CAMOST-G20-S20 CONSORTIUM

Seminar Series on Disruptive Sciences and Technologies

Book of ABSTRACTS

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Date & Time: August 16, 2023, 3:00 PM IST | Venue: IIT Tirupati

Quantum Information—It's Different

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Quantum information is one of the frontier areas of science with potential to revolutionise future computation and communication systems. In this talk, we will highlight some significant distinctions between classical and quantum information, emphasizing the delicate nature of quantum states and the limitations imposed by the laws of quantum mechanics. By asking the question how different quantum information is from classical information, we can make progress in our understanding about the nature of quantum information. This will help us underpinning what is `quantum' about quantum information.

References:

1. W. K. Wootters and W. H. Zurek, Nature (London) **299**, 802 (1982).
2. A. K. Pati and S. L. Braunstein, Nature (London) **404**, 164 (2000).
3. R. Jozsa, IBM J. Res. Dev. **48**, 79 (2004).
4. M. Horodecki *et al.*, Found. Phys. **35**, 2041 (2005).
5. S. L. Braunstein and A. K. Pati, Phys. Rev. Lett. **98**, 080502 (2007).
6. J. R. Samal, A. K. Pati, and Anil Kumar, Phys. Rev. Lett. **106**, 080401 (2011).
7. K. Modi, A. K. Pati, A. Sen(De), and U. Sen, Phys. Rev. Lett. **120**, 230501 (2018).

Date & Time: August 17, 2023, 12:00 PM IST	Venue: Zoom Meeting

Quantum imaging: an overview

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Quantum science and technology are attracting world-wide attention due to the impacts they will have on computing and communications, which have no classical counterpart. However, quantum also impacts imaging and sensing. Leaving aside how new detection technologies can sense both single photons and measure their arrival time with pico-second precision, the quantum nature of light enables new types of imaging system, which again have no easy classical implementation.

This lecture will give a brief overview of the historical development of quantum imaging, focussing on how the photon pairs created through spontaneous parametric down-conversion lead to unusual imaging systems. Referring to the work from across the global community and some work of my own group we will consider which of these imaging approaches might be considered truly quantum and which might also have classical analogy. In all cases I will emphasise those system which seem to offer practical advantage over traditional approaches giving performance benefits in terms of resolution, signal to noise or wavelength coverage.

References:

1. Pittman, T. B., Shih, Y. H., Strekalov, D. V. and Sergienko, A. V., Phys. Rev. A 52(5), 3429–3432 (1995).
2. Howell, J. C., Bennink, R. S., Bentley, S. J. and Boyd, R. W., Phys. Rev. Lett. 92(21), 210403 (2004).
3. Aspden, R. S., Tasca, D. S., Boyd, R. W. and Padgett, M. J., New J. of Phys. 15(7), 073032 (2013).
4. Gatti, A., Brambilla, E., Bache, M. and Lugiato, L. A., Phys. Rev. A 70(1), 013802 (2004).
5. Bennink, R. S., Bentley, S. J., Boyd, R. W. and Howell, J. C., Phys. Rev. Lett. 92(3), 33601 (2004).
6. Shapiro, J., Phys. Rev. A 78(6), 061802 (2008).
7. Duarte, M. F., Davenport, M. A., Takhar, D., Laska, J. N., Sun, T., Kelly, K. F. and Baraniuk, R. G., IEEE Signal Processing Magazine 25(2), 83–91 (2008).
8. Lemos, G. B., Borish, V., Cole, G. D., Ramelow, S., Lapkiewicz, R. and Zeilinger, A., Nature 512(7515), 409–412 (2014).
9. Kviatkovsky, I., Chrzanowski, H. M., Avery, E. G., Bartolomaeus, H. and Ramelow, S., Sci. Adv. 6 (2020).
10. Jedrkiewicz, O., Jiang, Y. K., Brambilla, E., Gatti, A., Bache, M., Lugiato, L. A. and Trapani, P. D., Phys. Rev. Lett. 93(24), 243601 (2004).
11. Edgar, M. P., Tasca, D. S., Izdebski, F., Warburton, R. E., Leach, J., Agnew, M., Buller, G. S., Boyd, R. W. and Padgett, M. J., Nat. Commun. 3, 984 (2012).
12. Lloyd, S., Science 321(5895), 1463–1465 (2008).
13. Brida, G., Genovese, M. and Berchera, I. R., Nat. Photon. 4, 227–230 (2010).
14. Gregory, T., Moreau, P. A., Toninelli, E. and Padgett, M. J., Sci. Adv. 6(6), eaay2652 (2020).
15. Ndagano, B., Defienne, H., Branford, D., Shah, Y. D., Lyons, A., Westerberg, N., Gauger, E. M. and Faccio, D., Nat. Photon. 16(5), 384–389 (2022).
16. Casacio, C. A., Madsen, L. S., Terrasson, A., Waleed, M., Barnscheidt, K., Hage, B., Taylor, M. A. and Bowen, W. P., Nature 594(7862), 201–206 (2021).

