Dr. Anirudha Menon

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Work Experience

Faculty & Mentor | Apr 2022-Present | Vector Educational & Consultancy Services

· Mentored students to be efficient and effective problem solvers in physics and mathematics

· Fostered adaptive learning, curiosity, and independent thinking

· Participates in technical as well as administrative roles

Research Scientist | Jan 2022-Present | Indian Statistical Institute Kolkata

· Initiated research in the field of emergent fractal structures in socio-economic contexts as an inter-disciplinary venture combining mathematics, physics, and climate studies

· Worked on global moisture content datasets presented as Geotiff files using python modules to extract the emergent fractal structures embedded in the data

· Calculated the temporal evolution of fractal dimension for the distribution of moisture content

Education

PhD Physics | Sept 2021 | University of California, Davis (UCD)

· PhD in Physics (Sept 2021)

· Graduated with a GPA of 3.825 out of 4.

· Advanced to Candidacy (2018) in Conformal Field Theory

· Changed fields to Condensed Matter Theory shortly after advancing to candidacy

· Core coursework: Quantum Mechanics, Statistical Mechanics, Mathematical Methods in Physics

· Elective coursework: Condensed Matter Physics, Quantum Field Theory, Particle Physics, High Energy Experiment, Collider Physics, String Theory, Conformal Field Theory, General Relativity, Cosmology, Super Symmetry

Master of Science, Physics (M.S.) | 2015 | University of Illinois at Chicago (UIC)

· Graduated 1st in the cohort with a GPA of 4.0 out of 4.

· Passed the Ph.D. qualifying examination in 2015 with the highest score in Quantum Mechanics, Classical Mechanics and Statistical Mechanics. Was awarded the Paul M. Raccah Award for the highest score on

Ph.D. qualifying examination.
· Core coursework: Quantum Mechanics, Classical Mechanics (undergraduate course), Statistical
  Mechanics (undergraduate course), Electrodynamics
· Elective coursework: Solid State Physics, Mathematical Physics

Bachelor of Engineering, Civil Engineering (B.E.) | 2011 | Jadavpur University

· Graduated with 2nd class and a CGPA of 6.36 out of 10
· General coursework: Structural Mechanics, Engineering Physics, Mathematics, Soil Engineering, Steel
  Design, Environmental Engineering, Hydrology, Woodwork Workshop, Metal Workshop, Surveying,
  Concrete Design, Transportation Engineering

Research Experience

Post-doctoral Researcher at Freie University and Helmholtz-Zentrum Berlin (Sep 2021-Jan 2022)

· Worked on aspects of quantum magnetism including Quantum Spin Liquids, Emergent Fractionalization,
  and Fractons
· Used numerical techniques like Exact diagonalization, and Numerical Linked Cluster Expansions to study
  the properties of quantum Fractons in two dimensions
· Studied the dynamics of the crossover between disordered phases and glassy phases in two dimensional
  J_1-J_2 models on a square lattice using Classical Monte Carlo techniques
· Studied the phase transitions of the Heisenberg-DMI model on the pyrochlore lattice using numerical
  Linked cluster techniques

Research Assistant in the Luty group, UCD (Sep 2016 – May 2018)

· Conducted research on conformal field theories in greater than two dimensions, with a focus on the
  conformal bootstrap program, and focused on the development of Lorentzian bootstrap using analytic
  continuation
· Made significant progress in eliminating certain configurations of operators in 4-point functions which
  were unsuitable for extracting meaningful insights about the bounds on the operator-product-expansion
  (OPE) coefficients
· Discovered a suitable 4-operator configuration which was consequently used to derive the complex
  version of the bootstrap equations developed by Ricardo Rattazzi et al which could potentially yield
  sharper bounds on the OPE coefficients

Research Assistant in the Singh group, UCD (Sep 2018 – Jun 2021)

· Examined the properties of quantum spin liquid spin ½ models on the pyrochlore lattice, specifically the
  random transverse field Ising model and the random bond easy axis Heisenberg anti-ferromagnetic
  model

