accretion rate falls leading to enhanced cooling and condensation of cold gas, restarting the cycle. The 3D simulation shows the formation of a few-kpc scale, rotationally-supported, massive cold gas torus. Since the torus gas is not accreted, it is decoupled from the feedback cycle. While AGN feedback can heat the cores such that  $t_{\text{cool}} / t_{\text{ff}} > 10$  for reasonable efficiencies, it cannot raise the entropy to the values observed in non-cool-core systems.

# DNA elasticity from short DNA to nucleosomal DNA

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## Abstract

Active biological processes like transcription, replication, recombination, DNA repair and DNA packaging; encounter bend DNA. These processes occur at short length (<100 base pair) scale. Thus the study of elasticity of DNA at such length scale is very important. We use fully atomistic simulation along with various theoretical methods [1,2,3] to determine elastic properties of DNA of different length and sequence. We also study DNA elasticity in nucleosome core particle (NCP) both in presence and absence of salt. At room temperature and in equilibrium with different salt concentrations for our different systems we calculate contour length distribution, end-to-end length distribution and bend angle distribution, which are nearly Gaussian. We determine stretch modulus and persistence length of such short DNA and nucleosomal DNA from contour length distribution and bend angle distribution, respectively. The stretch modulus increases with ionic strength while persistence length decreases with salt concentration. Calculated stretch modulus and persistence length for DNA is in quantitative agreement with available experimental data. In contrast our study for the first time reports the elastic properties for the DNA when it is wrapped around the histone core in NCP. We further show that WLC model is inadequate to describe the DNA elasticity at shorter length scale. Our results not only provide a deeper understanding of DNA mechanics but also are applicable to most protein-DNA complexes.

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## **Abstract:**

The low surface brightness galaxies are gas-rich and yet have a low star formation rate, this is well-known puzzle. Further, these galaxies are featureless and exhibit no spiral features. These galaxies are known to be dominated by the dark matter halo from the innermost regions. Here we carry out axisymmetric and non-axisymmetric local perturbation analysis in the galactic disk of UGC 7321, a low surface brightness, superthin galaxy, for which the various observational input parameters are available. We show that the disk is stable against axisymmetric and non-axisymmetric perturbations. The Toomre Q parameter values are found to be large ( $>> 1$ ) mainly due to the low disk surface density and the high rotation velocity resulting due to the dominant dark matter halo, which could explain the observed low star formation rate. While treating the stars-alone, the disk shows finite swing amplification but the addition of dark matter halo suppresses that amplification almost completely. Even the inclusion of the low-dispersion gas which constitutes a high disk mass fraction does not help in causing swing amplification. This can explain why these galaxies are featureless. Thus the dynamical effect of a halo that is dominant from inner regions can naturally explain why star formation and spiral features are largely suppressed in low surface brightness galaxies, making these different from the high surface brightness galaxies.

# Anomalous Universal Conductance Fluctuations in Dual-Gated Bilayer Graphene

M. A. Aamir and Arindam Ghosh

Bilayer graphene is a technologically promising material because it has high carrier mobility and also a tunable band gap conducive to a high ON-OFF ratio vital for transistor applications. However, the band gaps found in electronic transport are much lower than those found in optical experiments. It has been pointed out that in electronic transport, disorder probably limits the band gap and thereby its potential electrical characteristics. This necessitates a thorough study of disorder in bilayer graphene which can be achieved by examining higher-order statistics of its conductance fluctuations. Conductance fluctuations is also a very reliable indicator of the universality class – which classifies systems according to the symmetries retained by its charge carriers. This is an outstanding unknown in the case of bilayer graphene where a combination of its symmetries – time reversal, spin, valley and layer – may already be spontaneously broken due to electron-electron interaction. In this work, we study the conductance fluctuations in bilayer graphene over its large phase space that is traversed by Fermi energy and band gap. We find that the conductance fluctuations peak at zero Fermi energy which reflects a lack of screening and the peak height increases for higher band gaps which corroborates to this idea. However, this result is contradicted in another device with different size and mobility that has an enormous dip at zero Fermi energy. This implies the importance of mobility and device size in determining the effect of disorder. Another surprising result is that conductance fluctuation as a function of the magnetic field shows a decrease by an anomalous factor of 4, instead of 2 which is usually the case for time-reversal symmetric systems. These new results can probably shed light to several unanswered questions about the importance of disorder and interactions in bilayer graphene and probably also in a 2D metal in general.

# Conductance properties of graphene nano-constrictions

Amogh Kinikar, T Phanindra Sai and Arindam Ghosh

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We present a novel experiment to create graphene nano constrictions, or point contacts, and measure their conductance in situ. Our experiments show the predicted behaviour of conductance quantization in units of  $2e^2/h$ . However, they also have astonishing feature of having conductance plateaus at non-integer rational values. We also measure edge transport on these graphene nano constrictions and suggest that the effect we see is an outcome of edge states.

The experiment involves using an STM built in to an SEM. The graphene nano constrictions are created by mechanical nano exfoliation of a highly ordered pyrolytic graphite (HOPG) crystal using the STM. The exfoliated layers are then pulled back till they taper off and tear. We simultaneously monitor the entire process using the SEM to generate high magnification images, while measuring the conductance of nano constriction during the exfoliation. We can also manoeuvre the STM tip to touch the edge of an already exfoliated constriction and measure electric transport through the edge.

Our results indicate conductance quantization at room temperature in such nano constrictions. We also see plateaus at rational fractions such as:  $1/3, 1/2, 1/4, 1/8, 2/3$  and others. We do not yet have a theoretical understanding of the non-integer fractions. The conductance quantization becomes more stable and more pronounced when the surface of the HOPG is doped with gold.

## **Synthesis of Nitrogen rich nanostructured carbon nitride by chemical vapor deposition method**

**N. Naresh, R. Venkatesh, Pumlianmunga, K. Ramesh**

**Department of Physics, Indian Institute of Science, Bangalore 560012.**

Nanostructured carbon nitride films were prepared by pyrolysis assisted chemical vapour deposition(CVD). A two zone furnace with a temperature profile having a uniform temperature over a length of 20 cm length has been designed and developed. The precursor adenine ( $C_5H_5N_5$ ) was taken in a quartz tube and evaporated at  $800\text{ }^{\circ}\text{C}$  in zone1. The dense vapours enter the pyrolysis zone (zone 2) kept at a desired temperature (between 500 and  $1000\text{ }^{\circ}\text{C}$ ) and deposit on the quartz substrates. X-ray diffraction of the prepared films showed the amorphous nature.

The FTIR spectrum of the prepared samples shows peaks at  $1100\text{ cm}^{-1}$  (C–N stretching) and  $1600\text{ cm}^{-1}$  (C=N) confirms the bonding of nitrogen with carbon. Raman spectra shows the disorder (D) band at  $1385\text{ cm}^{-1}$ . The graphitic (G) peaks are observed between  $1525$  and  $1575\text{ cm}^{-1}$ . XPS core level spectra of C 1s and N 1s show the formation of  $\pi$  bonding between carbon and nitrogen atoms. SEM images shows the presence of nano tubes with diameter varying between 100-300nm. The EDAX measurements shows about 55 % of nitrogen which is very close to the stoichiometric carbon nitride (Carbon 43 % and nitrogen 57 %).

# **Phylogenetic and structural analysis reveals the evolution of promiscuous DNA binding of histone like proteins HU and IHF**

**Debayan Dey and Suryanarayananarao Ramakumar**

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**Abstract:** Nucleoid-associated proteins (NAPs) are chromosome organizing factors in bacteria and are considered to influence the transcriptional landscape of bacterial cell. Various NAPs alter the DNA topology in a well regulated manner and influence each other's expression. HU is a histone like protein in prokaryotes, which binds to promoter regions of gene in a promiscuous or multi-specific manner. IHF (Integration Host Factor), having the same HU-IHF fold, binds to DNA sequences with comparatively high specificity. Promoter target site specificity along with differential binding affinities of NAPs plays crucial role in regulatory dynamics of the cell. After nearly four decades of biochemical, structural and cell biology research on HU-IHF family proteins, a detailed evolutionary picture remained unexplored. The major question in this field remains the specificity of HU-IHF family proteins. To understand the sequence determinants of HU-IHF family, which influence the promiscuity, we undertook a phylogenetic study in conjunction with structural analysis, to address fundamental differences in HU-IHF family. To understand this issue, we systematically searched and analyzed the HU-IHF like proteins in both prokaryotes and eukaryotes. We show that three major subfamilies are present along with intermediate sequences, sharing distant evolutionary relationship. We found positional and compositional based differences in these three subfamilies, which ultimately affect the promiscuity, dynamics and DNA bending. Our analysis shows specific positions of positively and negatively charged amino acids in different HU-IHF family proteins from different organisms determine their differential binding ability, thus exhibit species specific evolutionary tuning. We further propose that class and species specific residue positioning as well as different state of dimerization in HU-IHF family makes it a versatile NAP to control gene regulation of bacteria. Our analysis suggests small changes in DNA binding region of HU-IHF like proteins can affect not only its genomic target, but affects the whole transcriptional program.