Date & Time: August 18, 2023, 3:00 PM IST	Venue: IIT Tirupati

Pulsar Spin-down, Timing, and Gravitational Waves

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Pulsars are fast spinning neutron stars that lose their rotational energy via various processes such as gravitational and magnetic radiation, particle acceleration and mass loss processes. This dissipation can be quantified by a spin-down equation that measures the rate of change of the frequency as a function of the rotational frequency itself. The spin-down of the pulsar can be utilized to study its various properties like frequency evolution, age, internal structure, etc. Most pulsars that have exceptionally stable frequencies and periods are often used to detect gravitational waves by a process called Pulsar Timing. This involves considering an array of pulsars and measuring the correlation of their pulse arrival times on earth. However, spin-downs happen due to various energy loss mechanisms, such as the emission of electromagnetic and gravitational waves. This talk will focus on the spin-down evolution of pulsars, gravitational waves, SKA, timing arrays of pulsars to detect these waves in the nanohertz region, and pulsar navigation.

References:

1. R. Hulse Reviews of Modern Physics 66:699 1-July (1994)
2. J. H. Taylor, and J. M. Weisberg Astrophysical Journal 253:908-920 15-Feb (1982)
3. H. Padmanabhan, and A. Loeb ARxIV:2207.14309 V2. 29-May (2023)
4. W. Becker et al. Acta Futura 7:11-28 May (2013)
5. G. Agazie et al. The Astrophysical Journal Letters 951:L8 (2023)
6. V. Upadhyaya et al. arXiv:2307.11270 20-July (2023)

Date & Time: August 19, 2023, 5:30 PM IST	Venue: Zoom Meeting

The Quantum Internet

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Many organized efforts across the world are racing to realize the "Quantum Internet" -- the internet of the future that is upgraded to provide an additional service: that of reliably transmitting qubits between distant users. Just like the internet's classical data communications service, the quantum communications service must reliably support many user groups, and support diverse and dynamic applications---each with its unique requirements on the quality of service for transmission of qubits, e.g., rate, latency, fidelity etc. Supporting long-distance quantum communications at high rates and fidelities will require scalable quantum repeaters and quantum-capable satellites for continental-scale quantum connectivity. In this talk, I will describe the underlying theory of quantum networking and quantum repeaters, allude to a few important applications, and give a glimpse of a large effort underway as part of an NSF-funded 10-year engineering research center called the Center for Quantum Networks (CQN). CQN is a highly interdisciplinary effort with research ranging material-science theory to design high-coherence time quantum memories, quantum memory design and fabrication, building efficient interfaces between matter and photon qubits, cryogenic compatible packaging capabilities, quantum error correction theory to design codes for quantum communication and entanglement distillation, repeater architecture design and analysis, the entire network protocol stack up to the application layer, and finally network control, tomography and management protocols. I will also describe how CQN engages disciplines such as law and policy, social and behavioral sciences and economics through a research thrust focusing on societal impacts of the quantum internet.

