ABSTRACT BOOK

not abstract though …….

4th PRL CCMP
PRL Conference on Condensed Matter Physics 2023

Physical Research Laboratory, Navrangpura, Ahmedabad

6 - 8 February 2023

Keynote Talk: 1

Non-abelian anyons : From Majoranas to parafermions

Sumathi Rao

International Centre for Theoretical Science, Bengaluru, Karnataka

Abstract: We will start with an introduction to non-abelian anyons and their relevance to topological quantum computation. Then we will discuss Majorana modes and the current status of the search for Majoranas and briefly describe our recent proposal to look for them in a quantum spin Hall insulator. We will then go on to discuss further generalizations of non-abelian anyons such as parafermions ending with a brief discussion of some of our recent work on the parafermion Josephson effect.

Keynote Talk: 2

Why are twisted bilayers different from their untwisted counterparts?

Priya Mahadevan

Department of Condensed Matter Physics and Material Science, S.N. Bose National Centre for Basic Sciences, Kolkata, India

Abstract: The Mo and W based transition metal dichalcogenides have been known for several decades as examples of semiconductors whose electronic structure is well described by band theory. It is only recently that one finds unusual phenomena arising in them on doping holes via gating into twisted bilayers [1], an aspect that we would associate with correlated materials. We have recently examined the electronic structure of twisted bilayers of Mo [2] and W [3] based transition metal dichalcogenides. In contrast to graphene, we find the emergence of flat bands for several angles of rotation. The origin of this can be linked to patches of various types of stackings which include an atom-on-atom as well as a staggered stacking. The former lead to larger inter-layer separations because of the larger repulsion between the electrons in the two layers in contrast to the latter. This leads to larger perturbations in some regions of the moire cell. Building on the fact that these materials represent van der Waals structures, and so the perturbation induced by one layer on the other should be small, we explore different twist angles and quantify the perturbation in each instance from the untwisted limit. Surprisingly, at large twist angles we find that we recover the low energy electronic structure of the untwisted limit, while at small angles we find flat band formation as well as other unusual aspects of the electronic structure.

References:

[1]. L. Wang et al., Nat. Mat. 19, 861 (2020).
[2]. Sumanti Patra, Poonam Kumari and Priya Mahadevan, Phys. Rev B 102, 205415 (2020).
[3]. Sumanti Patra, Prasun Boyal and Priya Mahadevan, Phys. Rev. B 107, L041104 (2023).

Keynote Talk: 3

Probing new phases in twisted bilayer graphene with thermoelectricity

Arindam Ghosh

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Abstract: When two layers of atomically thin lattices are made to come within van der Waals distance, thereby forming a moire lattice, electronic proerties properties of the composite are dramatically modified from their individual counterparts. The angular mismatch between the individual lattices, or the twist angle, then becomes a knob to explore the rich phase space of fundamental interaction and functionality. Twisted bilayer of graphene (tBLG) is one such emerging platform where plethora of new phases, ranging from superconductivity, Mott insulating phase, to ferromagnetism etc, have been observed, and often attributed to strong Coulomb interaction that can become very high at certain twist angles (the 'magic angle'). Strong Coulomb interaction also raises several questions which remain unanswered, for example, nature of quasi-particles, the validity of the Fermi liquid theory, to the possibility of new broken symmetry phases. In this talk, I shall discuss a few such questions and explain how such phases can be explored with novel experimental techniques. Specifically, I shall show how electrical and thermoelectric transport can be used probe novel effects of Coulomb interaction in precisely engineered moire superlattices of graphene.

Keynote Talk: 4

Title: TBA

Pratap Raychaudhuri

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Abstract: TBA

Theoretical Physics Colloquium at KRR Auditorium on the 6th February

Measuring Entanglement in Electronic Interferometers

Yuval Gefen

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Abstract: This talk will rely on two fundamental themes of quantum physics: the statistics of identical particles, and entanglement. The former was thrust into the limelight, given the theoretical and experimental search for anyonic (fractional) statistics. The latter is a pillar of quantum mechanics: quantum entanglement prevents us from obtaining a full independent knowledge of a subsystem. Can one, theoretically and experimentally, focus on and isolate statistics-induced entanglement? Here I will address this question, addressing the case of fermions.

Conference Evening Talk at KRR Auditorium on the 6th February

Air Pollution and Climate Change: Challenges

S. Ramachandran

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Abstract: Air pollution refers to the contamination of air that we breathe, irrespective of indoors or outside. Aphysical, biological or chemical alteration to the air in the atmosphere can be termed as pollution. It occurs when any harmful gas, dust, and smoke enter into the atmosphere from industrial, vehicular and urban emissions, and makes it difficult for plants, animals and humans to survive as the air becomes dirty. The introduction of particulate matter, biological molecules, or other harmful materials into Earth's atmosphere, to sufficiently high concentrations can cause allergies and diseases to humans, damage to animals and food crops, ecosystems, monuments and art works. Air pollution can influence air quality and climate on local, regional and global scales. Although the pollutants are more concentrated near source regions where they are produced, they can get transported to other regions due to prevailing/changes in the mean atmospheric circulation patterns and can have global impact. Our present knowledge on air pollution, aerosols, challenges involved in their characterization, insights gained in attributing the impact of aerosols on climate and climate change and the associated uncertainties will be discussed.

Invited Talk: 1

Quantum dots and Stone Wale Topological Defects in Graphene

Shikha Varma

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Abstract: We discuss the tuning of the photo-response and electronic behavior of graphene quantum dots (GQDs), obtained through variations in the ion irradiation process of monolayer graphene. The results display a method that can be useful in designing GQD based photodetectors without incorporation of any metal-nanoparticles. We also discuss observation of topological Stone Wale defects in graphene and their rich vibrational behavior.

Invited Talk: 2

Electronic transport and Planar Hall effect in Dirac semimetal $PdTe_2$

C. S. Yadav

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Abstract: The dichalcogenides of group 10 transition metal (Ni, Pd, Pt) are at the forefront of research activities owing to their exotic properties: topological surface states, Dirac fermions, superconductivity, charge density wave etc.[1] $PdTe_2$ is known to exhibit topological type II Dirac semimetallic properties along with the superconductivity (T_c=1.7 K). [2,3] Its intercalation with copper lead to enhancement in the Tc to 2.5 K, with BCS like gap Δ_0 of 0.33 meV, leading to $2\Delta_0/k_BT_C \sim 4.25$. [4] Recently, there have been observation of the planar Hall effect (PHE) in topological semimetals, which is generally attributed to the chiral anomaly. However, the coexistence of chiral anomaly and orbital magnetoresistance (MR) has complicated the understanding of the PHE. $PdTe_2$ shows a positive longitudinal magnetoresistance (MR), with the signature of chiral anomaly and orbital MR in the transport properties. We probed the PHE in the Cu and Ag intercalated $PdTe_2$ systems and observed a positive longitudinal MR, linear field dependence of the amplitude of PHE, and the tilted prolate shaped orbits in parametric plot.[5,6] Our results point toward the importance of Fermi surface anisotropies in understanding the origin of PHE in these systems. Moreover, chiral anomaly cannot be used as a probe to identify PHE in such systems, as it requires a negative longitudinal MR.

References:

[1] M.K. Hooda, C. S. Yadav, D. Samal; J. Phys: Cond Matt. 33, 103001 (2021).
[2] M.K. Hooda, C.S.Yadav; EPL 121, 17001 (2018).
[3] H.Yang, M.K.Hooda, C.S.Yadav, D.Hrabovsky, A.Gauzzi, Y.Klien; Phys. Rev. B 103, 235105 (2021).
[4] A.Vasdev, A. Shirohi, M.K.Hooda, C.S.Yadav, G.Sheet; J. Phys: Cond Matt. 32 125701 (2020).
[5] Sonika, M.K. Hooda, Shailja Sharma, and C.S. Yadav; Appl. Phys Lett. 119, 261904 (2021).
[6] Sonika, Sunil Gangwar, Pankaj Kumar, C.S.Yadav (to be published).

Invited Talk: 3

Tunable interband and non-reciprocal plasmons in moire systems

Amit Agarwal

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Abstract: Flat bands in twisted moire superlattices support a variety of topological and strongly correlated phenomena along with easily tunable electrical and optical properties. Here, we demonstrate the existence of tunable, long-lived, and flat intraband and interband terahertz plasmons in twisted double bilayer graphene. We show that the interband plasmons originate from the presence of a Van Hove singularity in the joint density of states and a finite Berry connection between the pair of bands involved. We demonstrate that the undamped and flat plasmon modes in moire systems are highly tunable and can be controlled by varying the vertical electric field and electron doping, and they persist over a wide range of twist angles.

Next, we explore intrinsic nonreciprocity in bulk plasmon propagation based on underlying symmetries. We demonstrate that the interband, as well as the intraband bulk plasmon modes, follow asymmetric dispersion with broken inversion and time-reversal symmetry. We show that the nonreciprocity in the interband plasmon dispersion is dictated by the quantum metric connection, which is a band geometric quantity. We demonstrate the existence of intrinsic nonreciprocal intraband and interband plasmon modes in moire systems such as twisted bilayer graphene.