# Carrier density and disorder dependent charge transport in poly(3,4- ethylenedioxythiophene) devices

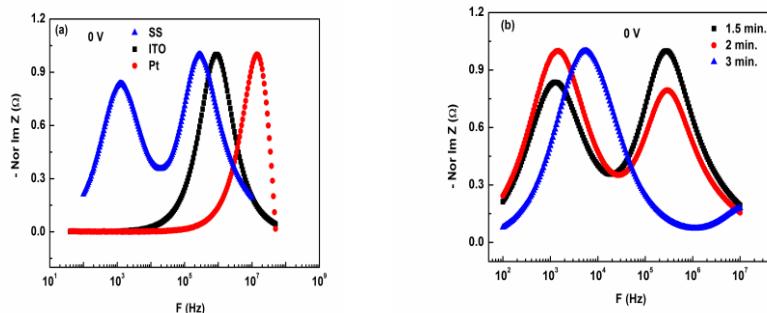
Amit Roy,<sup>1\*</sup> Vaibhav Varade, P. Anjaneyulu and Reghu Menon

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## ABSTRACT

Poly (3, 4-ethylenedioxythiophene) (PEDOT) doped with poly (styrene sulfonate) (PSS) is one of the well-studied highly conducting polymer and also extensively used as a transparent material in polymeric/organic devices. The conjugated polymer PEDOT can be doped to very high conductive state, and its morphological structure is very interesting for device point of view. This polymer is mainly synthesized via chemical route to make solution processed devices. There are only few reports available on this material prepared via electrochemical methods, which has also potential to be utilized in large area organic devices, super capacitors and battery materials. In our present work, PEDOT samples are prepared by using electrochemical synthesis with a dopant PF<sub>6</sub>. Impedance spectroscopy technique is employed to understand the growth mechanism and metal-polymer interface interaction. The PEDOT samples were prepared on various metal electrodes [Platinum (Pt), Stainless steel (SS) and Indium tin oxide (ITO)] and then de-doped for different extent of time to obtain samples with different resistances. The measurements were carried out in metal/polymer/metal device geometry. The results show that the growth conditions will severely affect the relaxation mechanism through the reactance spectrum (-Im Z vs F). The reactance spectrum will give information about the relaxation of carriers and interface states, if present any. The normalized reactance spectrum on the all the three devices at 0 V bias is presented in Fig. 1(a). It can be seen that SS/PEDOT:PF<sub>6</sub>/Ag (D1) device show two relaxation peaks in the reactance spectrum, whereas the other two devices (ITO or Pt/PEDOT:PF<sub>6</sub>/Ag, D2 and D3) show only one such relaxation peak, which is due to the bulk related phenomena. In case of D1 device, the relaxation peaks either slowly disappear or move towards higher frequency with increased de-doping time as shown in Fig 1(b). It is also observed that for a particular doping concentration the interface related phenomena is dominant by showing more magnitude peak in the reactance spectrum. It is known that the carriers relaxation in the device are solely governed by the bulk property of the material and the reactance spectrum shows only one relaxation peak, if there is no contribution from interface or other related states, which is the case in our D2 and D3 devices. The future studies will explore the structural organization and their electrical characterization details.



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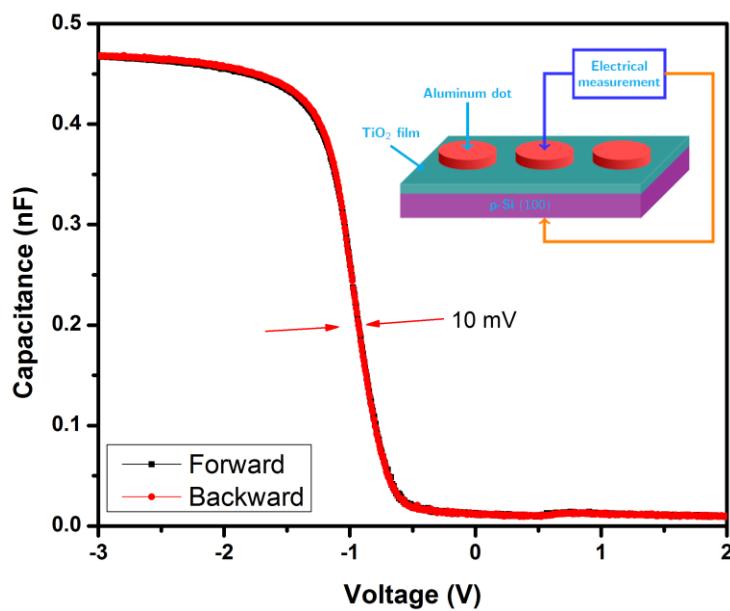
## Sol-Gel Spin Coated High- $\kappa$ TiO<sub>2</sub> Thin Films for CMOS applications

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High- $\kappa$  TiO<sub>2</sub> thin films on p-type silicon substrate was deposited by a combined sol-gel and spin coating method. Deposited films had an anatase phase with a small grain size of  $\approx 17$  nm and surface roughness of  $\approx 0.6$  nm, calculated from XRD and AFM respectively. We fabricate Metal oxide semiconductor (MOS) structures to study the electrical properties of the films. The oxide capacitance ( $C_{ox}$ ), flat band capacitance ( $C_{FB}$ ), flat band voltage ( $V_{FB}$ ), oxide trapped charges ( $Q_{ot}$ ), calculated from the high frequency (1 MHz) C-V characteristics was found 0.47 nF, 0.16 nF, -0.91 V,  $4.7 \times 10^{-12}$  C, respectively. As compared to the previous reports, a high dielectric constant of 94 at 1 MHz frequency was observed in the devices investigated here and an equivalent oxide thickness (EOT) was 4.1 nm. Leakage current density was found in acceptable limits ( $2.1 \times 10^{-5}$  A/cm<sup>2</sup> for -1 V and  $5.7 \times 10^{-7}$  A/cm<sup>2</sup> for +1 V) for CMOS applications.



**Figure.** Capacitance - Voltage (C-V) characteristic of Al/TiO<sub>2</sub>/p-Si (100) MOS structure.

## **Unique Electrical switching in Cu-As-Se glasses**

**Pumlianmunga, R. Venkatesh, N. Naresh, and E.S.R. Gopal, K. Ramesh**

Department of Physics, Indian Institute of Science, Bangalore 560012.

A unique electrical switching behaviour has been observed in bulk  $\text{Cu}_x\text{As}_{30}\text{Se}_{70-x}$  glasses prepared over a wide range of composition ( $0 \leq x \leq 35$ ). For  $x < 15$ , the glasses do not exhibit switching, whereas glasses in the range  $15 \leq x < 25$  show a threshold type switching. An unusual switching from low resistance to high resistance state is observed for the glasses in the range  $25 \leq x < 30$ . When the concentration of Cu is  $\geq 30$ , the glasses are found to show memory switching.

These glasses were thermally crystallized in two ways to understand the different kinds of switching behaviour observed. First the glasses were crystallized by annealing at their respective crystallization temperatures ( $T_c$ ). Second the glasses were heated up to their melting temperatures ( $T_m$ ) under vacuum and cooled back to room temperature. Samples annealed at  $T_c$ , shows the formation of  $\text{Cu}_3\text{AsSe}_4$  phases only for the entire range of composition. On the other hand samples crystallized by melting showed  $\text{Cu}_3\text{AsSe}_4$  for the composition range  $0 \leq x \leq 20$  and for  $25 \leq x \leq 35$ ,  $\text{Cu}_3\text{AsSe}_4$  and  $\text{Cu}_3\text{AsSe}_3$  phases were observed.

Normally, the memory switching is explained by the models based on thermally induced transitions and threshold switching is explained by the models based on the electronic transitions. The present studies provide a unique way to understand both the threshold and memory switching based on the thermal model and filament formation. This study also indicates that the crystalline phases formed from the melt state are responsible for switching. Hence, at the time of switching the sample in between the electrodes undergo the phase change by glass  $\rightarrow$  melt  $\rightarrow$  crystal transformation and not by the direct glass  $\rightarrow$  crystal transformation.