Date & Time: August 21, 2023, 3:00 PM IST	Venue: IIT Tirupati

Quantum Internet with Local Access

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Encrypting data over communication channels requires reliable key distribution. Quantum key distribution (QKD) offers unconditional security, and protection against known algorithms that can be broken on quantum computers. Our work on a metro area quantum access network (MAQAN) and our plans for a quantum internet with local access (QuILA) are important deliverables under India's national quantum mission. MAQAN is a collaborative effort between multiple academic institutions and national laboratories. We rely on complementary strengths in quantum optics, hardware and firmware engineering, post-quantum cryptography and a key management layer to create an national test-bed for quantum secure communication.

QKD protocols that rely on distributed phase use weak coherent sources with decoy states to ensure security. We demonstrated two of these protocols, coherent one way and differential phase reference, in our laboratories and then deployed them in MAQAN. The quantum bit error rates of less than 10% and secure key rates of kbps are competitive with other demonstrations. The indigenous development of hardware is currently being extended to indigenous designs of photonic integrated circuits (PICs), with a view to reducing the costs while also increasing the stability of the system.

References:

1. V. Ramanathan et al, arXiv:2305.11822
2. G. Shaw et al, IEEE Photonics, 14:1-7 (2022)
3. G. Shaw et al, Optik, 250, 168280, 2022
4. S K Ranu et al, Quantum Information Processing, 20, 67, 2021

Date & Time: August 21, 2023, 8:30 PM IST	Venue: Zoom Meeting

Error correction of a logical quantum bit beyond the break-even point

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The accuracy of logical operations on quantum bits (qubits) must be improved for quantum computers to surpass classical ones in useful tasks. To that effect, quantum information needs to be made robust to the noise that affects the underlying physical system. Rather than suppressing noise, quantum error correction aims at preventing it from causing logical errors. This approach derives from the reasonable assumption that noise is local: it does not act in a coordinated way on different parts of the physical system. Therefore, if a logical qubit is encoded non-locally in the larger Hilbert space of a composite system, it is possible, during a limited time, to detect and correct the noise-induced evolution before it corrupts the encoded information. We will present an experiment based on a superconducting cavity and a transmon artificial atom – the latter employed here as an auxiliary non-linear element [1] – that implements autonomous error correction, incorporating novel primitive operations [2] and feedback control based on reinforcement learning [3]. Recently, we have stabilized in real-time a logical qubit manifold spanned by the so-called Gottesman-Kitaev-Preskill grid states, reaching a correction efficiency such that the lifetime of the encoded information was prolonged by more than a factor of two beyond the lifetime of the best physical qubit composing our system [4].

References:

1. Campagne-Ibarcq, Eickbusch, Touzard, *et al.*, Nature **584**, 368-372 (2020).
2. Eickbusch *et al.*, Nature Physics **18**, 1464 (2022).
3. Sivak *et al.*, Phys. Rev. X **12**, 011059 (2022).
4. Sivak *et al.*, Nature **616**, 50-55 (2023).

Date & Time: August 22, 2023, 3:30 PM IST	Venue: Zoom Meeting

Quantum computing with trapped ions

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Quantum technologies allow for fully novel schemes of hybrid computing. We employ modern segmented ion traps. I will sketch architectures, the required trap technologies and fabrication methods, control electronics for quantum register reconfigurations, and recent improvements of qubit coherence and gate performance. Currently gate fidelities of 99.995% (single bit) and 99.8% (two bit) are reached. We are implementing a reconfigurable qubit register and have realized multi-qubit entanglement [1] and fault-tolerant syndrome readout [2] in view for topological quantum error correction [3] and realize user access to quantum computing [4]. The setup allows for mid-circuit measurements and real-time control of the algorithm. We are currently investigating various applications, including variational quantum eigensolver approaches for chemistry or high energy relevant models, and measurement-based quantum computing. Complementary to scaling up the number of fully connected qubits, we aim for improving on the speed of entanglement generation. The unique and exotic properties of ions in Rydberg states [5] are explored experimentally, staring with spectroscopy [6] of nS and nD states where states with principal quantum number n=65 are observed. The high polarizability [7] of such Rydberg ions should enable sub-μs gate times [8].