- Used numerical techniques like exact diagonalization and Numerical Linked Cluster expansions to study various physical properties like Entanglement Entropy, Bandwidth, Ising correlations, and Dynamical Structure Factor, and to map out the phase diagrams of these models
- Conducted research on the nature and effects of light-matter interactions on the transport properties of topological multi-Weyl semimetals using Floquet theory, the Matsubara Green's function formalism, and the Kubo formalism
- Studied the effects of a perpendicular magnetic field on the continuum multi-Weyl semimetal model and determined the effects on the topological Hall conductivity in the type-I and type-II phases
- Studied the chiral magnetic effect and anomalous Hall effect in time-reversal and inversion symmetry breaking lattice models of multi-Weyl semimetals as a function of material parameters such as tilt
- **Technical skills:** Exact diagonalization, Krylov space methods, Numerical Linked Cluster Expansions, Sparse matrix computations, Representation Theory, Tensor Networks, Series Expansions, Tensor Algebra, Graph Theory, Lattice Perturbation Theory, Linear response theory, Kubo-Floquet formalism, Floquet-Matsubara formalism, Lorentz Invariant QFTs, Languages: Python, C++, Mathematica
- **Thesis title:** *Theoretical and Computational Explorations of Topological Materials*
- Significant results from thesis research are summarized as follows:
    - Determined the phase diagram of the random transverse field Ising model on the pyrochlore lattice. Obtained the phase boundary scaling as a function of the mean and variance of the magnetic field distribution
    - Devised a modified version of the numerical linked cluster expansion to study the phase transition from the paramagnetic phase to the quantum spin liquid phase by restricting to the ground-state manifold of spin-ice states and fixing the external spins on the pyrochlore hexagonal loops as part of the mean field effect.
    - Derived the Floquet version of the Matsubara Green's function formalism to leading order in the Van-Vleck perturbative expansion
    - Found the analytic expressions for the Hall conductivity, the thermal Hall conductivity, and the Nernst coefficient for laser driven Weyl and multi-Weyl semimetals in the type-I and type-II phases in the high frequency limit
    - Calculated the Hall conductivity for a multi-Weyl semimetal continuum model in a perpendicular magnetic field, and discovered that the topological term vanishes in the type-II phase
    - Employed computational methods to calculate the chiral magnetic parameter in lattice models of multi-Weyl semimetals, and found that the Lifshitz transition is characterized by a peak in the chiral magnetic parameter versus tilt plot

CMP summer school at Princeton University (Jul 2019, Jul 2020)

- Attended the summer school at Princeton University in person in 2019 and online in 2020
- Presented a talk on the random transverse field Ising model research conducted with Rajiv Singh and Tom Pardini at UC Davis and Lawrence Livermore National Laboratory

Correlated20: Invited program at KITP, University of California, Santa Barbara (Sep 2020 – Dec 2020)

· Was invited to participate in this prestigious invite-only two-month program at UC Santa Barbara in 2020
· Attended lectures, talks, and seminars on quantum spin liquids and Moire materials over the course of the program
· Got to interact with world-renowned faculty and researchers like Leon Balents and Lucile Savary in an informal setting

Master of Science, Physics M.S. candidate at University of Illinois at Chicago (Mar 2014 – May 2015)

· Modelled cholesterol transport in cholesterol using diffusion equations, leading to a poster presentation at Institut Laue–Langevin
· Attempted to use the more complex Fokker-Planck formalism to map cholesterol transport in lipid membranes

Research Publications

· *A. Menon,* S. Chattopadhyay, B. Basu, **Chiral magnetic effect in lattice models of tilted multi-Weyl semimetals**, Phys. Rev. B 104, 075129, 2021

· *A. Menon,* B. Basu, **Hall transport of Landau quantized stated in tilted models of multi-Weyl semimetals**, J. Phys.: Condens. Matter 33, 045602, 2020