Invited Talk: 4

Effect of strain on transition metal dichalcogenides: Experimental investigations at high pressures

Goutam Dev Mukherjee

Indian Institute of Science Education and Research, Kolkata

Abstract: 2D transition metal dichalcogenides (TMDs) are layered compounds, which have great technological potential in opto-electronic materials, data storage devices, sensors, spintronics materials etc. For understanding fundamental aspects of strong electron correlations, TMDs are ideal materials due to their diverse physical properties like strong spin orbit coupling, charge density wave, superconductivity and Kondo effect. TMDs stabilize in different structures and are associated with different stacking order, with most common polymorphs, trigonal (1T), hexagonal (2H) and rhombohedral (3R) phases. Different morphologies lead to distinct electronic behavior, ranging from insulators, semiconductors, semimetal and even superconductors. Pressure is a very effective physical parameter which can tune the electronic behavior of TMDs by modifying their crystal structure in a controlled way. In this talk, I shall discuss the experimental aspect of generation of high pressure in the laboratory and then use it to study the effect of compression on the changes in the fundamental properties.

Invited Talk: 5

Topological and ordered phases in Di-Chalcogenide materials $NbSe_2$ and monolayer 1T'-Wte_2

Shantanu Mukherjee

Department of Physics, Indian Institute Technology, Madras

Abstract: Transition metal di-chalcogenides show a rich variety in their electronic structure and low temperature ordered phases. The material NbSe 2 shows charge density wave transition and a low temperature superconducting state. The monolayer quantum spin Hall insulator 1T'-WTe 2 shows nontrivial edge state physics including the observation of a helical Tomonaga Luttinger liquid at the 1D edge states. We will discuss the low temperature phase of 2H-NbSe 2 and 1T'-WTe 2 including some problems of current interest in these material systems.

Invited Talk: 6

Nonlinear Transport/optical effects via quantum geometric quantities

Pankaj Bhalla

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Abstract: The nonlinear responses are actively studied as probes of topology and band geometric properties of solids. To deal with it, we devise a quantum kinetic theory that can be applied to materials with arbitrary band structures and captures intraband and interband coherence effects, finite Fermi surfaces, and disorder effects. In this talk, we will discuss how the optical/transport properties serve as a probe of the Berry curvature, quantum metric, and quantum geometric connection. As illustrations, we discuss the cases of time reversal symmetric Weyl semimetal WTe2 and the parity-time reversal symmetric topological antiferromagnet CuMnAs.

Invited Talk: 7

Electrical switching of metallic antiferromagnet/non-magnet heterostructure

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Abstract: Utilization of antiferromagnets (AFMs) as multifunctional components has opened new directions for next-generation low-power spintronic devices [1]. A major roadblock concerns electrical recording of information in AFMs without auxiliary ferromagnets. Previous investigations demonstrated the utilization of Néel spin-orbit torques (SOTs) [2] and/or interfacial SOTs in AFM-insulator/heavy metal (HM) [3] as aviable route for electrical manipulation. The realization of AFM devices using these materials is, however, limited by material choice and epitaxial structure constraints. Here, we demonstrate electrical writing in polycrystalline metallic AFM/HM sub./buffer/PtMn(10)/Pt(5)/Ru(1) (in nm) structures by spin-orbit torques. Electrical writing is achieved by sourcing pulsed currents along orthogonal directions, while read-out was achieved by using inverse spin-Hall effect [4]. A combination of electrical measurements with X-ray magnetic imaging on identical structures shows reorientation of antiferromagnetic Néel vector under the application of current pulses. Our experimental results demonstrate the prospect of metallic AFMs for next generation antiferromagnetic spintronic architectures [5].

References:

[1] V. Baltz et al., Rev. Mod. Phys. 90, 015005 (2018).

[2] P. Wadley et al., Science 351, 587 (2016). [3] T. Moriyama et al., Sci. Rep. 8, 14167 (2018)

[4] S. DuttaGupta et al., Appl. Phys. Lett. 113, 202404 (2018).

[5] S. DuttaGupta et al., Nature Communications 11, 5715 (2020).

Invited Talk: 8

Higher-Order Topological Superconductors: Statics and Dynamics

Arijit Saha

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Abstract: Non-equilibrium aspects of topological phases have attracted a great deal of attention in the community as the driven topological systems exhibit non-trivial properties which are absent in the corresponding static phase. The Floquet machinery allows one to keep track of the time-dependent problem of periodically driven systems in a time-independent way with an effective Floquet Hamiltonian, defined in the frequency space. Interestingly, Floquet engineering by suitably tuning appropriate perturbation can lead to Floquet Higher Order Topological Insulator (FHOTI) and Superconducting (FHOTSC) phases starting from a lower order or non-topological phases. In this talk, I shall discuss different driving protocols (three step periodic drive and time-periodic sinusoidal drive) to engineer two-dimensional (2D) Floquet quadrupole superconductors and three-dimensional (3D) Floquet octupole superconductors hosting both regular 0- and anomalous p-Majorana corner modes (MCMs), based on unconventional d-wave superconductivity. Interestingly, the p-MCMs don't have any static analogue. We employ the periodized evolution operator to construct the dynamical invariants, namely quadrupolar and octupolar motion in 2D and 3D respectively, that can topologically characterize the 0- and anomalous p-MCMs separately. We study the local density spectra and the time evolution of MCMs in the presence of time-periodic sinusoidal drive. Furthermore, we employ the Floquet perturbation theory (FPT) in the strong driving amplitude limit and emphasize that the agreement between exact numerical and the FPT results are more prominent in the higher frequency regime as far as 0-MCMs are concerned. Our study paves the way for the realization of dynamical quadrupolar and octupolar topological superconductors.

References:

[1] Phys. Rev. B, XX, XX (2023) (in press) arXiv: 2208.05749 [cond-mat].

[2] Phys. Rev. B 105, 155406 (2022); arXiv: 2201.07578 [cond-mat].

Invited Talk: 9

Quantum oscillations in the magnetization and density of states of insulators

Sumilan Banerjee

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Abstract: The Fermi surface, the defining characteristic of metals, leads to oscillatory behavior of various observables as a function of the inverse of the magnetic field. It was thus a great surprise when such oscillations were seen in insulators without any Fermi surface, like in Kondo insulators and semiconductor quantum wells. I will discuss a general theory of quantum oscillations in insulators, focusing on a minimal model of an insulator with a hybridization gap. I will show that, in striking contrast to metals, the oscillation frequency for magnetization differs from observables like resistivity, which depend on the low-energy density of states of electronic excitations. To complement our detailed analysis of their frequency, phase, and temperature-dependent amplitude, I will present a simple physical picture for understanding why quantum oscillations occur in insulators and why they differ in significant ways from the well-understood metallic case.

Invited Talk: 10

Very high energy collective modes of partons in fractional quantum Hall fluids

Ajit C Balram

The Institute of Mathematical Sciences, Chennai, India

Abstract: The low-energy physics of fractional quantum Hall (FQH) states—a paradigm of strongly correlated topological phases of matter—to a large extent is captured by weakly interacting quasiparticles known as composite fermions. In this talk, I will demonstrate that some *high-energy* states in the FQH spectra necessitate a different description based on *parton* quasiparticles. The Jain states at filling factor $\nu = n/(2pn\pm1)$ with integers n, $p\geq2$ support two kinds of collective modes: In addition to the well-known Girvin-MacDonald-Platzman (GMP) mode, they host a high-energy collective mode, which we interpret as the GMP mode of partons. I will elucidate observable signatures of the parton mode in the dynamics following a geometric quench. I will also present a microscopic wave function for the parton mode and demonstrate agreement between its variational energy and exact diagonalization. These results point to partons being "real" quasiparticles which, in a way reminiscent of quarks, become observable only at sufficiently high energies.

Invited Talk: 11

Non-Kramers Quantum Spin-Ice

Subhro Bhattacherjee

Department of Physics, Indian Institute Technology, Mandi

Abstract: In this talk, I shall discuss recent developments in realizing a U(1) quantum spin liquid in non-Kramers pyrochlore magnets such as $Pr_2Zr_2O_7$ aided by spin-lattice coupling facilitated by novel implementation of Time reversal symmetry. I shall also discuss possible ways of detecting them via spectroscopy experiments and associated other novel magnetic phases relevant to such systems.

Invited Talk: 12

Floquet engineering of solid-state systems: An algebraic approach

Jayendra Nath Bandyopadhyay

Department of Physics, Birla Institute of Technology and Science, Pilani, Rajasthan

Abstract: The control of diverse features of quantum systems by external periodic driving is a well studied concept. The key idea behind this approach is to drive a given system out of its equilibrium state and then find a non-equilibrium steady state where the system behavior is fundamentally different from the original system. Traditionally, Floquet theory is used to study various effects of periodic driving on any quantum systems. Therefore, this technique of inducing synthetic phase in a given material is known as *Floquet engineering*. In this talk, we shall introduce the basics of Floquet engineering, particularly in the context of designing solid state systems with desired properties. In the remaining part of the talk, we shall discuss our recent work [JNB and J. Thingna, Phys. Rev. B **105**, L020301 (2022)], where we exploited the underlying Lie algebraic structure of the given system to design Floquet engineering protocol.

Invited Talk: 13

Spintronics in antiferromagnetic helix

<u>Santanu K. Maiti</u>

Physics and Applied Mathematics Unit, Indian Statistical Institute, 203 Barrackpore Trunk Road, Kolkata-700 108, India

<u>Abstract:</u> We report spin filtration operation considering an antiferromagnetic helix, possessing zero net magnetization. Geometrical conformation plays an important role in spin-channel sepa-ration, and here we critically investigate the effects of short-range and long-range hoppings of electrons in presence of a transverse electric field. We find that the filtration performance gets improved with increasing the range of hopping of electrons. Moreover, the phase of spin polarization can be altered selectively by changing the strength and direction of the electric field, and also by regulating the physical parameters that describe the antiferromagnetic helix. Finally, we explore the specific role of dephasing. Our analysis may provide a route of getting conformation-dependent spin polarization possessing longer range hopping of electrons, and can be generalized further to different kinds of other fascinating antiferromagnetic systems.