References:

1. Kaufmann er al, Phys. Rev. Lett. 119, 150503 (2017)
2. Hilder, et al., Phys. Rev. X.12.011032 (2022)
3. Bermudez, et al, Phys. Rev. X 7, 041061 (2017)
4. https://iquan.physik.uni-mainz.de/
5. A. Mokhberi, M. Hennrich, F. Schmidt-Kaler, Trapped Rydberg ions: a new platform for quantum information processing, Advances In Atomic, Molecular, and Optical Physics, Academic Press, Ch. 4, 69 (2020), arXiv:2003.08891
6. Andrijauskas et al, Phys. Rev. Lett. 127, 203001 (2021)
7. Niederlander et al, NJP 25 033020 (2023)
8. Vogel et al, Phys. Rev. Lett. 123, 153603 (2019)

Date & Time: August 24, 2023, 3:00 PM IST | Venue: IISER Tirupati

Dual Unitaries: From Many-Body systems to Euler's Officers

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Unitary operators, possessing a form of "space-time duality" have recently drawn wide attention [1,2,3]. Circuits constructed from such operators are special class of random unitary circuits that have been used in attempts to demostrate quantum supremacy. They have been used for constructing in some sense solvable many-body models that can be nonintegrable to measurement induced phase transitions. They are also intimately related to the construction of absolutely maximally entangled quantum states [4]. These are a family of highly entangled many-particle states that can have many potential applications in quantum protocols such as secret sharing and parallel teleportation. The talk will introduce these operators, discuss some consequences for many-body systems [5] and how they helped show that quantum solutions were possible for the classically impossible Euler's famous combinatorial problem of 36 officers [6].

References:

1. Bruno Bertini, Pavel Kos, and Tomaž Prosen. Exact correlation functions for dual-unitary lattice models in 1 + 1 dimensions. Phys. Rev. Lett., vol. 123, 210601 (2019).
2. M Akila, D Waltner, B Gutkin, and T Guhr. Particle-time duality in the kicked Ising spin chain. Journal of Physics A: Mathematical and Theoretical, vol, 49, 375101 (2016).
3. Lorenzo Piroli, Bruno Bertini, J. Ignacio Cirac, and Tomaž Prosen. Exact dynamics in dual-unitary quantum circuits. Phys. Rev. B, vol 101, 094304 (2020).
4. Dardo Goyeneche, Daniel Alsina, Jose I. Latorre, Arnau Riera, and Karol ˙Zyczkowski. Absolutely maximally entangled states, combinatorial designs, and multiunitary matrices.
5. Phys. Rev. A, vol 92, 032316 (2015).
6. S. Aravinda, Suhail Ahmad Rather, and Arul Lakshminarayan. From dual-unitary to quantum Bernoulli circuits: Role of the entangling power in constructing a quantum ergodic hierarchy.
7. Phys. Rev. Research, vol 3, 043034 (2021).
8. Suhail Ahmad Rather, Adam Burchardt, Wojciech Bruzda, Grzegorz Rajchel-Mieldzio´c, Arul Lakshminarayan, and Karol ˙Zyczkowski. Thirty-six entangled officers of Euler: Quantum solution to a classically impossible problem. Phys. Rev. Lett., vol. 128(8), 080507 (2022).