# Interaction of quantum dots and proteinwithmodel cell membrane

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Semiconductor quantum dots (QDs) are potential candidate for targeted drug delivery and cell imaging for their tunable fluorescent properties. We have studied charge dependent interactions of QDs with model cell membranes of zwitterionic lipids. We incubated DMPC lipid bilayers, prepared by Langmuir-Blodgett method, in differently charged CdSe/ZnS core shell QDs at physiological condition when DMPC remains in fluid phase. X-ray reflectivity (XR) data was collected before and after incubation and was analyzed modeling bilayer as head-tail-tail-head

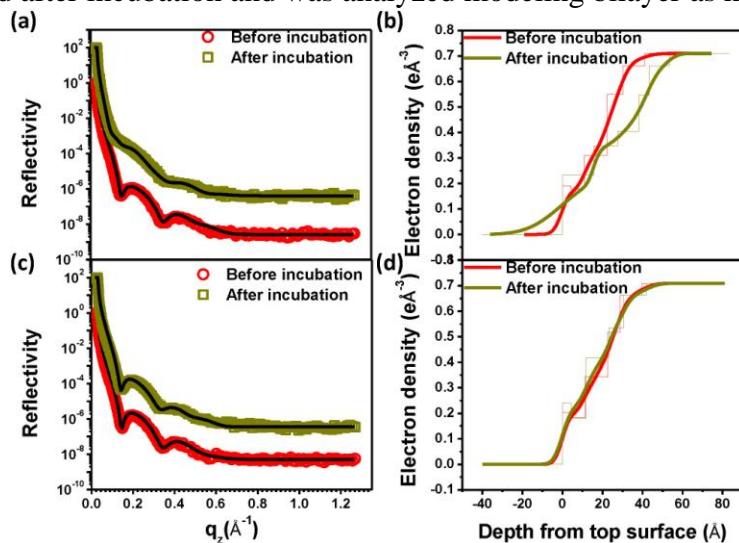


Fig: (a) Reflectivity profile and (b) EDP of bilayer incubated in cationic QDs. (c) Reflectivity profile and (d) EDP of bilayer incubated in anionic QDs. The narrow lines in EDP are electron density plots without roughness convolution. Reflectivity curves are upshifted for clarity. Symbol: data, black line: fit.

configuration on the Si substrates. XR data (Fig. (a)) for the bilayer incubated in cationic QDs and extracted electron density profile (EDP) (Fig. (b)) show that thickness of bilayer has increased accompanied by increase in electron density of the top layer. On the other hand, thickness change was not observed in bilayer incubated in anionic QDs (Fig. (c) and (d)). These results show that the adherence with zwitterionic lipids is stronger for cationic QDs.

Using X-ray scattering, we have also explored how amyloid-beta protein, responsible for Alzheimer's disease, penetrates in a model membrane as a function of density.

Acknowledgement: We acknowledge Dr. S. Velaga, Dr. R. Bhattacharya, Ms. Roobala C. for their help during experiments.

## Abstract for Poster:

### Title: Structural Characterization of Co-crystals by Solid-State NMR

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Co-crystals are systems constituted by two or more different molecules held together by supramolecular interactions. The study of structure-property relations of co-crystals is one of the active areas of the modern solid-state chemistry due to their important pharmaceutical applications. Solid-state NMR (SSNMR) is emerging as a fundamental tool for the structural identification and characterization of co-crystalline materials. Accessing information on crystal packing, conformation and hydrogen bonding arrangements, which are the fundamentals in determining the final solid-state properties of a given form of co-crystal, is possible by newly emerged NMR techniques<sup>1</sup>. Here we illustrate the combined use of two dimensional pulse sequences that exploit homonuclear and heteronuclear dipolar couplings for characterization of co-crystals. The molecular association is probed using both short- and long-range <sup>1</sup>H (FSLG)-<sup>13</sup>C CP HETCOR, <sup>1</sup>H (DQ)-<sup>1</sup>H (SQ) experiments at fast MAS (30 kHz) have been used for achieving information on proton-proton proximities and thus on hydrogen-bond networks in the co-crystals. However, close proximities of N—H and aromatic protons hindered the full assignment of the <sup>1</sup>H spectra. To unveil this problem we are planning to perform <sup>1</sup>H (DQ)-<sup>1</sup>H (SQ) at ultra-fast MAS (~60 kHz) along with exploiting of more exotic spin pairs <sup>14</sup>N-<sup>1</sup>H by <sup>14</sup>N-<sup>1</sup>H heteronuclear multiple-quantum correlation (MHQC) experiment. The NMR methods utilized will be illustrated with some examples.

# High detectivity in Photosensitive Graphene-hBN-MoS<sub>2</sub> multilayer heterostructures

Tanweer Ahmed, Kallol Roy and Arindam Ghosh

## ABSTRACT:

Suitable band structures of 2D crystals like graphene and transition metal di-chalcogenides (TMDCs), make them interesting for optical and electronic applications. Graphene is suitable for ultrafast electronic applications due to its high carrier mobility  $\sim 10^5 \text{ cm}^2 \text{ V}^{-1}\text{s}^{-1}$ <sup>[1]</sup>. But its weak photo absorption (2.3%) and absence of a gain mechanism have restricted the responsivity of the pure Graphene photodetectors down to very low value<sup>[2]</sup>. Monolayer crystals of TMDCs have direct band gaps, and in their DoS (Density of States), they have Van Hoff singularities which give rise to a high absorption coefficient and efficient electron-hole generation under photo excitation<sup>[3]</sup>. Despite its reach optical properties, variable range hopping transport limited slow carrier dynamics<sup>[4]</sup> leaves the photoresponsivity of MoS<sub>2</sub> based photodetectors, down to a low value<sup>[5]</sup>. A material having high optical absorption coefficient, when coupled together with another having high conductivity, to form a composite, can give rise to a high sensitivity photo-detectors, and opens up possibilities of many other potential optoelectronics applications. Single layer TMDCs and Graphene have direct bandgap and huge carrier mobility respectively and so they are perfect candidates for such a composite. Recently it has been demonstrated that a MoS<sub>2</sub>-Graphene heterostructures can show responcivity of  $\sim 10^{10}$  along with versatile applicabilities<sup>[6]</sup>. In this work we show that insertion of an insulating layer of h-BN, which acts as a trap free substrate for Graphene, not only restores the properties of Graphene-MoS<sub>2</sub> hybrid, but also, empowers it with high detectivity due to reduction of Graphene's noise. Our Graphene-hBN-MoS<sub>2</sub> multilayer hetero-structure shows a detectivity of  $2*10^{13}$  Jones. This calculated value of detectivity lies in the highest regime of reported values of detectivities of all kinds of photodetectors.

# **Sensitive detection of C- reactive protein using optical fiber Bragg gratings**

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## **Abstract:**

An accurate and highly sensitive sensor platform has been demonstrated for the detection of C-reactive protein (CRP) using optical fiber Bragg gratings (FBGs). The CRP detection has been carried out by monitoring the shift in Bragg wavelength ( $\Delta\lambda_B$ ) of an etched FBG (eFBG) coated with an anti-CRP antibody (aCRP) - graphene oxide (GO) complex. The complex is characterized by Fourier transform infrared spectroscopy, X-ray photoelectron spectroscopy and atomic force microscopy. A limit of detection of 0.01 mg/L has been achieved with a linear range of detection from 0.01 mg/L to 100 mg/L which includes clinical range of CRP. The eFBG sensor coated with only aCRP (without GO) show much less sensitivity than that of aCRP-GO complex coated eFBG. The eFBG sensors show high specificity to CRP even in the presence of other interfering factors such as urea, creatinine and glucose. The affinity constant of  $\sim 1.1 \times 10^{10}$  M<sup>-1</sup> has been extracted from the data of normalized shift ( $\Delta\lambda_B / \lambda_B$ ) as a function of CRP concentration.

**Keywords:** C-reactive protein, Fiber Bragg gratings, Graphene oxide, Bragg wavelength.

# **Direct and Fowler-Nordheim tunneling in Siloxene Nanosheets and across grain boundries in Silicon Nanocrystals**

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The successful synthesis and outstanding properties of graphene have promoted significant interest in studying graphene-like silicon sheet (silicene). Very recently, 2D silicon nanosheet stabilized by H atoms and OH groups (siloxene nanosheet, a close silicon analogue of graphene oxide nanosheet) was reported. We have investigated the tunneling characteristics of siloxene nanosheets and silicon nanocrystals, obtained by heating of siloxene nanosheets at 900°C under vacuum, using scanning tunneling spectroscopy. Electrons are transported from the tip to the substrate through siloxene nanosheets and silicon nanocrystals. The siloxene nanosheets and silicon nanocrystals exhibit nonresonant tunneling; in siloxene nanosheets the transport mechanisms are based on direct tunneling at low bias voltages less than 0.8V and Fowler-Nordheim tunneling at high bias voltages while in silicon nanocrystals, the transport is due to direct tunneling. Inter grain and intra grain in plane transport properties of silicon nanocrystals are also studied in order to understand the effect of grain boundaries on electrical properties of silicon nanocrystals. Individual grain boundaries are found to impede the electrical transport. At higher bias the current is increased due to transition in to FN tunneling from direct tunneling through the grain boundary.