Invited Talk: 14

Quantum phases of dipolar bosons in a multilayer optical lattice

Angom Dilip Kumar Singh

Manipur University, Manipur, India

Abstract: We consider a minimal model to investigate the quantum phases of dipolar atoms in multilayer optical lattices. The model is a variant of the Bose-Hubbard model, which incorporates nearest neighbor intralayer repulsion and interlayer attraction. Different quantum phases of this model emerge from the competition between the attractive interlayer interaction and the interlayer hopping. Our results from the analytical and cluster-Gutzwiller mean-field theories reveal formation of multimer in the regime of weak intra- and interlayer hopping due to the attractive interaction. At higher interlayer hopping, the multimers are destabilized to form resonating valence-bond-like states.

Invited Talk: 15

Oceans of water deep in the Earth's mantle

Swastika Chatterjee

Dept. of Earth Sciences, Indian Institute of Science Education and Research, Kolkata

Abstract: The mantle transition zone (MTZ), lying at the depth of 410-660 km inside the earth, is widely accepted as a potential water reservoir in the Earth's interior. The two dominant mineral phases in the MTZ, namely, wadsleyite and ringwoodite can store up to 3wt% water in their crystal structure in the form of hydroxyl ions. Using first principles density functional theory, we study the water incorporation mechanism in wadsleyite under mantle transition zone conditions. Our calculations find that in general pressure suppresses the P and S wave 'velocity-reduction' that is caused by hydration. However, the suppression is not significant in the case of wadsleyite. So it is very unlikely that the pressure suppression will severely affect the accuracy of seismic waves in detecting the water content of the upper part of mantle transition zone, where wadsleyite is stable. Comparison of our theoretical results with the existing seismic data indicates that the water content of the transition zone decreases with increasing depth, with the region close to the 410 km discontinuity being saturated in water, thereby supporting previously proposed theories on mantle convection.

Contributed Talk: 1

Unconventional emergent Hall effect phenomena and its modification in a van der Waals ferromagnet Fe_3GeTe_2

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Abstract: Magnetism in two-dimensional (2D) van der Waals (vdW) materials has emerged as a new paradigm enunciating new condensed matter phenomena, bearing potential for application in future spintronic and quantum computing devices [1]. Among 2D vdW ferromagnets (FMs), metallic Fe_3GeTe_2 (FGT) is interesting owing to high Curie temperature, uniaxial magnetic anisotropy, and unusual magnetic ground state. Here, we clarify the underlying physics responsible for nontrivial ground state and demonstrate tuning of emergent properties by substitution at magnetic (Fe) or nonmagnetic (Ge) site in 2D vdW FGT. High quality single-crystalline FGT, $(Fe_{1-x}Co_x)_3GeTe_2$, $Fe_3(Ge_{1-x}As_x)Te_2$ ($0 \leq x \leq 0.55$) were grown by chemical vapor transport method. Magnetotransport measurements under H || c-axis result in sizeable anomalous Hall effect, arising from topological nodal lines in the band structure, whereas transverse resistivity under H $\perp$ c-axis result in unconventional magnetoresistive behavior with prominent cusp-like feature [2]. Separation of magnetoresistive responses indicates dominant unconventional emergent Hall effect [2], tunable with magnetic or non-magnetic doping. Our results clarify the underlying factors responsible for stabilization of non-trivial spin texture magnetic ground state in a 2D vdW FM.

References:

[1] B. Huang et al., Nature 546, 270 (2017).
[2] R. Roy Chowdhury et al., Sci. Rep. 11, 14121 (2021).

Contributed Talk: 2

Quantum Materials beyond the realms of Gross-Pitaevskii Equation

<u>Ayan Khan</u>

Department of Physics, SEAS, Bennett University

Abstract: Recent observations of liquid-like state in ultra-cold bosonic systems have opened up exciting prospects to study quantum many-body theory. The well established theoretical description of ultra-cold Bosonic systems relies heavily on the Gross-Pitaevskii (GP) equation where the particle interaction is modeled via mean-field theory. However, it is understood that the beyond mean-field effect plays a crucial role in stabilizing the newly emerged liquid-like state. Off late, we have reported the first analytical solution for these droplets in quasi one-dimensional homogeneous binary Bose-Einstein condensate (BEC). Here, we demonstrate the possibility of obtaining a density wave like solution and elaborate on the competing interactions. We extend our analysis to one-dimensional systems as well. The investigation also opens up the possibility to shed light on the newly observed super-solid phase.

Contributed Talk: 3

Quench dynamics of Ultracold gases

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Abstract: Ultracold atoms in optical lattices are excellent proxies for studying various quantum mechanical phenomena in condensed matter systems. Here we explore the non-equilibrium aspects of such systems under a quantum quench across the quantum phase transition between the Mott insulator and superfluid phases of the system described by the Bose-Hubbard model[1]. The quenched state in the superfluid regime is populated with topological defects (vortices) due to the U(1) symmetry breaking at the phase transition. The Kibble-Zurek (KZ) mechanism predicts universal scaling relations for the defect density in terms of equilibrium scaling exponents[2]. Our study investigates the KZ scaling laws using single-site Gutzwiller mean-field and cluster Gutzwiller mean-field methods.

References:

[1] D. Jaksch, C. Bruder, J. I. Cirac, C. W. Gardiner, and P. Zoller, “Cold bosonic atoms in optical lattices,” Phys. Rev. Lett. 81, 3108 (1998)
[2] Wojciech H. Zurek, Uwe Dorner, and Peter Zoller, “Dynamics of a quantum phase transition,” Phys. Rev.Lett. 95, 105701 (2005)

Contributed Talk: 4

Su-Schrieffer-Hegger (SSH) model with non-orientable bulk: Union of topology and flat bands

Bharathiganesh Devanarayanan

Theoretical Physics Division, Physical Reserach Laboratory, Ahmedabad and Indian Institute of Technology Gandhinagar.

Abstract: The Su-Schrieffer-Hegger (SSH) model is one of the simplest yet complete model for understanding topological properties of matter. On the other hand there have not been many investigations on the impact of orientability of space over which the Hamiltonian is defined on its topological properties. In this talk we will introduce an extension of the SSH model called the SSH model with any bulk (SAB) and through this model study a system with a non-orientable bulk. We observe that the system is topologically non-trivial and has a doubly degenerate flat band at the Fermi energy.

Poster Number: 1

Non-Hermitian higher-order topological superconductors in two-dimensions: Statics and dynamics

Arnob Kumar Ghosh*, **Tanay Nag****

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***Department of Physics and Astronomy, Uppsala University, Box 516, 75120 Uppsala, Sweden*

Abstract: Being motivated by intriguing phenomena such as the breakdown of conventional bulk boundary correspondence and the emergence of skin modes in the context of non-Hermitian (NH) topological insulators, we here propose an NH second-order topological superconductor (SOTSC) model that hosts Majorana zero modes (MZMs). Employing the non-Bloch form of NH Hamiltonian, we topologically characterize the above modes by biorthogonal nested polarization and resolve the apparent breakdown of the bulk boundary correspondence. Unlike the Hermitian SOTSC, we notice that the MZMs inhabit only one corner out of four in the two-dimensional NH SOTSC. Such localization profile of MZMs is protected by mirror rotation symmetry and remains robust under on-site random disorder. We extend the static MZMs into the realm of Floquet drive. We find anomalous π-mode following low-frequency mass-kick in addition to the regular 0-mode that is usually engineered in a high-frequency regime. We further characterize the regular 0-mode with biorthogonal Floquet nested polarization. Our proposal is not limited to the *d*-wave superconductivity only and can be realized in the experiment with strongly correlated optical lattice platforms.

Reference:

[1] Phys. Rev. B **106**, L140303 (2022)

Poster Number: 2

Generation of multiple anomalous Majorana modes in realistic model systems

Debashish Mondal*, Arnob kumar Ghosh*, Tanay Nag, Arijit saha****

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Abstract: We theoretically investigate the emergence of Floquet Majorana Modes (FMMs) in two practically realisable models ([1] A one dimensional (1D) Rashba nanowire placed in closed proximity to a bulk s-wave bulk superconductor in presence of external magnetic field parallel to the direction of the wire, [2] An 1D chain of magnetic impurities, placed on the top of a s-wave superconductor) in presence of external periodic drive. For the static case, both of these models exhibit zero-energy Majorana modes in the topological superconducting phase. However, starting from the non-topological regime (with no Majorana present at the ends), we find that the FMMs (both regular 0- and anomalous π-modes) appear in Floquet topological phase due to application of external periodic drive. We also find that the number of FMMs can be tuned by modulating the frequency of the drive. We topologically characterised them via proper dynamical winding number using periodise evolution operator. Furthermore, we investigate the stability of the FMMs in presence of static random onsite disorder, and explored their topological characterisation using twisted boundary conditions in real space. Our works pave a possible realistic way to engineer multiple FMMs in a driven system.