Date & Time: August 28, 2023, 5:30 PM IST	Venue: Zoom Meeting

Quantum Computing: Ecosystem and End-user Applications

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Quantum computing is a rapidly developing field with the potential to revolutionize many industries. This talk will cover a breadth of topics, from what is quantum computing to who is using it today. The presenter will briefly discuss the mathematical and scientific foundations of quantum computing. This will then lead to a discussion on the global quantum ecosystem, which will highlight the entire value chain of quantum computing players from hardware to application. The talk will then continue to emphasize more on applications of quantum computing and will showcase some exciting and promising examples that have been carried out in various domains. The presenter, being an accomplished entrepreneur and technologist, will talk about his journey and communicate his vision of truly embracing the commercial revolution of quantum technologies as well as the need for quantum workforce readiness.

References:

1. State of quantum computing: Building a quantum economy. (2022) https://www.weforum.org/reports/state-of-quantum-computing-building-a-quantum-economy
2. Global Future Council on Quantum Computing - World Economic Forum, (2022) https://www3.weforum.org/docs/WEF_Global_Future_Council_on_Quantum_Computing.pdf
3. The Second Annual Report on Enterprise Quantum Computing Adoption. (2023) Zapata Computing, https://zapata.ai/enterprise-quantum-adoption-2022/.
4. Sorensen, Bob. Quantum Computing Early Adopters: Strong Prospects for Future QC Use, (Nov. 2022), https://www.dwavesys.com/media/yfohvw1r/hyperion_report_23_final.pdf.

Date & Time: August 31, 2023, 3:00 PM IST	Venue: IISER Tirupati

Thermodynamic study of quantum chaotic and many-body systems

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The notion of thermodynamic entropy in the context of quantum mechanics is a controversial topic. Although there were proposals to refer to von Neumann entropy as the thermodynamic entropy, it has its own limitations. Observational entropy has been developed as a generalization of Boltzmann entropy, and it is presently one of the most promising candidates to provide a clear and well-defined understanding of thermodynamic entropy in quantum mechanics.

In this talk, I will explain the concept of observational entropy and apply it to study two systems of interest. One is the quantum kicked top model, whose classical counterpart possesses different phases: regular, mixed, or chaotic, depending on the strength of the kicking parameter. Another is localization-delocalization transition for one-dimensional Aubrey-André (AA) model.

References:

1. "Witnessing quantum chaos using observational entropy", Sreeram PG, Ranjan Modak and S. Aravinda, Phys. Rev. E 107, 064204 (2023).
2. "Observational entropic study of Anderson localization", Ranjan Modak and S. Aravinda, Phys. Rev. A 106, 062217 (2022).

Date & Time: September 04, 2023, 3:00 PM IST	Venue: IISER Tirupati

Complexity growth for one-dimensional free-fermionic lattice models

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Complexity plays an essential part in quantum computing and simulation, where it measures the minimal number of gates required to implement a unitary circuit. In this talk, we will discuss the lower bound of the complexity for the unitary dynamics of the one-dimensional lattice models of non-interacting fermions. We show analytically, using quasiparticle formalism the bound grows linearly in time and is followed by saturation. Moreover, we demonstrate numerical evidence that for an initial Neel state, the bound is maximum for tight-binding Hamiltonians as well as for long-range hopping models. However, the increase of the bound is sub-linear in time for the latter, in contrast to the linear growth observed for short-range models.

References:

1. S Aravinda, RM; arXiv: 2302.06305 (2023); to be appear in PRB.
2. RM, V Alba, P Calabres; JSTAT (2020), 083110

Date & Time: September 05, 2023, 5:00 PM IST | Venue: Zoom Meeting

Science using x-ray free-electron lasers

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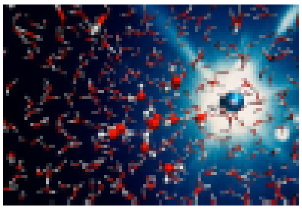
X-ray free-electron lasers (XFELs) offer exciting research opportunities for revealing ultrafast dynamics in matter in real time; measuring the atomically-resolved structure of complex molecules and molecular assemblies; and creating and probing astrophysically relevant, extreme states of matter. I will first provide an introduction to the basic physical interaction mechanisms that underlie and accompany applications of x rays. I will then explain the principles characterizing the operation of XFELs. Numerous insightful investigations have already been performed using XFELs. In my presentation, I will focus on three recent ones: the observation of the fastest chemical processes in the radiolysis of water [1]; the characterization of the femtosecond structural response of a photoactive protein to light [2]; and the imaging of complex single molecules using x-ray multiphoton-induced Coulomb explosion [3].