# Refraction effects in optical ct of scattering gel dosimeters.

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## Abstract

Gel dosimetry provides 3D spatial distribution of the complex dose profiles and is used in dose verification for radiation therapy planning. Optical tomography of gel dosimeters provides dose readout in 3D. The scanner involves the diode laser as the light source and the transmitted data is collected using a photodetector. Multiple projections are collected across the dosimeter. As light undergoes refraction at the boundaries of the dosimeter, filtered back-projection results are inaccurate and shows distortion in the dose profiles. In polymer gel dosimeters internal dose regions irradiated with higher dose values show a higher value of refractive index(RI). These interior RI changes lead to errors in reconstruction.

Algebraic reconstruction technique (ART) based method and pixel based reconstruction algorithms have been adapted to solve these problems. The system matrix is built by using pathlength information, which is obtained from Jacobs algorithm, a fast ray-tracing method. The improvement in accurate reconstruction of dose is evaluated using gamma-index. The effects of interior and boundary refraction and the approaches to overcome these limitations are presented.

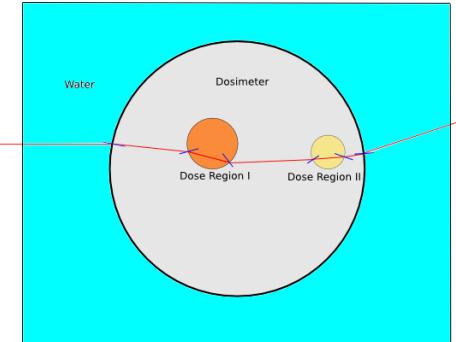


Figure 1: The ray bending due to refractive index mismatch at the boundary of the dosimeter and interior refractive index mismatch due to multiple inhomogeneities.

# Proximity Effect of Topological Insulators on the Electronic States of Graphene

Authors: Kimberly Hsieh Sui Mee, Arindam Ghosh

Two recent materials that garnered significant attention are graphene (Gr) and topological insulators (Tis). While both graphene and TI surface states share similarities in their low energy dispersion spectra with the conduction and valence bands meeting at Dirac points, there are significant differences between them. Graphene is characterized by a linear dispersion relation in the vicinity of its Dirac points giving rise to massless Dirac fermions with high mobility, which can be further enhanced by using hexagonal boron nitride (h-BN) as a substrate. Meanwhile, 3D topological insulators such as  $\text{Bi}_2\text{Se}_3$ ,  $\text{Bi}_2\text{Te}_3$ , BSTS (Bismuth Antimony Telluride Selenide) suffer from low mobilities. The TIs are insulating in the bulk but exhibit gapless surface states which are robust against back-scattering due to time reversal symmetry. These surface currents being dissipationless and spin-polarized allow potential applications of TIs in spintronic devices. It has been theoretically argued that proximity to Tis will induce spin-orbit (SO) coupling in graphene, thereby creating a band gap in an otherwise gapless band structure of graphene.

This work attempts to fabricate tri-layer heterostructures of TI-Gr-BN and study their transport properties and look for signatures of a band gap opening up in graphene via proximity effects. Such heterostructures are prepared by mechanical exfoliation, subsequently followed by pickup and alignment using micromanipulators and finally transferred onto Si-SiO<sub>2</sub> wafers under optimized temperature and baking induced polymer hardness conditions. Finally, these devices will be loaded into cryostats and low temperature electrical transport measurements performed on them.

**Abstract: Gate controlled Seebeck effect in twisted bilayer graphene**

**Authors:** PBS Mahapatra, Subroto Mukherjee, Arindam Ghosh

The recent developments in the technology of van der Waals heterostructures made from two dimensional atomic crystals have led to the observation of rich and intriguing physics. Graphene, an ideal two dimensional electron gas (2DEG), also exhibits rich electronic properties depending on how it is stacked on top of another graphene layer. Unlike bilayer graphene in Bernal stacking, twisted bilayer graphene with a random orientation of the layers has a massless electronic dispersion similar to that of single layer graphene. Recently several intriguing properties such as renormalization of Fermi velocity, van Hove singularities, electronic localization and incoherent interlayer electronic transport have been observed in twisted bilayer graphene. A remarkable degree of control of the electronic properties is achievable by means of adjusting the built in strain and relative orientation of the graphene layers in twisted bilayer graphene. Careful alignment of the crystallographic orientation of two graphene layers can achieve resonant tunnelling with conservation of both electron energy and momentum and exhibits negative differential conductance between the two graphene layers.

Even though the electronic properties of twisted bilayer graphene has gained much attention recently, its thermo-electric properties have never been studied in detail. In this work, we have looked into the thermal transport through a single van der Waal gap between the two graphene layers in the twisted bilayer graphene which was transferred on hexagonal Boron Nitride. We report observation of strong Seebeck effect across the van der Waal gap with a maximum Seebeck voltage of 2.5 kV/watt (77K) which can be controlled by the Silicon back gate.

# **Impact of annealing on transport and low frequency noise in ultrathin WSe<sub>2</sub> field effect transistors**

Author : Tathagata Paul, Subhamoy Ghatak, Arindam Ghosh

Transition metal dichalcogenides (TMDCs) are promising candidates for emerging devices and concepts in nanoscale electronics (ultrathin FETs, flexible electronics etc.). Members of the TMDC family exhibit diverse electronic properties. Depending on the number of d orbital electrons, they can be metallic, semiconducting or even superconducting. Among these, semiconducting TMDCs are important for their wide range of applications in the fields of photovoltaics, thin film transistors, optoelectronics etc.

One of the primary challenges with TMDC-based active electronic channels is the low carrier mobility. The underlying mechanism of degradation of mobility remains debated, and roles of crystalline disorder, trapped charges at the TMDC-substrate interface and large metal-TMDC Schottky barriers at the contacts have been suggested as possible in several experimental and theoretical investigations. Here we have investigated various factors that limit the carrier mobility and on-off transition in tungsten disulphide (WSe<sub>2</sub>)-based field-effect transistors. We have attempted to reduce contact resistance of WSe<sub>2</sub> FETs by vacuum annealing. The annealing process is repeatable and leads to an overall improvement in device performance. The effect of annealing on transport characteristics and noise magnitude is investigated.

We also report low frequency or 1/f noise measurements in ultrathin WSe<sub>2</sub> FETs. For high carrier densities noise seems to arise from carrier number fluctuations in the semiconducting channel, whereas for lower carrier concentrations the channel appears to be disordered with the noise originating from percolative transport. We also find a transition from discrete to continuous percolative transport with increasing carrier density.

# Electron Electric Dipole Moment Measurement Based on Chopped NMOR in Cs.

Harish Ravi, Ummal Mommen and Vasant Natarajan

November 12, 2014

## **Abstract**

The existence of an electron EDM implies time-reversal symmetry (T) violation in the laws of physics. Limits on electron EDM constrains theories that go beyond the standard model. EDM searches over the past few decades have resulted in the best estimate of  $10^{-26}$  e-cm using thallium atoms. We have proposed a new method to measure electron EDM in Cs using chopped NMOR, and use this technique to measure electron EDM with an accuracy of  $10^{-20}$  e-cm. We also propose ways of improving the accuracy of the technique.

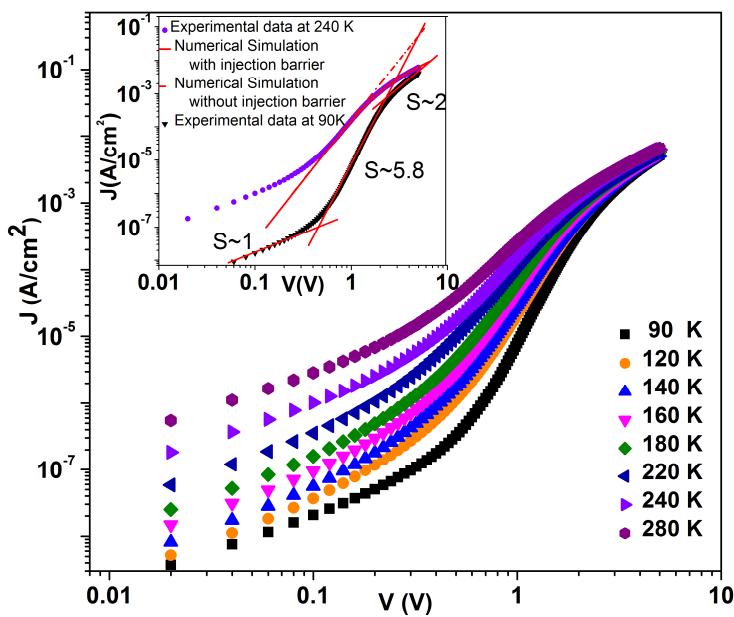
# Injection barrier induced deviations in space charge limited conduction in electrochemically prepared poly(3-methylthiophene) based devices

Motiur Rahman Khan, V. Varade, K.S.R.K.Rao and R. Menon

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The current-voltage ( $J-V$ ) characteristics of electrochemically prepared poly(3-methylthiophene) [P3MeT] have been investigated in Pt/P3MeT/Al devices in the temperature range 90–280 K. At low voltages, the current shows Ohmic behavior at all temperatures which is due to the thermally generated carriers or background doping. Space charge limited current controlled by exponentially distributed traps ( $V^{l+1}$  law,  $l > 1$ ) is observed in the intermediate voltage range at all temperatures, where  $l$  is defined as  $l = T_c/T$  with  $T_c$  as characteristic temperature of exponentially distributed traps. On increasing the applied bias, current decreases from  $V^{l+1}$  dependence and  $V^2$  law is observed at 90 K. However, at higher temperatures, current deviates from usual  $V^{l+1}$  law where the slope is found to be less than 2 on a log – log scale which is attributed to the presence of injection barrier. Numerical simulation of  $V^{l+1}$  law by introducing injection barrier shows good agreement with experimental data. The plausible reasons for the origin of injection barrier and its effect on transport mechanism are discussed.