Poster Number: 3

Engineering 2D topological superconductivity, hosting Majorana flat band, via magnetic spin texture and their possible material realization

Pritam Chatterjee*, **Sandip Bera****, **Arnob Kumar Ghosh***, **Sayan Banik****, **Saurabh Pradhan*****, **Arijit Saha***, **and Ashis K. Nandy****

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Abstract: We theoretically investigate a realistic path to engineering two-dimensional (2D) Kitaev's model of topological superconductivity via magnetic spin texture with some particular configuration placed on top of an s-wave superconductor. The prime proposal of 2D Kitaev's model is that a p-wave superconductor can exhibit a gapless topological superconducting phase in the bulk hosting non-dispersive Majorana flat edge mode (MFEM). Our study reveals the architecture of the same phenomena via helical spin texture of locally varying magnetic impurities along the effective x+y direction and placed in proximity to a pure s-wave superconductor. In this case, the gapless superconducting phase as well as MFEM appear within the non-topological Shiba bands formed due to magnetic impurities. We also topologically characterize this gapless phase and identify the signature of MFEM via spectral function analysis. Moreover, We propose some possible candidate materials to realize our model setup in a real system. Our proposed heterostructure has been configured by the Mn layer as an antiferromagnetic spin spiral placed on top of a Nb(110) (s-wave superconductor) surface. In that case, we also obtain a signature of the MFEM from the local density of state spectra. Our study paves the way for possible experimental realization of 2D topological superconductivity hosting MFEM with helical spin texture.

Poster Number: 4

Signatures of orbital selective Mott state in doped $Sr_3Ru_2O_7$

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Abstract: Bilayer Strontium Ruthenate $Sr_3Ru_2O_7$ is a strongly correlated electronic system that shows di-verse electronic and structural phases. Upon doping with Mn, an orbital selective Mott phase is observed before the material transitions to a Mott insulating state. Additionally, Mn doping leads to the emergence of an anti ferromagnetic state with $q_{AFM} = (\pi/2, \pi/2)$ ordering wavevector. Quasiparticle interference (QPI) experiments find a sharp but highly dispersive peak at the AFM wavevector. Another set of QPI peaks is observed at $q^* = (\pi, 0)$ possibly due to a charge order effect. In this work we utilize a tight binding model relevant to Mn doped $Sr_3Ru_2O_7$, and show that the origin of observed orbital selective Mott phase is inherently dependent upon the presence of a strong onsite exchange interaction and oxygen octahedral rotation suppression induced by the Mn doping. We further find that the experimentally observed QPI spectra including the peaks at q_{AFM}, and q^* wavevectors can be concomitantly explained within this formalism.

Poster Number: 5

Non-trivial effects of interface coupling in 1T'-WTe2 /2H-NbSe2 hetero-structure

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Abstract: Heterostructures between quantum spin Hall insulators (QSHI) and superconducting materials are being extensively studied to explore the non-trivial edge state properties by inducing superconductivity into the conducting topological edge states. Although a strong interface hybridization can help induce a reasonable superconducting gap on the topological material, the hybridization can modify the topological nature of the material's electronic structure. In this work, we utilize a realistic model to explore topological edge state physics in a heterostructure where a monolayer quantum spin Hall insulator 1T'-WTe2 is placed over an s-wave superconductor 2H-NbSe2. We find that even in the presence of strong inter-layer hybridization the edge state shows a significantly enhanced local density of states and induced superconductivity. We provide an alternate heterostructure geometry that could utilize the strong inter-layer hybridization and realize a spatial interface between a regime with a QSHI gap and a topological conducting edge state.

Poster Number: 6

Thin film coatings of low dimensional functional derivatives of carbon from HiPCO SWCNTs for stray light control space applications

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Abstract: Research on carbon based thin films with low light reflectance has received significant attention recently to develop high absorber coatings that can be used for stray light control space applications. Compound films comprising different low dimensional structural deriva-tives of carbon including carbon nanotubes (CNTs), graphene sheets (GS) and carbon nanoscrolls (CNS) have shown tremendous potential [1]. These coatings can be used in thermal detectors and baffles, various optical components, sensors, space telescopes and components in space crafts. In this work, we report emergence of different functional derivatives of carbon from HiPCO single wall carbon nanotubes (SWCNTs) after subjecting them to post-synthesis purification and covalent functionalization process. Purification was carried out to remove cat-alytic Fe impurities from the raw SWCNTs via wet oxidation, HCl acid wash and annealing [2], while covalent functionalization is performed on the purified sample with a mixture of H2SO4 and HNO3 in a ratio of 3:1 followed by magnetic stirring [1]. Resultant product we achieve is a mixture of multi wall carbon nanotubes(MWCNTs), GS, CNS and other functional derivatives along with SWCNTs. Highly stable CNTs, GS and CNS based thin film coatings on the aluminium (Al) substrate was fabricated by using a hand spray brush to coat the functionalized solution with a binder into an organic solvent [1]. These films exhibit low reflectance of the order of 2–3% in the visible and near-infrared (NIR) spectral bands and are highly stable which sustain the fundamental space environmental simulation tests (SESTs) with the reflectance values almost unaltered [1]. We discuss synthesis of the CNS from the HiPCO SWCNTs as well as the preparation, characterization, stability and application of the CNT, GS and CNS based thin film coatings [1], [2] in the space domain.

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Poster Number: 7

Tuning topological phases in N-stacked Su-Schrieffer-Heeger chains by the systematic breaking of symmetries

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Abstract: A two-dimensional model of a topological insulator with N-stacked Su-Schrieffer-Heeger (SSH) chains is proposed. This study considers a basic model with all the fundamental symmetries (particle-hole, chiral, and time-reversal) preserved. This model is topologically trivial irrespective of the topological property of the individual SSH chain. The fundamental symmetries are systematically broken to induce topologically nontrivial properties in the system. This study reveals that breaking the chiral and time-reversal (TR) symmetries are a minimum requirement for the induction of the nontrivial topology. The chiral symmetry is broken by introducing intra-sub-lattice hopping in the system. Following Haldane, the TR symmetry is broken by introducing imaginary strength to the intra-sub-lattice hopping. These results are verified analytically. The basic model is then driven by circularly polarized light to investigate its response to periodic driving. Floquet theory is employed to study this driven Hamiltonian. This driving facilitates us to form a Floquet topological insulator which was trivial in the static state.

Poster Number: 8

Periodically Driven Kitaev Chain: Emergence of multiple pairs of Floquet-Majorana modes

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Abstract: Kitaev chain with the nearest neighbor hopping or tunneling and p-wave superconducting pairing consisting of gapped bulk and zero energy edge states1 is investigated under periodic driving. The periodic driving consists of a sequence of two pulses. This pulse driving scheme facilitates an exact derivation of this system's effective static Hamiltonian or Floquet Hamiltonian. In the effective Hamiltonian, additional long-range tunneling and p-wave superconducting pairing terms appear. The appearance of additional terms, due to the periodic driving, provides long-range Majorana modes that are known as Floquet-Majorana modes2. The strength of the periodic driving can be used as a control parameter to tune the range of the Floquet-Majorana modes. Depending on system parameters like chemical potential, tunneling probability, pairing strength, and driving parameters like amplitude and frequency, the Floquet-Majorana modes may not survive. Since the method followed here is exact, we can investigate the system's response in all frequency regimes by tuning the parameters that govern the strengths of the appeared Floquet-Majorana modes. The strength of the periodic driving can be used as a control parameter totune the range of the Floquet-Majorana modes. Depending on system parameters like chemical potential, tunneling probability, pairing strength, and driving parameters like amplitude and frequency, the Floquet-Majorana modes may not survive. Since the method followed here is exact, we can investigate the system's response in all frequency regimes by tuning the parameters that govern the strengths of the appeared Floquet-Majorana modes.

Key-words: Floquet. Majorana, Kitaev chain

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Poster Number: 9

Monte-Carlo exploration of generalized Kitaev model on a square lattice

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<u>Abstract:</u> Kitaev honeycomb model is an exactly solvable with a spin liquid ground state. In recent studies[1][2] the model has been generalised to spin-orbital models without breaking its solvability for honeycomb as well as square lattice system in presence of magnetic field. Variational studies of these (with isotropic spin exchanges) show different flux phase ground states with magnetic field. Here we explore the impact of spin exchange anisotropy for such models. Owing to the enlarged parameter space, the possible set of variational states to be examined in order to get to the ground state is difficult to anticipate. We thus explore the anisotropic model within an unbiased Monte-Carlo scheme. Here we treat the bond-dependent conserved quantities of the model as classical variables that are annealed with a Metropolis algorithm. We not only recover the variational phases (of the isotropic case) but also uncover a series of novel phases with magnetic field in the anisotropic case. In addition the Monte-Carlo approach provides direct access to the thermal excitations of the low T ordered flux phases. We map out the 'magnetic field-temperature' phase diagrams at various anisotropies and relate the temperature ordering to microscopic excitations of the model by computing temperature evolution of specific heat.

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Poster Number: 10

Time reversed propagation in barrier tunneling

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Abstract: Tunneling, though a physical reality, is shrouded in mystery. Wave packets cannot be con-structed under the barrier and group velocity cannot be defined. The tunneling particle can be observed on either sides of the barrier but its properties under the barrier has never been probed due to several problems related to quantum measurement. We show that there are ways to bypass these problems in mesoscopic systems and one can even derive an expression for the quantum mechanical current under the barrier. A general scheme is developed to derive this expression for any arbitrary interaction and system. One can use mesoscopic phenomenon to subject the expression to several theoretical and experimental cross checks. For demonstration we consider an ideal 1D quantum ring with Aharonov-Bohm flux Φ, connected to a reservoir. It gives clear evidence that propagation occur under the barrier resulting in a current that can be measured and theoretically cross checked. Time reversed states play a role but there is no evidence of violation of causality. The evanescent states are known to be largely stable and robust against phase fluctuations making them a possible candidate for device applications and so formalizing current under barrier is important.