X rays capture the ultrafast proton transfer reaction in ionized liquid water, forming a hydroxyl radical and a hydronium ion.
Credit: DESY,
Caroline Arnold

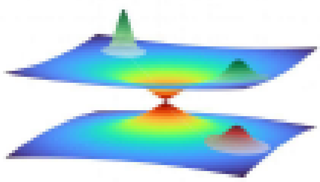
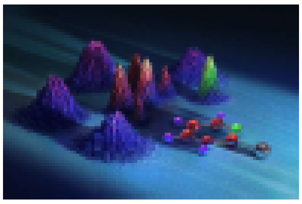


Illustration of a quantum wave packet in close vicinity of a conical intersection between two potential energy surfaces. The wave packet represents the collective motion of many atoms in the photoactive yellow protein.
Credit: DESY,
Niels Breckwoldt



Scientists use x rays to trigger a violent explosion of single molecules. From the fragmentation pattern they infer detailed information on the molecule and its fragmentation. Copyright: illustratoren.de/Tobias Wuest ef eld in cooperation with European XFEL

References:

1. Z.-H. Loh et al., Science 367, 179 (2020); https://doi.org/10.1126/science.aaz4740
2. A. Hosseinizadeh et al., Nature 599, 697 (2021); https://doi.org/10.1038/s41586-021-04050-9
3. R. Boll et al., Nature Physics 18, 423 (2022); https://doi.org/10.1038/s41567-022-01507-0

Date & Time: September 06, 2023, 5:30 PM IST | Venue: Zoom Meeting

The physics of photosynthetic light harvesting

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Strong excitonic interactions are a key design strategy in photosynthetic light harvesting, expanding the spectral cross-section for light absorption and creating considerably faster and more robust excitation energy transfer. These molecular excitons are a direct result of an exceptionally high density of pigment molecules held in a precise arrangement by one or more proteins. The excitons are also strongly coupled to a noisy environment, a phonon bath created by the pigments and their surrounding protein environment, giving rise to a complex dissipative system. In some light-harvesting complexes, small protein structural changes allow the excitonic states to mix into charge-transfer states. These mixed exciton–charge-transfer states offer additional physiological functions to the organisms by either enhancing their light-harvesting capability or aiding in photoprotection.

I will start this seminar by briefly introducing Biophysics and specifically Quantum Biology [1], after which I will present a few examples of how photosynthetic light-harvesting complexes use excitonic states and exciton–charge-transfer hybrid states to improve their light-harvesting and photoprotective capabilities and to enhance robustness to static disorder [2-4]. I will also show how these protein complexes can be interfaced with metallic nanoparticles to enhance their emission rate by two orders of magnitude [5]. I will focus on spectroscopic methods developed in my laboratory to study light-harvesting complexes at the individual molecular level using single-molecule spectroscopy and real-time single-particle tracking [4-6].

References:

1. A. Marais et al. *J R Soc Interface* 15: 20180640 (2018).
2. T.P.J. Krüger et al. *Proc Natl Acad Sci USA* 108:13516-13521 (2011).
3. T.P.J. Krüger et al. *Proc Natl Acad Sci USA* 114: E11063-E11071 (2017).
4. M. Gwizdala et al. *J Phys Chem Lett* 9:2426-2432 (2018).
5. F. Kyeyune et al. *Nanoscale* 11:15139-15146 (2019).
6. B. van Heerden et al. *Small* 18:2107024 (2022).