# Two Dimensional Electron Transport in Array of Te/Ag<sub>2</sub>Te Nanowire Composites

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Various semiconductor nanowires (NWs) have been synthesized by using either physical or chemical growth methods in the past decades. These NWs have been applied to single electron devices, Field Effect Transistors, opto-electronics and nano-electronics applications. Tellurium (Te), and its product compound, Silver Telluride (Ag<sub>2</sub>Te), both being narrow band-gap semiconductors, are also very good candidates for these purposes. In the present work, a temperature dependent transport measurement on an array of Te and Ag<sub>2</sub>Te NW composites will be demonstrated.

Ultra-thin array of Te and Ag<sub>2</sub>Te NWs have been fabricated via chemical method on a cover slip (glass) substrate and formation of those NWs with a precise boundary between them has been confirmed by TEM imaging. We have investigated the electron transport in the array of Te NWs, array of Ag<sub>2</sub>Te NWs and the junction between them. The preliminary results show that the transport in Te NWs is thermally activated in high temperature (>170K) and in the low temperature (<170K), 2-d Mott Variable Range Hopping (VRH) takes place, where the carriers hop from one NW to another giving rise to an “inter-NW hopping”, in spite of the fact that the NWs are one dimensional. The Ag<sub>2</sub>Te NWs, on the other hand, show a predominant thermally activated transport behavior without any VRH. The activation energy comes out to be almost of the order of the band-gap itself, which shows that the carriers are thermally excited directly from the valence band to the conduction band, without coming from any impurity level in between.

Apart from the array, we will also demonstrate field effect study done on a single Te NW, patterned on a Si/SiO<sub>2</sub> substrate using electron beam lithography. This reveals the evidence of a Field Effect Transistor (FET) behavior in the Te NW with hole (p) type conduction.

## **Structural, electrical and optical characterization of InSe thin films**

**M. Teena<sup>a</sup>, R. Venkatesh<sup>b</sup>, N. Naresh<sup>b</sup>, A. G. Kunjomana<sup>a</sup>, K. Ramesh<sup>b</sup>**

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Indium selenide (InSe) is a potential absorber material in photovoltaic devices due to its fascinating physical characteristics. Its high absorption coefficient and optimum energy band gap are suitable for solar energy conversion. The preparation of stoichiometric InSe is limited due to the co-existence of many phases such as InSe, In<sub>2</sub>Se<sub>3</sub>, In<sub>4</sub>Se<sub>3</sub>, In<sub>5</sub>Se<sub>6</sub> etc. and the high vapour pressure difference between indium and selenium. In this work, stoichiometric compound of InSe was synthesized by fusing indium and selenium at 750°C in a pre-cleaned quartz ampoule sealed under a vacuum of  $\sim 10^{-6}$  mbar. Thin films of InSe were coated on to glass substrates at room temperature using thermal evaporation technique. The X-ray diffraction patterns of as-deposited and 200°C annealed samples showed amorphous nature, whereas films annealed at 300°C showed crystalline structure. Elemental analysis ensured high degree of stoichiometry of the compound, which existed as a single phase. The SEM and AFM images coherently indicate that, the size of crystallites increases up on increasing the annealing temperature. The electrical resistivity of the samples was subsequently decreased on annealing mainly due to the removal of structural defects. At higher annealing temperature, reduction in grain boundaries can also contribute to the reduction in the resistivity of the InSe thin films. The optical absorption measurements in the wavelength range 200–1100 nm shows that, the prepared InSe film has a direct band gap with a value of 1.87 eV. The successful preparation of single phase InSe films can facilitate the preparation of solar cell devices with superior physical properties.

# COLOURED PDMS MICROPILLAR ARRAYS FOR DROSOPHILA LARVA FORCE MEASUREMENT

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In humans as well as in other organisms we observe large variations in the ability to do mechanical tasks. For example a marathon runner may not be able to run as fast as a sprinter and vice versa. While both are runners, they might apply forces in a different way. Thus the study of muscular forces might be important in determining the underlying biological mechanisms of force generation. *Drosophila melanogaster* is a good model to study such processes because it is possible to mimic human muscle mutations in *Drosophila*. Moreover, the larval crawling in *Drosophila* is well defined and can be used to observe the effects of mutations that affect muscles. In this work, we demonstrate for the first time the measurement of forces generated by moving *Drosophila* larvae. Our device consists of a 2 dimensional array of coloured Polydimethyl Siloxane (PDMS) micropillars (50  $\mu\text{m}$  diameter and 120  $\mu\text{m}$  height) fabricated using soft lithography. Using our technique, the micropillars can be coloured selectively leaving the base of the pillars transparent. The larvae deflect the pillar tips as they move on the bed of micropillars. Bending stiffness of the pillars is calibrated using commercial micro Newton force sensor. The motion of larvae and pillar tips is video-recorded and analysed to convert the pillar tip deflections to the forces exerted on them. We analysed early third instar larvae ( $n = 10$ ) of two strains *Canton-S* (wild type) and *hdp*<sup>2</sup> (muscle mutant). Our results indicate that the tail region of wildtype larvae produced an average force of  $\sim 87 \mu\text{N}$  whereas the muscle mutant larvae produced a smaller force of  $\sim 73 \mu\text{N}$ . Thus our device can pick up and quantify the differences between the forces generated by *Drosophila* wildtype and mutant larvae.

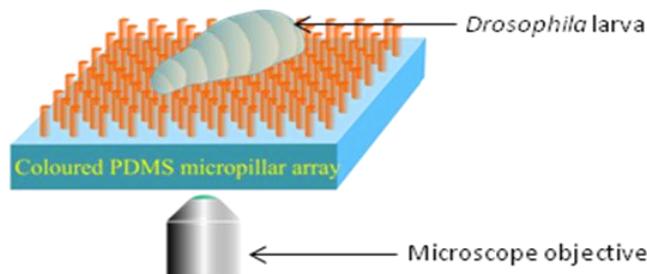


Figure 1: *Drosophila* larva moving on bed of Coloured PDMS micropillar device

## ACKNOWLEDGEMENTS

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# **Exchange Bias Studies on Single Ferrimagnetic Fe<sub>3</sub>O<sub>4</sub> Thin Films**

**Shwetha G. Bhat\* and P. S. Anil Kumar**

Department of Physics, Indian Institute of Science, Bangalore – 560012

Exchange bias effect in a combination of ferromagnet/anti-ferromagnet has been quite remarkable since its discovery from the application point of view. But the origin of exchange bias in Fe<sub>3</sub>O<sub>4</sub> film is still a puzzle to understand. Magnetization measurements on (100) and (111) oriented Fe<sub>3</sub>O<sub>4</sub> thin films on GaAs with and without MgO under-layer respectively, indicate the similar nature and origin of exchange bias with blocking temperature for both being ~ 200 K. Anti-phase boundaries in the (100) oriented Fe<sub>3</sub>O<sub>4</sub> is observed implying there could be changes in the magnetic exchange interactions in these boundaries. Similarly, (111) oriented thickness dependent magnetization studies on Fe<sub>3</sub>O<sub>4</sub> films indicate the same nature of exchange bias. As the thickness increases, we see that the exchange bias decreases which is consistent with the modulation of the density of anti-phase boundaries.

