Shovan Dutta Curriculum Vitae June 2018

Contact Information

Cornell University
Laboratory of Atomic and Solid State Physics
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Academic Position

Graduate Research / Teaching Assistant — August 2012 - present
Cornell University

Supervisor: Prof. Erich Mueller
Group website: muellergroup.lassp.cornell.edu

Education

Cornell University, Ithaca, NY — 2012 - 2018
Ph.D. in Physics, 2018 (Advisor: Prof. Erich Mueller)
Dissertation: Collective phenomena in quantum gases
M.S. in Physics, 2015

Jadavpur University, Kolkata, India — 2008 - 2012
B.E. in Electronics and Tele-Communication Engineering
1st class with Honours, CGPA: $9.42/10$

Howrah Zilla School, Howrah, India — 1998 - 2008
Passed Higher Secondary Examination in 2008 with 96.33% in Science group

Awards and Academic Achievements

Division of Atomic, Molecular, and Optical Physics (DAMOP) Travel Award from the American Physical Society (APS), 2017 and 2018

Dr. V. Ramachandra Rao Summer Fellowship, Cornell University, 2013

Hartmann Memorial Teaching Award, Cornell University, 2012-2013

Dr. Shyama Prasad Mukherjee (SPM) Fellowship from the Council of Scientific and Industrial Research (CSIR), India, 2012

1st all over India in CSIR National Eligibility Test (NET) in the Physical Sciences, 2012, for award of Junior Research Fellowships and eligibility for lecturership

1st all over India in Joint Entrance Screening Test (JEST) in Physics, 2012, organized by 23 premier research institutes in India

Within top 50 in TIFR (Tata Institute of Fundamental Research) Physics Nationwide Entrance examination 2012

1st all over India in Graduate Aptitude Test in Engineering (GATE) Physics 2011, organized by the Indian Institute of Science (IISc) and the Indian Institutes of Technology (IITs)

Best paper award in National Students Paper and Circuit Design Contest (NSPCDC) 2011, organized by IEEE Jadavpur University Students' Branch and IEEE Calcutta Section

Late Supriya Basu Scholarship from Jadavpur University Alumni Association (Mumbai Branch) for securing the highest grade in the entire Engineering faculty in 2010

1st among 67,655 students in the West Bengal Joint Entrance Examination (WBJEE) in engineering, 2008 [news article in The Telegraph] – Gold medal from Howrah Zilla School

Estimated rank 19 among 424,651 students in the West Bengal Higher Secondary Examination, 2008. Government of India, Ministry of Human Resource Development (MHRD) Scholarship

Ranked 2nd in West Bengal in the Achievement-cum-Diagnostic Test in Mathematics (ADTM) 2007, organized by the Centre for Pedagogical Studies in Mathematics

RESEARCH DURING PHD

Theoretical study of ultracold quantum gases: As matter is cooled to very low temperatures, strange quantum-mechanical properties emerge. My research consists of analyzing mathematical models of such quantum gases of atoms and photons using a blend of analytical and numerical techniques. The projects I work on fall under the following broad research areas:

- **Superfluidity in ultracold gases of fermions and bosons:** kinetics of Bose condensation, spread of impurities, stability and dynamics of collective excitations such as domain walls, vortices, and polarons, experimental signatures of different superfluid states.
- **Quantum phase transitions and crossovers:** Characterizing quantum phase transitions and crossovers by studying the variation of physical properties, e.g., the Superfluid-Mott transition in Bose gases, BEC-BCS crossover in Fermi gases, and dimensional crossovers.
- **Nonequilibrium dynamics:** Spread of impurities, condensate formation, thermalization, soliton dynamics, collective oscillations and waves, driven optical cavities. Different theoretical tools – rate equations, Fermi's golden rule, Heisenberg/Schrodinger equations, Bogoliubov-de Gennes equations, Lindblad type master equations, and variational ansatz.
- **Exotic many-body quantum states:** Proposing experimental protocols to prepare, detect, and manipulate quantum states with exotic features, such as FFLO (Fulde-Ferrell-Larkin-Ovchinnikov) and breached-pair superfluidity in spin-imbalanced Fermi gases, and photonic Laughlin states and anyons in specially designed optical cavities.
- **Emergent macroscopic structures:** Stability and dynamics of persistent nonlinear waves or solitons and quasiparticle excitations such as polarons and bipolarons in superfluids.
- **Open quantum systems:** Modeling driven dissipative quantum systems to study the formation and detection of novel many-body states, such as those accessible through strong light-matter coupling in a cavity. Examples include the study of fractional quantum Hall states of polaritons and anyonic quasiparticles in a driven optical cavity.

RESEARCH AS AN UNDERGRAD

Bifurcation in dynamical systems: Analyzing equations of motion of simple nonlinear systems with feature-rich bifurcation diagrams, coming up with theoretical techniques to characterize borderline cases where linear stability analysis fails, and proposing tunable electronic circuits which will possess a given set of bifurcations.

Random walks: Using probability arguments to construct and solve integro-differential equations describing the dynamics of a particle executing a continuous-time random walk under an arbitrary time-varying external field, leading to subdiffusive transport seen in disordered media.

Photoemission from thin films: Analyzing quantum Boltzmann rate equations to study the photocurrent from a semiconductor film as a function of the film thickness and the frequency and polarization of the incident light.

PT-symmetric quantum mechanics: Exploring the mathematical properties of a class of non-Hermitian Hamiltonians that are are symmetric under spacetime reflection, and showing how they are physically equivalent to Hermitian Hamiltonians used in ordinary quantum mechanics.

Liquid-gas phase transition of cold nuclear matter: Using the Bethe-Peierls approximation of quantum statistical mechanics to model the liquid-gas phase transition in a cubic lattice gas model of cold nuclear matter.