Date & Time: September 07, 2023, 5:30 PM IST	Venue: Zoom Meeting

Visualizing Quantum Matter

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Everything around us, everything each of us has ever experienced, and virtually everything underpinning our technological society and economy is governed by quantum mechanics. Yet this most fundamental physical theory of nature often feels as if it is a set of somewhat eerie and counterintuitive ideas of no direct relevance to our lives. Why is this? One reason is that we cannot perceive the strangeness (and astonishing beauty) of the quantum mechanical phenomena all around us by using our own senses.

I will describe the recent development of techniques that allow us to image electronic quantum phenomena directly at the atomic scale. As examples, we will visually explore the previously unseen and very beautiful forms of quantum matter making up *electronic liquid crystals[1,2], high temperature superconductors[2,3,4] or electron-pair crystals [5,6,7,8]*. I will discuss the implications for fundamental physics research and also for advanced materials and new technologies, arising from quantum matter visualization.

References:

1. **Science 344**, 612 (2014).
2. **Nature 570**, 484 (2019).
3. **Science 357**, 75 (2017).
4. **Science 364**, 976 (2019)
5. **Nature 571**, 234 (2020).
6. **Nature 532**, 343 (2016)
7. **Science 372**, 1447 (2021).
8. **Nature 618**, 921 (2023)

Date & Time: September 08, 2023, 3:30 PM IST	Venue: IISER Tirupati

Embracing the Quantum Era

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Discover the forefront of quantum computing with IBM Quantum. In this keynote talk, I explore recent developments in quantum hardware and software. I unveil IBM Quantum's roadmap, offering a glimpse into the future of quantum computing. I showcase recent activities and advancements as IBM Quantum continues to push the boundaries of what's possible, driving quantum computing towards quantum advantage.

Date & Time: September 11, 2023, 6:30 PM IST	Venue: Zoom Meeting

Electron Collisions with Atoms, Ions, and Molecules: Fundamental Science Empowering Advances in Technology

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Electron collisions with atoms, ions, and molecules are critically important to the understanding and modeling of low-temperature plasmas (LTPs), and hence in the development of technologies based on LTPs [1]. Recent progress in obtaining experimental benchmark data and the development of highly sophisticated computational methods is highlighted [2]. We demonstrate how accurate and comprehensive datasets for electron collisions [3,4] enable complex modeling of plasma-using technologies that empower our high-technology society.

References:

1. K. Bartschat and M.J. Kushner, Proceedings of the National Academy of Sciences 113: 7026-7034 (2016)
2. O. Zatsarinny and K. Bartschat, Journal of Physics B: Atomic, Molecular and Optical Physics 46: 112001 (2013)
3. J. Tennyson et al., Plasma Sources Science and Technology 31: 095020 (2022)
4. https://us.lxcat.net/home/

Date & Time: October 13, 2023, 8:30 PM IST	Venue: Zoom Meeting

Precision measurement and spectroscopy with Nitrogen-Vacancy centers in diamond

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Color centers in wide-bandgap semiconductors have emerged as a leading platform in the field of quantum sensing, broadly defined as the use of qubits to measure environmental parameters. My research group uses Nitrogen-Vacancy (NV) centers in diamond to image magnetic phenomena in condensed-matter and biological systems over a broad range of length scales. At the nanometer scale, we are building super resolution magnetic microscopes to image magnetic nanoparticles with 50-100 nm resolution. At the micrometer scale, we embed diamond sensors inside microfluidic chips to perform nuclear magnetic resonance spectroscopy at the scale of single cells [1]. At the millimeter scale, we use magnetic flux concentrators to detect femtotesla-level magnetic fields [2,3], with potential applications in medical imaging, navigation, and even dark matter detection [4]. I will provide an introduction to the field, discuss recent results and ongoing challenges, and outline future directions.