## **Ultra-low noise atomically patterned nanostructures in Si**

Saquib Shamim,<sup>1</sup> Bent Weber,<sup>2</sup> Michelle Y. Simmons,<sup>2</sup> and Arindam Ghosh<sup>1</sup>

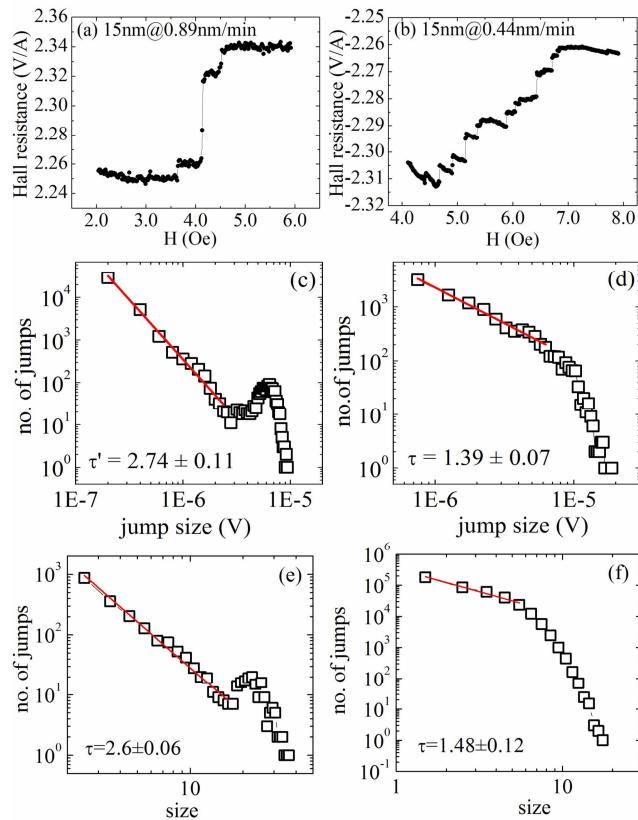
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Advancement in scanning tunnelling microscopy (STM) based lithography has made it possible to achieve low resistivity atomic scale wires and single donor quantum dot devices in silicon. Due to extreme sensitivity of these devices to any disorder or charge traps, it is of paramount importance to explore the noise magnitude in these systems and ways to reduce them. Here we investigate low frequency noise measurements in two STM patterned atomic scale wires of phosphorous dopants in Si of diameters 4.5 nm and 1.5 nm. The variation of noise with gate voltage indicates that the noise arises due to trapping-detrappling of electrons between the wire and charged traps. The Hooge parameter for these wires is  $10^{-4}$  to  $10^{-6}$  (for different gate voltages), which is one of the lowest reported for any one-dimensional system. The reason for such low noise magnitude can be two-fold. First, a complete monolithic fabrication procedure avoids any direct metallic contact to the one-dimensional system and hence prevents any Schottky barrier. Second possibility is that the Coulomb repulsion between the charges on traps doesn't allow many traps to be activated simultaneously. Aimed at being the backbone of silicon quantum computation scheme, a reduced noise in these devices is technologically crucial.

TITLE: Disorder induced critical phase transition in NiFe magnetization reversal  
 AUTHOR: Arnab Roy

Several models of Barkhausen noise have predicted that a disordered ferromagnetic system should undergo a critical phase transition in its magnetization reversal mode upon changing the disorder level [1,2,3]. Magnetization reversal below the critical disorder level  $R_C$  is characterized by the presence of a single large magnetization switching event, resulting in the reversal of a magnetic volume comparable to the sample size. Its magnitude decreases to zero  $R_C$ . We present here the first direct experimental demonstration of this disorder-induced phase transition in Permalloy ( $\text{Ni}_{80}\text{Fe}_{20}$ ) thin films. Permalloy Hall bars,  $100\mu\text{m}$  wide and  $15\text{nm}$  thick, were fabricated on  $\text{Si}(100)$  substrates by pulsed laser ablation and optical lithography. Disorder in the samples was controlled by varying the rate of deposition and its quantification was carried out by measuring the residual resistivity. It was seen that a faster deposition rate produces films with lower residual resistivity and consequently lower disorder (not shown). Planar Hall effect showed clear qualitative difference in the switching behaviour of two representative films deposited at  $0.89\text{nm/min}$  [Fig 1(a)] and  $0.44\text{nm/min}$  [Fig 1(b)]. A large Barkhausen jump was present for the former while it was clearly absent for the latter. Size distribution of Barkhausen jumps were similarly qualitatively different [Fig 1(c)] and [Fig 1(d)]. These observations are in remarkable agreement with our simulations of 2D Gaussian Random Field Ising Model [4,5] carried out below critical disorder [Fig 1(e)] and above critical disorder [Fig 1(f)]. Further consistency with the critical phase transition picture comes from temperature dependence of Barkhausen statistics (not shown). The subcritical sample had a monotonically increasing power-law exponent  $\tau$  whereas for the critical sample it was temperature independent.



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# Yielding behaviour and Creep dynamics in a tumbling nematic of worm-like micelles

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Recently there has been a lot of interest in understanding the yielding or long time creep flows in a wide range of yield stress fluids in soft matter systems where a solid to fluid transition occurs at a critical shear stress termed as the ‘yield stress’  $\sigma_y$ , in the increasing stress runs. Many of these studies have been confined to amorphous soft solids that exhibit a simple yield stress behaviour.<sup>[1]</sup> The objective of the present work<sup>[2]</sup> was to address creep flows in a nematic phase that exhibits a thixotropic yield stress behaviour by combining time resolved x-ray scattering studies with creep measurements. The creep experiments investigated the onset of flow both in polycrystalline and monodomain samples. In polycrystalline nematic phases, creep curves (see Figure) reveal an Andrade creep below the yield stress, where the shear rate decreases as a power law with time. Above the yield stress, a transient steady state of flow is followed by a gradual increase in shear rate with time. Rheo-SAXS investigations reveal that the onset of flow is related to the reorientation of domains in the direction flow as signified by the gradual increase in the bulk orientational order parameter  $\langle S \rangle$  with time. More significantly from creep measurements on monodomain samples, we can correlate the Andrade creep and the thixotropic yield stress behaviour with the decreasing orientational order of a tumbling nematic as the applied shear stress  $\sigma \rightarrow \sigma_y$ .

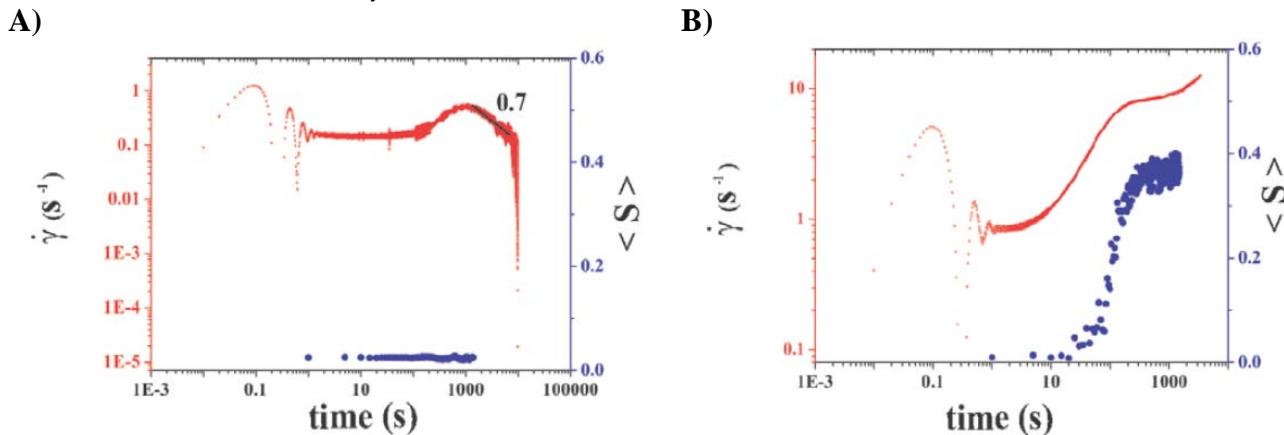


Figure : The temporal evolution of the shear rate (red filled circles) and mean orientational order parameter  $\langle S \rangle$  (blue circles) at shear stress = 20Pa (A), 80Pa (B)

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Presenting author – P.K. Bera

Abstract preference line: Poster presentation

## **Synthesis of bamboo like structured carbon nitride nanotubes**

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Carbon nitride ( $C_3N_4$ ) is predicted to be an ultrahard material with a hardness value comparable to that of Diamond. It also shows a combination of high hardness, wide band gap, and excellent thermal conductivity, wear resistance, etc. The carbon to nitrogen ratio in a stoichiometric carbon nitride should be 0.75 (carbon 43 % and nitrogen 57%). The bottleneck in the synthesis of the stoichiometric carbon nitride is the amount of nitrogen that can be incorporated into the structure. It has been generally, observed that the concentration of N in the prepared samples are about 30 - 40 % against the required 57 % irrespective of the preparation methods.