Journal Publications

[Summary with illustrations available at shovandutta.org/research/]

1. **Shovan Dutta** and Erich J. Mueller, "Coherent generation of photonic fractional quantum Hall states in a cavity and the search for anyonic quasiparticles," Phys. Rev. A **97**, 033825 (2018) [pdf] [supplement] [arXiv] [news story].
2. **Shovan Dutta** and Erich J. Mueller, "Protocol to engineer Fulde-Ferrell-Larkin-Ovchinnikov states in a cold Fermi gas," Phys. Rev. A **96**, 023612 (2017) [pdf] [arXiv].
3. **Shovan Dutta** and Erich J. Mueller, "Collective modes of a soliton train in a Fermi superfluid," Phys. Rev. Lett. **118**, 260402 (2017) [pdf] [arXiv] [news story].
4. **Shovan Dutta** and Erich J. Mueller, "Dimensional crossover in a spin-imbalanced Fermi gas," Phys. Rev. A **94**, 063627 (2016) [pdf] [arXiv].
5. **Shovan Dutta** and Erich J. Mueller, "Kinetics of Bose-Einstein condensation in a dimple potential," Phys. Rev. A **91**, 013601 (2015) [pdf] [arXiv].
6. **Shovan Dutta** and Erich J. Mueller, "Variational study of polarons and bipolarons in a one-dimensional Bose lattice gas in both the superfluid and the Mott-insulator regimes," Phys. Rev. A **88**, 053601 (2013) [pdf] [arXiv].

Unpublished research

1. Thermalization in a quasi-one-dimensional quantum gas [A-exam problem – manuscript and slides available in shovandutta.org/research/#unpublished].
2. 1D-to-3D crossover in a spin-imbalanced Fermi gas in an array of coupled tubes [extension of work on dimensional crossover in a single tube].

Conference posters

1. Shovan Dutta and Erich Mueller, "Creating Laughlin states and braiding anyons in an optical cavity."
   - 49th Annual Meeting of APS DAMOP, May 30, 2018, Ft. Lauderdale, FL [poster]
   - CCMR Symposium on Photonics & Quantum Optics, May 23, 2018, Ithaca, NY [poster]
   - ITAMP workshop on Many-Body Cavity QED, Oct 10, 2017, Boston, MA [poster]
   - ARO AFOSR Quantum Matter MURI review, Oct 12, 2017, Gaithersburg, MD
2. Shovan Dutta and Erich Mueller, "Collective modes of a soliton train in a Fermi superfluid."
   - 48th Annual Meeting of APS DAMOP, Jun 6, 2017, Sacramento, CA [poster]
   - ARO AFOSR MURI Program Review, Sep 27, 2016, Chicago, IL [poster]

Undergrad research papers

1. **Shovan Dutta** and Subhankar Ray, "Damped bead on a rotating circular hoop - a bifurcation zoo," arXiv:1201.1218 (2012) .
2. **Shovan Dutta** and Subhankar Ray, "Bead on a rotating circular hoop: a simple yet feature-rich dynamical system," arXiv:1112.4697 (2011).
3. **Shovan Dutta**, Subhankar Ray, and J. Shamanna, "Continuous Time Random Walk with time-dependent jump probability: a direct probabilistic approach," arXiv:1112.3253 (2011).
4. **Shovan Dutta**, "A simple circuit model showing feature-rich Bogdanov-Takens bifurcation." Selected as the best paper in the National Students Paper and Circuit Design Contest (NSPCDC) 2011.
   Available at http://ewh.ieee.org/sb/calcutta/jadavpur/Papers/Circuit_Model_for_Bogdanov-Takens_Bifurcation.pdf.

WORK IN PROGRESS	Understand how the B phase nucleates in experiments when superfluid ^{3}He is supercooled below the A-B transition temperature [more details at shovandutta.org/research/#workinprogress].
REFEREED FOR	Physical Review Letters, Physical Review A
TEACHING EXPERIENCE	Teaching Assistant at Cornell University [evaluations available at shovandutta.org/teaching/]

1. PHYS 3327: Advanced Electricity and Magnetism — Fall 2016
   Instructed discussion section, designed numerical problems in Mathematica
   Course instructor: Prof. Itai Cohen [course website]
2. PHYS 2216: Introduction to Special Relativity — Fall 2016
   Prepared clicker questions, quiz and exam problems, graded
   Course instructor: Prof. Michelle Wang
3. PHYS 1116: Mechanics and Special Relativity — Spring 2016
   Instructed discussion and lab sections, prepared quizzes, graded
   Course instructor: Prof. Michael Niemack
4. PHYS 2213: Electromagnetism — Fall 2015
   Instructed two discussion sections and one lab section, graded,
   created new demos, managed discussion forum in Piazza
   Course instructor: Prof. Kyle Shen
5. PHYS 1203: Physics of the Heavens and the Earth — Spring 2015
   Instructed discussion section, supervised projects, graded
   Course instructor: Prof. David A. Kronreich
6. PHYS 2208: Fundamentals of Physics II — Spring 2014, Spring 2013
   Instructed three discussion sections, prepared quizzes, graded
   Course instructor: Prof. Matthias Liepe
7. PHYS 2207: Fundamentals of Physics I — Fall 2012
   Instructed two discussion and one lab sections, prepared quizzes, graded
   Course instructor: Dr. Kathy Selby

LANGUAGES	English (fluent), Bengali (native), Hindi (working knowledge), Sanskrit (beginner)
EXTRA-CURRICULAR ACTIVITIES	Music – learned Indian raagas and Bengali music for ten years, won singing competitions! Reading non-fiction, watching documentaries, movies, and interviews Walking through the woods, boating on lakes Playing cricket, tennis, and the harmonium