References:

1. J. Smits*, J. Damron*, P. Kehayias, A. F. McDowell, N. Mosavian, N. Ristoff, I. Fescenko. A. Laraoui, A. Jarmola, V. M. Acosta, Science Advances 5 eaaw7895 (2019).
2. I. Fescenko, A. Jarmola, I. Savukov, P. Kehayias, J. Smits, J. Damron, N. Ristoff, N. Mosavian, V. M. Acosta, Physical Review Research 2, 023394 (2020).
3. Y. Silani, J. Smits, I. Fescenko, M. W. Malone, A. F. McDowell, A. Jarmola, P. Kehayias, B. Richards, N. Mosavian, N. Ristoff, V. M. Acosta, Science Advances 9 : eadh3189 (2023).
4. P.-H. Chu*, N. Ristoff*, J. Smits, N. Jackson, Y. J. Kim, I. Savukov, V. M. Acosta, Physical Review Research 4, 023162 (2022).

Date & Time: October 16, 2023, 3:00 PM IST	Venue: IIT Tirupati

Valley polarization in two-dimensional borocarbonitride systems

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In case of honeycomb lattices with staggered sublattice potentials, e.g., transition metal dichalcogenides, gapped graphene etc., the broken spatial inversion symmetry can induce non-zero Berry curvature [1]. The presence of two inequivalent time-reversal pair gapped valleys at high-symmetric points, K and K' in their first Brillouin zone exhibit opposite Berry curvatures and hence opposite valley polarizations [2]. Such systems are expected to interact differently with different circularly polarized lights, leading to circular dichroism Hall effect [3]. This additional electronic degrees of freedom in these low-dimensional systems can be exploited for advanced device applications. The low-energy optical excitations in these systems are mostly dominated by excitons that are localized in momentum space. However, increased interactions of excitons between two different valleys can lead to intervalley exciton scattering and can decrease the valley polarization significantly, as has been observed in hexagonal boron-nitride system [4]. In this presentation, I shall demonstrate our recent findings of valley polarizations in non-centrosymmetric honeycomb lattices of different borocarbonitride systems with insignificant intervalley exciton couplings. Our proposed systems are experimentally conducive and can be exploited to realize valley-Hall devices [5]. We have adopted the computational framework of ab-initio GW and GW – Bethe Salpeter equation approaches to incorporate the quasiparticle excitations and the many-body interactions among them [6].

References:

1. D. Xiao et al., Phys. Rev. Lett. 108: 196802 (2012)
2. S. A. Vitale et al., Small 1801483 (2018).
3. K. F. Mak et al., Science 334: 1489 (2014)
4. F. Zhang et al., Phys. Rev. Lett. 128: 047402 (2022)
5. S. Adhikary et al., communicated (2023)
6. A. Chernikov et al., Phys. Rev. Lett. 113: 076802 (2014)

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An excursion in quantum matter

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The term "quantum matter" is typically used to describe many-body systems with emergent macroscopic properties that are intrinsically quantum mechanical. A theoretical description of "quantum matter" is beyond the scope of two most successful paradigms of many body physics, namely notion of symmetry breaking and the notion of integrity of electron as a quasi-particle.

In this talk I will focus on such quantum matter phases in the context of magnetism. IA hallmark of the quantum matter phase is a long-range entangled ground state with fractional, non-local quasiparticles. I will discuss recent progress in understanding such fractional quasiparticles in several magnetic systems of topical interest.

References:

1. S. Sanyal, A. Wietek, J. Sous, arXiv preprint arXiv:2210.00012 (2022)
2. S. Sanyal, K. Dhochak, S Bhattacharjee, Physical Review B, 99,13, 134425(2019)
3. K. Sahoo, PhD Thesis (unpublished).
4. S.Sanyal, K. Damle, J.T. Chalker, R. Moessner. Physical Review Letters, 127,12, 127201 (2021)

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PANEL DISCUSSION

Panelists: To Be Announced