We have attempted to prepare carbon nitride thin films by chemical vapour deposition (CVD) using triazine ( $C_9H_{18}N_6$ ) as the precursor. The films deposited on to quartz and Si substrates were found to be amorphous in nature. The diameter of the prepared carbon nitride films is about 20 to 50 nm and the length is about 90  $\mu m$  with a bamboo like structure. The FTIR spectrum shows the presence of C-N, C=N, C-H and N-H bonds with more of C=N bond. Raman D and G peaks, are observed at  $1385\text{ cm}^{-1}$  and  $1605\text{ cm}^{-1}$  respectively. TEM images shows the bamboo like carbon nitride nanotubes. The length of the nanotubes are up to several micrometers long with a diameter of about 50 to 100 nm. The nanotubes were found to be the repetition of an elementary unit looking like nanobell, i.e., the nanotubes possess a very frequent and regular compartmentalized morphology. The hardness was found to be 11 GPa which is far below the expected hardness.

# **Thermoelectric properties of $Pb_{0.75-x}Mn_xSn_{0.25}Te$ alloys with variable manganese content**

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**Abstract:** Lead tin telluride is one of the well-established thermoelectric materials in the temperature range 350 – 750 K. In the present study,  $Pb_{0.75-x}Mn_xSn_{0.25}Te_{1.00}$  alloys with variable manganese (Mn) content were prepared by solid state synthesis and the thermoelectric properties were studied. X-ray diffraction (XRD) showed that the samples followed Vegard's law, indicating solid solution formation and substitution of Mn at the Pb site. Scanning Electron Microscopy (SEM) showed that the grain sizes varied from  $< 1\mu m$  to more than  $10 \mu m$  and MnTe rich phase was present for higher Mn content. Seebeck coefficient, electrical resistivity and thermal conductivity were measured from room temperature to 720 K. At 300 K, large Seebeck values were obtained, possibly due to increased effective mass on Mn doping and low carrier concentration of the samples. At higher temperatures, transition from n-type to p-type indicated the presence of thermally generated carriers. Temperature dependent electrical resistivity showed the transition from degenerate to non-degenerate behavior. For thermal conductivity, low values ( $\sim 1 \text{ W/m-K}$  at 300 K) were obtained. At higher temperatures bipolar conduction was observed, in agreement with the Seebeck and resistivity data. Due to low power factor, the maximum thermoelectric figure of merit ( $zT$ ) was limited to 0.23 at 329 K for the sample with lowest Mn content.

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## Fabrication of Graphene hBN heterostructures and 1/f noise set up

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Department of Physics Indian Institute of Science, Bangalore.

Last one decade Graphene research has been attractive because of its unique properties like two-dimensional structure with linear band and widely tunable carrier concentration by applying electric field. However, the mobility of graphene on Si/SiO<sub>2</sub> substrate has been limited due to the presence of charge in-homogeneity on substrate, which prevents to look at the physics near Dirac point. Recently, there have been attempts to transfer the graphene on insulating substrates like hexagonal boron nitride (hBN) and could achieve to enhance the mobility by ten to hundred times compared to Si/SiO<sub>2</sub> substrate. Here, we have carried out low-temperature transport experiments with fluctuation measurements at 77K on n-p-n/p-n-p geometry of a bi-layer graphene sandwiched between two thin hBN layers. In this report we present how the low-frequency fluctuations depend on carrier concentration as well as band gap opening in hBN-bi-layer-hBN device. Our measurements will help in understanding the source of low-frequency noise in graphene based devices.

# **Investigation of Lateral Photovoltaic Effect in lead Sulphide Colloidal Quantum Dots/Silicon heterojunction by light beam Induced Current Technique.**

**Atul Prakash Abhale and K. S. R. Koteswara Rao**

Department of physics, Indian institute of science - Bangalore.

In this work lead sulphide colloidal quantum dots and silicon (PbS-CQD/ Si) heterojunctions are studied under zero bias conditions, using remote contact light beam induced current (RC-LBIC) technique, which is widely utilised for photodetector array characterization. Here, photoresponse of the heterojunction is obtained by the spatial scanning of the focused laser beam at the contacts which are far away from the reach of minority carriers. For the PbS/n-Si system it is observed that, as a function of laser beam position, the RC-LBIC signal profile for a single device is unipolar in nature i.e. single device shows either positive or negative current, which goes to zero at the ends of the device. This is in contrast to the conventional observations, which is bipolar with zero signal magnitude at the centre of the device. In the PbS/p-Si system conventional bipolar profile is found to be retained. We have investigated this observation experimentally as well as by simulations. Simulation results are in agreement with the observed experimental RC-LBIC profiles both for PbS/p-Si and PbS/n-Si under the similar experimental parameters. In order to explain the entirely different response of the two similar systems, along with the conventional local lateral photovoltage model, majority carrier diffusion current model is proposed. Simulation results further predicts that, when carrier generation rate is increased by the few orders of magnitude PbS/n-Si RC-LBIC profile shifts to the conventional one, with gradual change for the intermediate generation rates. A presence of two different kinds of mechanisms in the same device under different experimental parameters, as well as in the analogues system of devices, will open a new insight to understand and utilise the information obtained by RC-LBIC.

# Pulsed Laser Deposition of exchange-biased metallic spin valves

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We report an appreciable in-plane-magneto-resistance of 1.04% in  $\text{Ni}_{80}\text{Fe}_{20}$ (8 nm)-/Co(4.5 nm)/Au(6 nm)/Co(5.5 nm)/ $\text{Fe}_{50}\text{Mn}_{50}$ (8 nm) exchange-biased metallic spin valves deposited in ultra high vacuum using pulsed laser deposition technique. An improved performance of 2.34% is observed with Cu replacing Au as spacer layer. This is attributed to band-matching of the spacer layer with ferromagnetic electrodes. The magnetic response, additionally characterised by magneto-optic Kerr effect, is found to be similar for devices on both Si(111) and  $\text{SiO}_2$  substrates. This is attributed to seed-layer effect of  $\text{Ni}_{80}\text{Fe}_{20}$ .

The general theme of a spin valve involves two ferromagnetic layers with different coercivities separated by a non-magnetic spacer layer. With application of external magnetic field, relative orientation of magnetizations of higher-coercivity hard layer and lower-coercivity soft-layer changes between parallel and anti-parallel configurations. This leads to a field-dependent resistance contrast between the configurations called magneto-resistance effect. This magnetic response is investigated using magneto-optic Kerr effect and magneto-resistance measurements. If the hard layer is pinned so as to restrict its switching, for example, due to exchange coupling with an anti ferromagnetic layer, we have an exchange-biased spin valve. Depending on whether the hard layer is pinned or not, we respectively get symmetric or asymmetric response with respect to applied magnetic field. We investigate exchange-biased spin valve effect in a system with permalloy( $\text{Ni}_{80}\text{Fe}_{20}$ ) as the soft layer, Cobalt(Co) as the hard layer, Gold(Au) as the spacer layer, and FerroManganese alloy( $\text{Fe}_{50}\text{Mn}_{50}$ ) as the antiferromagnetic layer to pin the hard layer using exchange coupling. Adding an interleaved Co layer to improve band-matching between  $\text{Ni}_{80}\text{Fe}_{20}$  and Au layer, we optimized the thicknesses for the various layers. The role of spacer layer is studied by replacing Au with Copper(Cu). The role of substrate is studied by comparing the response on Si(111) and  $\text{SiO}_2$  substrates.

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# Tunable Ultrafast Carrier relaxation and plasmon coupling in Graphene-plasmonic hybrid structure

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## Abstract

Graphene with nobel metal nanostructures exhibits a strong coupling to the plasmon modes and forms an interesting plasmonic system. Nonequilibrium carrier dynamics in graphene covered gold with array of 625nm diameter and 1μm periodicity holes is studied by ultrafast UV pump(3.1eV)/white light(1.2eV to 2.6eV) probe spectroscopy. Transient differential reflectivity signal shows a coherent transfer of energy between surface plasmon polariton (SPP) and excitons in graphene. We also demonstrate that an array of hole in a gold film reduces the electron phonon coupling thereby decreasing the relaxation rate via electron-phonon scattering of excited carriers. Moreover, relaxation rates of thermalized electrons in 6s band can be tuned back to that of a gold film by covering holed gold with graphene.