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Poster Number: 11

Triple phase transition in non-Hermitian system

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Abstract: Anderson's model unleashed a unique quantum mechanical view of metal-insulator transitions. Effects of non-Hermiticity on Anderson localization have been theoretically proven and experimentally observed. We study a non-hermitian Aubry-Andre-Harper model considering a combination of two non-Hermitian terms in the system: one at the standard onsite quasi periodic potential part and another at the commensurate modulated asymmetric hopping. We observe three separable phenomena, the bulk conductivity, the topology, and the non-Hermitian symmetry breaking are interlinked and form a triple phase transition for a specific window of parameters. The transition points are observed via the phase diagrams. Our study also reveals how one can infer the behavior of all three transitions from the eigenspectra.

Poster Number: 12

Chemical Solution Deposition of BiaxiallyTextured $Sm_2Zr_2O_7$ buffer layers for REBCO-coated conductors

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Abstract: High-temperature superconducting coated conductors based on $REBa_2Cu_3O_{7-x}$ (REBCO) (RE=Y,Sm) have been receiving a lot of attention due to electrical power applications. They are composed of a sandwich-like structure of REBCO/buffer layer(s)/metal substrate. $Sm_2Zr_2O_7$ (SZO) buffer layer on Ni–5%W RABIT substrate (Ni5W) are incredibly exciting buffer layer for coated conductors which are synthesized by chemical solution deposition for the first time. Texture and morphology evolution of SZO films can be controlled by the Substrate properties, Solution chemistry, or by regulating the processing parameters like Annealing Temperature, Spinning time, and Spinning speed. The Structural, Microstructural, and Morphological properties of the films were investigated by X-ray diffraction (XRD), Scanning electron microscopy (SEM), Optical microscopy (OM), and Atomic force microscopy (AFM).Results show that both the growth orientation and surface morphology of films are dependent on the annealing temperature. XRD investigations showed that the SZO buffer layer formed on Ni5W (200) substrate can be grown with highly c-axis oriented and with high in-plane and out-of-plane texturing. The SZO (222) pole figure revealed a single cube on a cube epitaxy.SEM and AFM results showed a dense, microcrack-free, smooth surface.

Poster Number: 13

Magnetic superconductors and topological transitions on Lieb Lattice

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Abstract: Metal Organic Framework (MOF) and Covalent Organic Framework (COF) are examples of engi-neered two-dimensional (2D) functional materials with tailor-made properties that has increasingly become in-vogue in condensed matter. These artificial materials are relevant to future electronic, spintronic and energy harvesting applications. The electronic structure of the MOFs support non trivial combinations of flat and dispersive bands, wherein customized electronic properties are obtained via tuning of the interactions in these materials. Here, we make use of the interplay between the fermionic and spin degrees of freedom to bring forth novel spectroscopic and topological properties of MOF materials. Our system, defined on a Lieb lattice, (simulating MOF), is an attractive Hubbard model in the presence of a Kondo coupling between localized spins and itinerant fermions. Within this model, we study the co-existence of magnetically ordered states with superconductivity brought about by an interplay of the attractive Hubbard interaction, lattice topology and the Kondo coupling. We elucidate the phase diagram in terms of the density, the Kondo coupling, and the interaction strength. Topological features inherent in the system are characterized by laying recourse to the Chern number. Finally, the spectral function is harnessed to study the evolution of the Fermi surface for different parameter regimes.

Poster number 14: Withdrawn

Poster Number: 15

Higher order topology in a Creutz ladder

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Abstract: A Creutz ladder, is a quasi one dimensional system hosting ro- bust topological phases with localized edge modes protected by different symme-tries such as inversion, chiral and particle-hole symmetries. Non-trivial topology is observed in a large region of the parameter space defined by the horizontal, diagonal and vertical hopping amplitudes and a transverse magnetic flux that threads through the ladder. In this work, we investigate higher order topology in a two dimensional extrapolated version of the Creutz ladder. To explore the topological phases, we consider two different configurations, namely a torus (periodic boundary) and a ribbon (open boundary) to look for hints of gap closing phase transitions. We also associate suitable topological invariants to charac-terize the non-trivial sectors. Further, we find that the resultant phase diagram hosts two different topological phases, one where the higher order topological excitations are realized in the form of robust corner modes, along with (usual) first order excitations demonstrated via the presence of edge modes in a finite lattice, for the other.

Poster Number: 16

Generalized Algorithm for CVD grown Transition Metal Dichalcogenides (TMDCs)

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Abstract: Atomically thin transition metal dichalcogenides (TMDCs) have expanded two-dimensional (2D) materials beyond graphene in electronic and optoelectronic device applications due to their intrinsic direct bandgap. The synthesis of monolayer TMDCs through Chemical Vapor Deposition (CVD) has been recently realized, but the controlled growth of large-area monolayers with homogenous crystallinity remains an experimental challenge. Here we present a generalized algorithm for directly synthesizing a range of TMDCs with an average single domain size of ~200 µm. This algorithm has been tested successfully by synthesizing MoS_2, WS_2, $MoSe_2$ and WSe_2 using an advanced CVD with a split tubular furnace from Quazar Technologies, which separates the substrates and the two precursors (S/Se and Mo/W) into different temperature zones, each with tightly controlled temperature profile. We further generalize previous arguments in the literature on the morphology of MoS_2 to a much wider class of TMDCs and present experimental proof of the generalization. Lastly, we explain how the growth parameters influence the domain size, defects, layers and homogeneity of the crystals.

Poster Number: 17

Domain Wall Effects in Unconventional Superconductors

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Abstract: The superconducting gap properties near a twin boundary can be highly modulated and can potentially support a superconducting state that breaks time reversal symmetry. It has been proposed in phenomenological studies that such interfaces can lead to such a modulated superconducting order parameter having a large coherence length. We perform a microscopic analysis of the problem within BdG formalism and study the effect of the twin boundary on coherence length in the presence of competing superconducting orders. For a single band model on a square lattice, we find that a twin boundary between two orthorhombic domains not only stabilizes a time reversal broken superconducting state, it leads to a long coherence length for such a state. For a simple two band model relevant to iron pnictides we introduce a twin boundary between two nematic domains and find a significant mixing between a sign changing s-wave and a d-wave superconducting order parameter near such boundaries.

Poster number 18: Withdrawn

Poster Number: 19

Theoretical demonstration of dominant three-magnon excitations in cuprate Mott insulators probed by Resonant Inelastic X-ray Scattering

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Abstract: Recent experiments have revealed that indirect resonant inelastic X-ray scattering (RIXS) is a powerful probe of elementary low-energy excitations in solids. We study a nearest and next nearest neighbor spin-model relevant for (undoped) cuprate Mott insulators, for analyzing RIXS data of recent experiments [1,2]. These Cu L-edge (2p-3d transition) experimental studies indicate the possibility of multi-magnon spin excitations. Within linear spin wave theory, we show that remarkably the three magnon scattering intensity has more significant contribution to the RIXS cross-section than the single-magnon and bi-magnon at low transferred momentum. These results are likely to be relevant for materials described by similar spin models.

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Poster Number: 20

Investigation of structural magnetic and transport properties of Ni substituted Weyl-semimetal $ZrCo_2Sn$

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Abstract: The discovery of the 3D topological semimetal has led to the exploration of new classes of topological materials such as Dirac semimetal, Weyl semimetal, a nodal-line semimetal, and triple point semimetal. They exhibit linear dispersion in the momentum space which results in a rich variety of exotic transport properties and oscillation of some physical properties due to the crossing of Landau quantized energy level over the Fermi surface. The Heusler Alloy $ZrCo_2Sn$ displays two Weyl nodes in the energy range of 0.1-0.6 eV above the Fermi level. The present study is aimed to tune the Fermi Energy (E F) in $ZrCo_2Sn$ to be as close as possible to that of Weyl nodes by adding electrons through Ni substitution at Co site which can fulfill the requirement. The Heusler Alloys $ZrCo_{2-x}Ni_xSn$ (x= 0.2, .4, 0.6, 0.8, 1.0) were synthesized by arc melting. The magnetic and electrical transport measurements show that the Ni substitution has a significant impact on the magnetic as well as electrical properties. A cusp in the near zero field susceptibility, the presence of Shubnikov de Hass (SdH) oscillation in resistivity, and weak anti-localization (negative magnetoresistance) unambiguously prove the existence of the relativistic Weyl fermion in this material.

Poster Number: 21

Ultrasonic attenuation in strontium ruthenate

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Abstract: Sr_2RuO_4, an unconventional superconductor having structure similar to high Tc cuprates and is believed to have a triplet superconductivity but recent research has shown some disagreement with this. One can use the phenomena of ultrasonic attenuation to discuss how different sound modes get attenuated when passed through a normal sample and study the same in a superconducting sample on the symmetry basis. The attenuation constant for superconductors can be calculated considering that it is induced by electron phonon interaction and depending upon the polarization and wave vector phonons, different sound modes attenuation can be calculated. This different modes' attenuation can be related to the elastic tensor components and the corresponding shear and compressional irreducible strains. From experimental techniques like RUS one can tell each particular irreducible strain's attenuation, which is further used to classify the superconductivity class and the possible type of superconductivity order parameter in this material.

Poster Number: 22

Competing ultrafast energy relaxation mechanisms in a zero hysteresis strongly correlated system

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Abstract: After excitation by a high energy ultrashort laser pulse, Pauli blocking at the bottom of the higher energy band is known to make secondary energy relaxation processes more relevant. Beyond the initial ~200 femtoseconds (which essentially describe the non-Fermi hot electrons without a characteristics temperature) , the energy transfer from the electrons to the lattice can be a multi-step process due to impact ionization, intraband scattering, auger recombination etc. We perform ultrafast pump probe measurements on $NdNiO_3$ films of thickness ~70 nm which shows remarkable reversibility of the first order transition with almost non-existent hysteresis loss. The origin of the signal at large negative delays is explained through modelling the heat current between the sample and the cryostat. Using the single valued nature of resistance temperature curves, one can estimate the "true phonon-bath temperature" which remains ambiguous for such high fluence studies. We then systematically study the non-monotonicity of our relaxation dynamics to understand the effects of Pauli blocking on the enhancement of secondary excitations. Beyond a threshold temperature, the secondary transitions dominate and eventually destroy the initial exponential relaxation.