· T. Nag, *A. Menon,* B. Basu, **Thermoelectric transport properties of Floquet multi-Weyl semimetals**, Phys. Rev. B 102, 014307, 2020

· *A. Menon,* T. Pardini, R. Singh, **Confinement, reduced entanglement, and spin-glass order in a random quantum spin-ice model**, Phys. Rev. B 101, 188423, 2020

· T. Pardini, *A. Menon,* R. Singh, **Local entanglement and confinement transitions in the random transverse-field Ising model on the pyrochlore lattice**, Phys. Rev. B 100, 144437, 2019

· *A. Menon,* D. Chowdhury, B. Basu, **Photoinduced tunable anomalous Hall and Nernst effects in tilted Weyl semimetals using Floquet theory,** Phys. Rev. B 98, 205109, 2018

· *A. Menon,* D. Chowdhury, B. Basu, **Hybridization and Field Driven Phase Transitions in Hexagonally Warped Topological** Insulators, Spin 6, 1640005, 2016

· *A. Menon,* D. Chowdhury, B. Basu, **Effect of perturbative hexagonal warping on quantum capacitance in ultra-thin topological insulators,** J. Phys. D: Appl. Phys. 49, 135003, 2016

Conference Presentations and Seminars

· A. Ghasemi, *A. Menon*, S. Gao, C. Broholm, R. Cava, R. Singh, N. Drichkos, **Determination of spin Hamiltonian for an ideal triangular lattice of Yb in NaBaYb(BO$_3$)$_2$,** Bulletin of the American Physical Society 2022

· _A. Menon_, T. Pardini, R. Singh, **Role of Disorder in the Physics of Quantum Spin Ice models,** Princeton Summer School for Condensed Matter Physics 2020
· _A. Menon_, D. Chowdhury, B. Basu, **Linearized Transport in Weyl Semimetals with Arbitrary Chern Numbers**, Condensed Matter Seminar at UC Davis 2019

Teaching experience

· Currently (2022-) teaching physics and mathematics at the Vector Institute of Physics, Kolkata, India for grades IX-XII. All instructions are in English
· Lectured physics courses (2018-2021) in classical mechanics, electromagnetism, quantum mechanics, and special relativity (Physics 9A, 9C, and 9D) at the University of California, Davis, designed for engineering and science students in their freshman and sophomore years
· Lectured physics courses (2017-2021) in classical mechanics (Physics 1A) at the University of California, Davis, designed for social science students in their freshman and sophomore years
· Taught classroom and lab based undergraduate physics courses as a teaching assistant (2015-2018) at UC Davis for physics, engineering, and social science majors including one advanced course in quantum field theory at the graduate level
· Taught classroom and lab based undergraduate physics courses as a teaching assistant (2013-2015) at the University of Illinois at Chicago for social science majors
· All lectures in the United States were delivered in English, and classes were held in-person except during COVID-19, i.e., in the timeline March 2020 to June 2021. The curriculum in use was the University of California's physics curriculum for undergraduate students in college.

Honors and awards

· Awarded the Paul M. Raccah award for the highest score on the Ph.D. qualifying examination at the University of Illinois at Chicago in 2015
· Travel Grant awarded to attend the Princeton summer school in condensed matter physics in 2019 by the department of physics at UC Davis
· Research assistantship awarded by the Lawrence Livermore National Laboratory (Mar 2019 – Dec 2019) as part of an NSF grant for studying quantum spin liquids using computational techniques

Test scores

· National Eligibility Test, **AIR: ??** (2022)
· TOEFL iBT: 118 on a scale of 120 (2012)
· Physics GRE: Scored 910 out of a possible 990 (90th percentile) in 2014
· General GRE: Scored 322 out of possible 340 (85th percentile) in 2012
· GATE Civil Engineering: Ranked 636 out of … candidates (2011)
· WBJEE: Ranked 1,587 out of over 1,00,000 candidates (2006)
· Indian School Certificate Examination: 88.5% (I.S.C. 2006)
· Indian Certificate of Secondary Education: 95.2% (I.C.S.E. 2004)