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# **Thermoelectric properties of Indium doped Cu<sub>2</sub>CdSnSe<sub>4</sub>**

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## **Abstract:**

Quaternary Cu based chalcogenide compounds are found interesting for studying thermoelectric properties due to their complex crystal structure which is responsible for the low thermal conductivity. In the present investigation, Indium doped quaternary chalcogenide compounds Cu<sub>2</sub>CdSn<sub>1-x</sub>In<sub>x</sub>Se<sub>4</sub> ( $0 \leq x \leq 0.1$ ) were prepared by melting and annealing. The Rietveld powder XRD (X-Ray Diffraction) pattern of all the samples revealed main phase corresponds to the stannite type crystal structure with *I-42m* as a space group. In addition to the main phase, a small amount of impurity phase CdSe present in all the samples. The homogeneity and phase purity of all the samples checked by EPMA (Electron Probe Micro Analysis) and the presence of impurity phases were also confirmed. A slight deviation from stoichiometry composition was also observed by EPMA. Transport properties of all samples measured in the temperature range between 300 K and 740 K. The positive Seebeck coefficient of all the samples in the entire temperature range indicating the holes are majority carriers. The combined effect of electrical resistivity and Seebeck coefficient resulted in the power factor value of  $4.5 \mu\text{W}/\text{cm}\cdot\text{K}^2$  at 740 K for the compound Cu<sub>2</sub>CdSn<sub>0.9</sub>In<sub>0.1</sub>Se<sub>4</sub>. Thermal conductivity of all the samples decreased with increase of temperature due to the dominance of Umklapp phonon scattering at higher temperatures. The maximum thermoelectric figure of merit  $zT=0.36$  at 740 K is obtained for the compound Cu<sub>2</sub>CdSn<sub>0.9</sub>In<sub>0.1</sub>Se<sub>4</sub> is mainly due to the large power factor and reasonably low thermal conductivity.

# Large Drag reduction and Anomalous Hydrodynamic interactions of Soft Colloid in Polymer Melts

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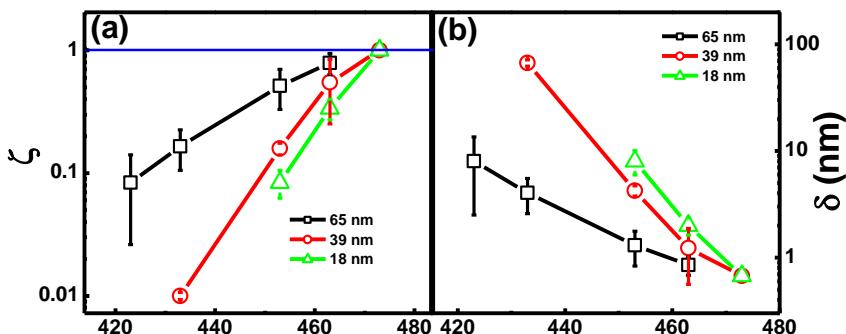
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Here we report unusually large reduction of effective drag experienced by soft colloids- polymer grafted gold nanoparticle, moving through a highly viscous and confined polymer, well above its glass transition temperature in a thin polymer nanocomposite film. The extent of drag reduction increases with decreasing temperature [1] and polymer film thickness. Figure below provides the effective drag with temperature for the films with different thicknesses (Fig. a) and corresponding approximate hydrodynamic slip length (Fig. b) at the colloid-polymer interface [1]. While in polymer melts hydrodynamic interactions are known to be screened [2], we observe the corresponding hydrodynamic interaction functions showing anomalous wave vector dependence with a power law exponent of  $\sim 2$  for the thinnest film [3]. We present the possibility of tuning the hydrodynamic slip length at the colloid-polymer interface with temperature and confinement for polymer nanocomposite films [4].



Renormalized hydrodynamic drag,  $\zeta$ , vs temperature (a) and approximate slip length,  $\delta$ , (b) for the films of thicknesses 65, 39 and 18nm

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# Noise in High-mobility Graphene Transistors: Contacts vs Bulk

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Noise provides a deep insight into the microscopic details of disorder in a system. Noise is also a versatile tool to assess the electronic quality of transistors. Here we report noise measurements on high-mobility graphene transistors. The evolution of noise as the device mobility increases provides an insight into the contribution to the noise from the contacts and the microscopic mechanism responsible. In literature, there have been conflicting reports on whether the major contribution to noise is from the contacts or the bulk. The consensus on the microscopic mechanism of noise, often modeled by substrate traps or the adsorbed impurities, is also lacking. High-mobility graphene has a clean bulk and offers an ideal platform to investigate these issues.

We report noise measurements on a number of devices with a large mobility range by utilizing various substrates and device geometries. These reveal that the variance in resistance time series ( $S_V$ ) goes as the fourth power of contact resistance ( $R_c$ ). In fact, we present a model of current injection in 2D materials which also reveals that  $S_V \propto R_c^4$ . This suggests that here noise is dominated by the contacts. We also show how certain device structures, fabrication techniques can suppress the noise.

# Fermi-Edge Transmission Resonance in Graphene Driven by a Single Coulomb Impurity

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The interaction between the Fermi sea of conduction electrons and a nonadiabatic attractive impurity potential can lead to a power-law divergence in the tunneling probability of charge through the impurity. The resulting effect, known as the Fermi edge singularity (FES), constitutes one of the most fundamental many-body phenomena in quantum solid state physics. Here we report the first observation of FES for Dirac fermions in graphene driven by isolated Coulomb impurities in the conduction channel. In high-mobility graphene devices on hexagonal boron nitride substrates, the FES manifests in abrupt changes in conductance with a large magnitude  $\approx e^2/h$  at resonance, indicating total many-body screening of a local Coulomb impurity with fluctuating charge occupancy. Furthermore, we exploit the extreme sensitivity of graphene to individual Coulomb impurities and demonstrate a new defect-spectroscopy tool to investigate strongly correlated phases in graphene in the quantum Hall regime.

Paritosh Karnatak, Srijit Goswami, Vidya Kochat, Atindra Nath Pal, and Arindam Ghosh, Phys. Rev. Lett. **113**, 026601 (2014).

Presentation title: Estimation of Magnetic Gradients using Photospheric and Chromospheric Magnetic Measurement

Presentation abstract: Magnetic field measurements at two different heights is an area of current interest in order to understand the magnetic gradients of active regions. Such measurements provide a valuable information on the nature of the magnetic field (potential vs non-potential) and constrain the existing extrapolation models. Such measurements techniques are feasible currently with the new instrumentation and analysis techniques. We present one such measurement carried out with the IBIS and FIRS instruments at the Dunn Solar Telescope, National Solar Observatory, Sunspot. A sunspot was observed using these two instruments in polarimetry mode. While FIRS was used with the Photospheric FeI 630.2nm line, IBIS was observing the Chromospheric 854.2nm line. The LOS magnetic field estimates from these two instruments were combined to arrive at the magnetic field gradients of this active region. The results for this active region will be presented along with the potential use of this method for solar atmospheric magnetic diagnostics.

# **Observation of transient superconductivity at LaAlO<sub>3</sub>-SrTiO<sub>3</sub>interface**

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## **Abstract**

The two dimensional electron gas (2DEG) formed at the interface of two insulators LaAlO<sub>3</sub> and SrTiO<sub>3</sub> due to electronic reconstruction. The coexistence of superconductivity and ferromagnetism in the conducting quasi two-dimensional electron gas formed at oxide interface has raised hopes of observing novel phenomenon not seen in conventional semiconductor devices. In this article, we report the observation of magnetic-field assisted transient superconducting state at the interface of LaAlO<sub>3</sub> and SrTiO<sub>3</sub> at 245 mK.

We have studied in detail the magnetoresistance of a 10 unit cell device at different values of back gate voltage V<sub>g</sub>. The device has superconducting ground state at very low temperatures whose critical temperature can be modulated by using back gate voltage V<sub>g</sub>. We observe that the magnetoresistance at 245 mK has a field sweep rate dependent hysteresis in the field range 0 T to 2 T. The hysteresis is largest at large negative V<sub>g</sub> (low carrier densities) and decreases as V<sub>g</sub> is made increasingly positive. At the highest positive V<sub>g</sub> (high carrier density) the hysteresis in magnetoresistance gives way to a transient superconductivity that decays to the normal state over a time period of a 10 seconds. The transient superconducting state appears concomitantly with a Lifshitz transition in the system as a consequence of the interplay between ferromagnetism and superconductivity and the finite relaxation time of in-plane magnetization.

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# **Core-shell nanostructured Bismuth telluride/Cadmium telluride based composite for efficient photovoltaic cells**

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A solar cell based on  $\text{Bi}_2\text{Te}_3/\text{CdTe}$  core shell composite anode is synthesized by wet chemical method.  $\text{CdTe}$  is photovoltaic (PV) material and  $\text{Bi}_2\text{Te}_3$  is thermoelectric material (TE). In a PV cell, the short wavelength of the solar radiation is (200 - 800 nm).The combination of  $\text{CdTe}$  and  $\text{Bi}_2\text{Te}_3$  can maximize the energy conversion efficiency as it can cover both the short and long wavelength of solar radiation. The results of X-ray diffraction and high-resolution transmission electron microscopy revealed that the as-prepared  $\text{Bi}_2\text{Te}_3/\text{CdTe}$  in a core/shell structure with high crystallinity. The efficiency of the thin film solar cell based on the core shell  $\text{Bi}_2\text{Te}_3/\text{CdTe}$  at room temperature is about 2% and when exposed to sunlight, bismuth telluride plays a role to convert heat energy to electricity and an efficient photo catalyst, which results in 4.5% of overall power conversion efficiency.