Poster Number: 23

The impact of moisture content on the complex permittivity of jowar and corn leaves over microwave frequency range

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Abstract: The measurement of complex permittivity of vegetation over microwave frequency range is helpful in microwave remote sensing applications, as the emissivity and back scattering coefficients are relegated with complex permittivity. The variation of the dielectric constant and dielectric loss of corn and jowar leaves, for various moisture contents, was measured using a Vector Network Analyzer (Anritsu Shockline Model-MS46322A) over 0.5 GHz to 15 GHz frequency range. It has been observed that the dielectric constant and dielectric loss increases with increase in moisture content of the leaves. The dielectric constant decreases with increase in frequency for given moisture content in the leaves. Below a certain critical moisture content, the dielectric loss of leaves decreases with increase in frequency. Above a certain critical moisture content in the leaves it decreases up to 3 GHz, after which it starts to increase with increase in frequency approaching towards the relaxation frequency of water. The critical moisture content found in corn and jowar leaves is 49% and 47%, respectively. The measured values of complex permittivity were compared with Debye-Cole Dual-Dispersion Dielectric Model and results are found to be a good agreement with dielectric model.

Key word: Complex Permittivity, Microwave Frequency, Moisture Content, Vegetation.

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Poster Number: 24

Electronic properties of the α-T_3 quantum ring

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Abstract: With the continuous tuning of the parameter $\alpha \in (0, 1)$, the α-T_3 lattice provides an interpolation between the honeycomb structure of graphene ($\alpha = 0$) and the dice lattice ($\alpha = 1$). We consider a quantum ring of radius R made from the α-T_3 lattice by freezing the radial motion of the charge carriers. We solve the pseudospin-1 Dirac-Weyl equation to obtain the energy spectrum and the corresponding eigenspinors. We find that the energy spectrum consists of a flat level with zero energy and discrete energy levels characterized by total angular momentum quantum number m. Each energy level corresponding to α=0 is two-fold degenerate. However, for an intermediate value of α, namely, $0 < \alpha < 1$ the energy levels become non-degenerate. Interestingly, this degeneracy is restored in the case of $\alpha = 1$ except for $m = 0$ level. It is also found that the valley degeneracy is broken for all values of α 6= 1. When the ring is subjected to a perpendicular magnetic field, the energy levels follow a substantial deviation from their typical 1/R-dependence. Moreover, the magnetic field lifts the degeneracy of each level. We also calculate the persistent current which exhibits quantum oscillations as a function of the magnetic field.

Poster Number: 25

Properties of the non-Hermitian SSH model: role of PT symmetry

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Abstract: We analyze the distinction between the topological and the localization properties of a PT symmetric and a non-PT symmetric versions for the non-Hermitian Su-Schrieffer-Heeger (SSH) model. The non-PT symmetric case is represented by non-reciprocity in both the inter- and the intra-cell hopping amplitudes, while the one with PT symmetry is modeled by a complex on-site staggered potential. In particular, we study the loci of the exceptional points, the winding numbers, band structures, and explore the breakdown of bulk-boundary correspondence (BBC) us- ing both the conventional and generalized Brillouin zone approach. We further study the interplay of the dimerization strengths on the observables for these cases. The non-PT -symmetric case denotes a situation where tuning of the non-reciprocity pa-rameters demonstrates the topological phase transitions, and includes a complete breakdown of the BBC, thereby showing non-Hermitian skin effect. The topological and the localization properties of the PT symmetric case appears to follow closely to its Hermitian analogue, except that it shows unbroken (broken) regions with complex (purely real) energy spectra and validates the conventional BBC.

Poster Number: 26

Driven quantum spin chain in the presence of noise: Anti-Kibble-Zurek behavior

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Abstract: A driven system passing through a continuous phase transition point results in the formation of finite-sized ordered domains. The boundary of the ordered domains hosts defects which in the context of spin systems are the domain walls or kinks. The Kibble-Zurek Mechanism (KZM) predicts that the size of the ordered domain and consequently the defect density depends on the sweep speed by which one traverses through the phase transition point. In particular, the KZM predicts that the density of defects scales as a universal power law with the quench time, $n \sim \tau^{-\beta}_Q$ (quench time, τ_Q is inversely proportional to the sweep speed), where $\beta > 0$ is the KZM exponent. In other words, the KZM predicts that slower drives through the phase transition point lead to decreased defect generation [1]. However, various recent experimental and numerical studies revealed behavior opposite to that of the KZM for the defect generation in the noisy drive through the quantum critical point (QCP), i.e., the defect density is enhanced for the slower drives in the presence of noise, this behavior has been termed as the anti-Kibble-Zurek (AKZ) behavior [2-5]. Consequently, one must drive the system with some noise-dependent optimal sweep speed to minimize defect generation. Motivated by these works, we have studied the defect generation in a quantum XY -spin chain and the one-dimensional Kitaev chain arising due to the linear drive through the QCP of the many-body Hamiltonian in the presence of a time-dependent fast Gaussian noise. We show via analytical calculations that the defect density, entropy, magnetization, and spin-spin correlations exhibit the signature of the AKZ behavior for the noisy transverse quench of quantum XY -spin chain [6]. In particular, in the limit of large chain length and long time, we calculate the entropy and magnetization density of the final decohered state and show that their scaling behavior is consistent with the AKZ picture in the slow sweep regime. We have also numerically calculated the sublattice spin correlators for finite separation by evaluating the Toeplitz determinants and find results consistent with the KZ picture in the absence of noise, while in the presence of noise and slow sweep speeds the correlators exhibit the AKZ behavior. Furthermore, by considering the large n-separation asymptotes of the Toeplitz determinants, we further quantify the effect of the noise on the spin-spin correlators in the final decohered state. We show that while the correlation length of the sublattice correlator scales according to the AKZ behavior, we obtain different scaling for the magnetization correlators [6].

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Poster Number: 27

Distinguishing topological ZBP from trivial ones

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<u>Abstract:</u> Majorana bound states (MBS) at the end of nanowires have been proposed as one of the most important candidates for topological qubits. One-dimensional semiconductor-superconductor heterostructures [1, 2] constitute an ideal system to realize Majorana in natural systems. Zeeman field drives these systems from a trivial phase with a finite gap to a topological phase containing a zero-energy Majorana bound state (MBS) in the gap. However, similar tunneling conductance features for both the MBS and trivial zero energy Andreev bound states (ABS) have turned out to be a major obstacle in verifying the presence of MBS in semiconductor-superconductor heterostructures. The presence of quantized ZBP is insufficient to conclude the existence of MBS as trivial ABS can also produce quantized ZBP [3, 4]. To distinguish topological states from normal zero-modes, one needs to go beyond the presence of Quantized ZBP and probe properties specific to MBS only. For a scenario involving quantized ZBP in the nanowire, we propose a scheme wherein the length of the topological region in the wire is altered. The tunneling conductance signatures can then be utilized to gauge the impact on the energy of the low-energy states. We show that the topological and trivial ZBP behave differently under our protocol. In particular, the topological ZBP remains robust at zero bias throughout the protocol, while the trivial ZBP splits into two peaks at finite bias. This protocol probes the protection of near-zero energy states due to their separable nature, allowing us to distinguish between topological and trivial ZBP [5].

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Poster Number: 28

Exact Diagonalisation of the Hubbard Model and the Interplay of Topology

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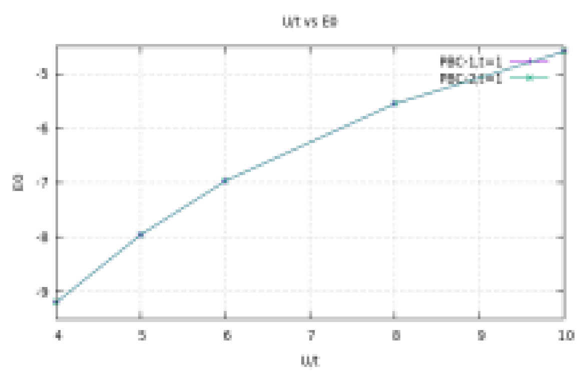
Abstract: In recent years topological orders have played increasingly important roles in condensed matter physics. It has been realized that quantum topology is a useful way of characterizing many-body ground states of interacting systems. In our study we investigate the effect of topology by exactly diagonalising the Hubbard model on 12-sites (3✕4) lattice. We consider two different periodic boundary conditions (PBC), in first we consider a closed ring of 3✕4 lattice, next we twisted the lattice so as to form a mobius strip. We found that the ground state energy of the system is invariant of the topology of the system. We calculate the ground state energy of the system for t=1 and U=4,5,6,8,10 and plotted the U/t vs E0 plot. The properties of the system will be described on the basis of correlation functions and related structure factors. The correlation functions are charge and spin and the corresponding structure factors are charge and spin structure factors. For our system we calculate the charge and spin correlations and the corresponding structure factors. In our study we find that the topology of the system does not senses the charge structure factor and it remains same throughout the PBC's where as it senses the spin structure factor and has different values in PBC-1 and PBC-2.



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Poster Number: 29

Low-temperature theory of inversion and quantum oscillations in Kondo insulators

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Abstract: We present a low temperature theory for the half-filled Kondo lattice model (KLM). We use a canonical representation (developed in Phys. Rev. B 77, 205115 (2008)) to do a minimal self-consistent theory. The half-filled KLM is found to show three phases in the temperature-hopping(T-t) plane: the strong coupling Kondo singlet phase(KS), the inverted Kondo singlet (iKS) phase, and the antiferromagnetic (AFM) phase. The KS and iKS are differentiated by the inversion of the charge quasiparticle dispersion. The density of state for the charge quasiparticles also undergoes a dimensional reduction for iKS phase leading to an enhanced specific heat, as compared to the KS phase. This can act as a tool to experimentally determine the respective phases. Magnetic quantum oscillations are seen in the intermediate to low coupling regimes for finite temperatures. These are found to follow the Lifshitz-Kosevich like behavior for temperature as well as inverse of hopping, suggesting that J 2/t behaves effectively similar to temperature.

Poster Number: 30

Theoretical study of Superconductor/ Normal metal -Quantum-Dot Based Thermoelectric Particle-exchange Heat Engines

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<u>Abstract:</u> Using Keldysh's non-equilibrium Green's function formalism for different decoupling schemes in the equation of motion (EOM), we analyzed single quantum dot (QD) based thermoelectric particle-exchange heat engines. For a strongly interacting QD, we used Lacroix approximation with $U \rightarrow \infty$. Within this Infinite-U limit, we examine the role of the symmetric dot-reservoir tunneling and external serial load in optimizing the performance of the QD heat engine. Our results show a good quantitative agreement with recent experiments and real-time diagrammatic theory [2]. Thus Green's function EOM technique, which is a computationally inexpensive and straightforward analytical method, gives reliable results in the Coulomb blockade regime. Further, we investigate the optimal power and corresponding thermoelectric conversion efficiency of a heat engine based on a QD coupled between a normal metal and Bardeen- Cooper-Schrieffer superconductor (N-QD-S). We have shown that for a strong Coulomb blockade and weak dot-reservoirs coupling limit, the non-linear N-QD-S heat engine exhibits a very high thermoelectric conversion efficiency (approx. 80% of the Carnot efficiency) with finite power output (approx. 0.5fW to 4fW). Furthermore, to obtain optimal thermoelectric performance, the external serial load should range from 3MΩ to 20MΩ. The results presented here are within the scope of available experimental capabilities.

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Poster Number: 31

Localization transition in bond disordered graphene

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Abstract: We numerically study a particle-hole symmetric disorder-driven quantum phase transition (QPT) in two dimensions, which is realized with dimerized random hopping disorder in graphene. Our aim is to understand the critical fluctuations across the QPT using Lyapunov spectra of the transfer matrix, conductance, and density of states. At weak disorder, the low energy density of states shows Gade singularity, while in the localized phase the density of states diverges in a power law with a disorder-dependent exponent. The sublattice Lyapunov spectra crossing zero dictates the critical disorder strength δc and a single parameter scaling collapse of ξ/M in the localized phase gives the critical exponent $\nu \sim 1$, close to the lower bound on the exponent by Harris criterion, where M is the transfer width of the system, and ξ being the correlation length. At the critical point, the conductance distribution becomes scale invariant. This insensitivity of the conductance fluctuations with sample geometry is reminiscent of the wavefunction freezing transition in two-dimensional disordered systems with Dirac fermions on a bipartite lattice.

Poster Number: 32

Dynamics of Vortex Structure in Superconducting Thin films of Re6Zr

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Abstract: In 2 dimensions, random pinning centers can destroy the Arbikosov lattice in superconductors and turn it into vortex glass (VG). The competition of pinning and vortex-vortex interaction can lead to rich dynamic states. Here we study the melting of the VG in superconducting amorphous Re6Zr thin films grown using Pulsed Laser Deposition. Scanning Tunneling Microscope studies on a 5 nm thick thin film reveal a VG from a very low magnetic field and temperature. However, vortices show various degrees of localization. The strongly pinned vortices remain immobile at their pinning locations whereas the weakly pinned one forms channels where the vortices are mobile. With an increasing magnetic field, the vortex structure melts gradually with the percolation of regions containing delocalized vortices. A similar observation is seen with an increase in temperature. IV characteristics also show the signature of interstitial liquid formed by delocalized vortices. This work provides insight into the effects of random pinning on the melting of vortex lattice structure. STM studies on thin film (5nm) reveals a vortex glass from very low magnetic field and temperature. However, vortices show various degrees of localization. Successive vortex images reveal chains of weakly pinned vortices amongst strongly pinned vortices. With increasing magnetic field, the vortex structure melts gradually with percolation of regions containing delocalized vortices. Similar observation is seen with increase in temperature. IV characteristics also shows signature of interstitial liquid formed by delocalized vortices. This work provides insight into the effects of random pinning on vortex lattice structure.

Poster Number: 33

Structural, Vibrational, Thermophysical and Electronic properties of $L1_0FeNiPt_2$

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<u>Abstract:</u> Using plane-wave pseudopotential density functional theory (DFT), a comprehensive first- principles computation of the structural, vibrational, and electronic characteristics of $L1_0FeNiPt_2$ alloy is examined. For the present computations, PAW type pseudopotentials with Perdew-Burke-Ernzerhof (PBE) exchange correlation are used. Our calculated equilibrium lattice constants agree closely with the reported results. Phonon dispersions and phonon density of states of $L1_0FeNiPt_2$ exhibit dynamically stable phases along the high symmetry directions of the Brillouin zone. Further, the electronic band structure along with the total and projected electronic density of states, electronic charge density and Fermi surfaces of $L1_0FeNiPt_2$ are also studied. Various thermophysical properties, namely Room temperature thermal equation of states, Coefficient of thermal expansion at different temperatures, isothermal bulk modulus at different temperatures, Specific heats as a function of temperature, Temperature dependence of Debye temperature, Grüneisen parameter as a function of temperature are investigated using methodology as implemented in quasi- harmonic Debye model. Conclusions based on the phonon dispersion curves, phonon density of states, electronic band structure along with the total and projected electronic density of states, electronic charge density, Fermi surface and thermophysical properties are outlined.

Keywords: $L1_0FeNiPt_2$, Invar, DFT, Phonon dispersion curve, Phonon density of states, Electronic band structure, Electronic charge density, Fermi Surface, Thermophysical properties.

Poster Number: 34

Collective excitations in cigar-shaped spin-orbit-coupled spin-1 Bose-Einstein condensates

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Abstract: We study theoretically the collective excitations of a spin-orbit-coupled spin-1 Bose-Einstein condensate with antiferromagnetic spin-exchange interactions in a cigar-shaped trapping potential at zero and finite temperature using the Hartree-Fock-Bogoliubov theory with Popov approximation. The collective modes at zero temperature are corroborated by the real-time evolution of the ground state subjected to a perturbation suitable to excite a density or a spin mode. We also analytically calculate a few low-lying modes and find excellent agreement with the numerical results. Based on the dispersion calculation, we confirm the presence of excitations belonging to two broad categories, namely, density and spin excitations. The degeneracy between a pair of spin modes is broken by the spin-orbit coupling. At finite temperatures, spin and density excitations show qualitatively different behavior as a function of temperature.

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Poster Number: 35

Near-exact quantum many-body scars in the one-dimensional spin-1 Kitaev model

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Abstract: Recent experimental findings of coherent oscillations in a Rydberg atom chain led to the discovery of quantum many-body scars (QMBS) which is a new paradigm for weak ergodicity-breaking. Much effort has been put into identifying similar kinetically restricted systems that show a weak violation of thermalization. In this paper, we study the QMBS that can arise in a spin-1 Kitaev chain. Owing to some conserved quantities, the Hilbert space of this system gets partitioned into unequal disconnected subspaces. Recently, You et. al [Phys. Rev. Research 4, 013103 (2022)] showed that the ground state sector of this chain can be mapped exactly into the PXP model, a prototypical model that is known to host QMBS. In this work, we demonstrate that the phenomenon of scarring is also present in other sectors, and in particular, we identify a sector that exhibits substantially more scarring than the ground state one. We propose an initial state and numerically demonstrate that its fidelity revivals are near-exact and more long-lived than those in the PXP model.

Poster Number: 36

A study of Josephson transport through an uncorrelated (U→0) quantum dot coupled between superconducting leads

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Abstract: Due to the potential applications in the field of nanoelectronics, the Josephson transport in mesoscopic superconductor quantum dots (QD) has been an active area of research for the past few decades. We discuss the theoretical understanding of the Josephson transport in such hybrid superconductor quantum dot devices within three different regimes (weak,intermediate, and strong coupling). We investigate the Josephson transport through an uncorrelated ($U \to 0$ or $U \ll \Gamma$) single level quantum dot linked between two Bardeen-Cooper-Schrieffer (BCS) superconducting leads (S-QD-S system). In this case, the microscopic model Hamiltonian is provided by the single impurity Anderson model. Green's function equation of motion technique is used to solve the Hamiltonian. For various positions of the quantum dot's (non-interacting) energy level relative to the Fermi level of the superconducting leads at absolute zero temperature, we demonstrate the current-phase (i-ø) characteristic and the corresponding Andreev bound states (ABSs) energy-phase (ω-ø) relation. We find that the Josephson supercurrent has a discontinuity at a phase $\Phi=\pi$, i.e., the Josephson supercurrent changes its sign from plus to minus at $\Phi=\pi$ (π-junction), and the corresponding upper and lower ABSs have no energy gap. This occurs when the QD energy level coincides with the Fermi level of the superconducting leads. Although, the current-phase characteristic changes to a sinusoidal pattern like an ordinary Josephson junction at a finite value of the QD energy level in relation to the superconducting leads, the corresponding ABSs exhibit a finite energy gap.

Keywords: Quantum dot, Superconductivity, Josephson Transport, π-junction, Anderson Hamiltonian, Green's Function.

Poster Number: 37

Spin-orbit-coupling-driven superfluid states in optical lattices at zero and finite temperatures

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Abstract: We investigate the quantum phase transitions of a two-dimensional Bose-Hubbard model in the presence of a Rashba spin-orbit coupling with and without thermal fluctuations.The interplay of single-particle hopping, strength of spin-orbit coupling, and interspin interaction leads to superfluid phases with distinct properties. With interspin interactions weaker than intraspin interactions, the spin-orbit coupling induces two finite-momentum superfluid phases. One of them is a phase-twisted superfluid that exists at low hopping strengths and reduces the domain of insulating phases. At comparatively higher hopping strengths, there is a transition from the phase-twisted to a finite-momentum stripe superfluid. With interspin interactions stronger than the intraspin interactions, the system exhibits a phase-twisted to ferromagnetic phase transition. At finite temperatures, the thermal fluctuations destroy the phase-twisted superfluidity and lead to a wide region of normal-fluid states. These findings can be observed in recent quantum gas experiments with spin-orbit coupling in optical lattices.

Poster Number: 38

Effective potentials in a rotating spin-orbit-coupled spin-1 spinor condensate

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<u>Abstract:</u> An important research direction opened up in the field of quantum degenerate gases with the experimental realization of artificial gauge fields [1, 2] and spin-orbit (SO) coupling between the spin and the linear momentum of electrically neutral bosons [3]. We theoretically study the stationary-state vortex lattice configurations of rotating spin-orbit- and coherently-coupled spin-1 Bose-Einstein condensates (BECs) in quasi-two-dimensional harmonic potentials. We explore the combined effects of rotation, spin-orbit, and coherent couplings on the spinor system from the single-particle perspective, which is exactly solvable for one-dimensional coupling, under specific coupling and rotation strengths. We illustrate that a boson in these rotating spin-orbit-coupled condensates is subjected to effective toroidal, symmetric double-well, or asymmetric double-well potentials. In the presence of mean-field interactions, using the coupled Gross-Pitaevskii formalism at moderate to high rotation frequencies, the analytically obtained effective potential minima and the numerically obtained coarse-grained density maxima position are in excellent agreement. The effects of rotation are further elucidated by computing the spin expectation per particle for the ferro- and the antiferro-magnetic BECs.

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Poster Number: 39

DFT study on the structural, electronic and thermophysical properties of $GdTiO_3$

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<u>Abstract:</u> Because of its unique features and simple structure, perovskite structure materials have attracted the curiosity of scientists and researchers. The density functional theory's generalised gradient approximation function was used to determine structural, electrical, and thermophysical parameters in the ground state cubic phase (SG 221) of GdTiO3 via Ultrasoft Pseudopotential. It shows that the calculated structural properties of cubic $GdTiO_3$ are in a good agreement with previous literature. Electronic characteristics, band structure, total and projected electronic density of states, electronic charge density, and fermi surface topology of GdTiO3 are all investigated in this study. In the temperature range of 0K to 1073 K, thermophysical characteristics such as specific heat capacity, thermal expansion (α), Gruneisen parameter (γ), isothermal bulk modulus (B_0), and Debye temperature (θ_D) were computed.

Keywords: Perovskite $GdTiO_3$; Electronic band structure; Electronic charge density, Density of states, Fermi surface; Thermophysical Properties; Density Functional Theory (DFT)

Poster number 40: Withdrawn

Poster Number: 41

Unity of universal parameter in an overdoped single crystal of high temperature superconductor $Bi_2Sr_2CaCu_{8+\delta}$

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Abstract: Recently, it has been observed that in some high temperature superconductors such as LSCO and Bi-2201, the temperature dependence of resistivity is found to be linear [1]. Such a linear temperature dependence of resistivity is assumed to arise due to a linear drop of quasiparticle decay rate with temperature enabling the existence of a Planckian dissipation timescale ħ/ in the system in overdoped samples [2]. In this work, we present the temperature dependence of resistivity in highly pure single crystals of $Bi_2Sr_2CaCu_{8+\delta}$ (BSCCO-2212) that were grown using a pressure technique and have been found to have minimal amount of intergrowth of competing BSCCO-2201 phase. By doing a linear fit to the temperature dependence of resistivity in the normal state, we were able to obtain the value of the universal parameter (), given by the relation $h/\tau = \alpha k_B T$, as 1.02, close to the expected value of 1.

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Poster Number: 42

Superconducting pairing symmetry in Ba_2CuO_{3+x} using first principle

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Abstract: Recent discovery of superconductivity in doped layered compound Ba_2CuO_{3+x} (BCO) with transition temperature as large as 73K at x = 0.2 has generated a lot of interest. Experiments in this alternately stacked octahedral and chained layered structure imply the compression of octahedra causes the Cu- dz^2 orbital to lie above the Cu- dx^2 $-y^2$ orbital. Our first-principle calculations and low-energy model Hamiltonian studies on the x = 0.25 system reveal that such an energy order leads to formation of dz^2 - electron pockets. The chained Cu layer with CuO4 square planer complexes produce db^2 $-c^2$ open electron pockets. The strong nesting between these pockets lead to an AFM spin fluctuation mediated modulated d-wave superconductivity. This is contrasting to the cuprate family of superconductor (eg. YBCO) where both electron and hole pockets exist and are formed only by the dx^2 $-y^2$ orbital, while dz2 orbital remains unoccupied. Unlike the earlier reports we find the interlayer hybridization has an important contribution to construction of the Fermi surface. We discuss the superconducting gap structure and relevant experimental signatures.

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Poster Number: 43

Electronic spectrum of a fractal geometry with hierarchical magnetic flux distribution

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Abstract: Fractal geometry presents us with a self-similarity in their pattern at various length scales that is prevalent in our natural world. We have theoretically modelled a Sierpinski fractal geometry using the tight-binding formalism and the single electron approach. In the presence of a hierarchical distribution of magnetic flux, we have explored the electronic spectrum in such Sierpinski fractal geometry. We have revealed that by manipulating the hierarchy strength in the magnetic flux, it is possible to control the degeneracy of the electronic states in such fractal geometry. In this complex system, we have also investigated the characteristics of persistent current as a function of the hierarchy parameter in the magnetic flux. It is observed that by adjusting the hierarchy parameter in the magnetic flux, we can effectively regulate the persistent current in this fractal structure, and this is true for different filling factors. Our results may be useful for creating nanoelectronic devices with molecular fractal structures.

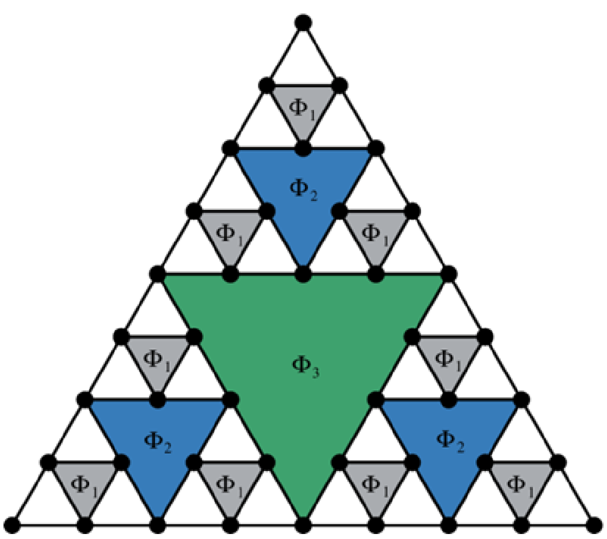

Fig.: Schematic diagram of a Sierpinski fractal model with hierarchical distribution of magnetic flux $\Phi_n=\lambda^n \Phi$.

*Webpage: https://sites.google.com/site/biplabpal2008

Poster Number: 44

Random Walks in Randomly Disordered Media

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Abstract: We have studied the competition between field-induced transport and trapping in a disordered medium by studying biased random walks on random combs and the bond- diluted Bethe lattice above the percolation threshold. While it is known that the drift velocity vanishes above a critical threshold, our focus is on fluctuations, characterized by the variance of the transit times. On the random comb, the variance is calculated exactly for a given realization of disorder using a 'forward transport' limit which prohibits backward movement along the backbone but allows an arbitrary number of excursions into random-length branches. The disorder-averaged variance diverges at an earlier threshold of the bias, implying a regime of anomalous fluctuations, although the velocity is nonzero. Our results are verified numerically using a Monte Carlo procedure that is adapted to account for ultra-slow returns from long branches. On the Bethe lattice, we derive an upper bound for the critical threshold bias for anomalous fluctuations of the mean transit time averaged over disorder realizations. Finally, as for the passage to the vanishing velocity regime, it is shown that the transition to the anomalous fluctuation regime can change from continuous to first order depending on the distribution of branch lengths.

Poster Number: 45

Electronic Properties of LiFeAs – An Iron Pnictide Superconductor

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Abstract: A Density Functional Theory (DFT) based computation was performed to study the electronic band structure, electron density of states (DOS), integrated DOS and partial DOS of LiFeAs - an iron pnictide superconductor, using Generalized Gradient Approximation (GGA) with ultrasoft pseudopotentials. The governance of 3s state of 'As' in the region far lower the Fermi level and therefore 3d state of 'Fe' near the Fermi level and of 'Li' upstairs the Fermi level are observed. The overlying of bands near the Fermi level displays the metallic nature of LiFeAs.