Curriculum Vitae

Himadri Barman

Post-doctoral Research Fellow
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Education

PhD in Theoretical Condensed Matter Physics, Jawaharlal Nehru Centre for Advanced Scientific Research (JNCASR), Bangalore, India, 2012.

Dissertation title: *Diagrammatic perturbation theory based investigations of the Mott transition physics.*

MSc in Physics, University of Pune, India, 2005.

BSc (Hons.) in Physics, Presidency College, University of Calcutta, India, 2003.

Employment/Post-PhD research experiences

Postdoctoral fellow in Institute of Mathematical Sciences (IMSc), Chennai, India: March 03, 2016 - present.

Visiting Fellow (postdoctoral) in Dept. of Theoretical Physics, Tata Institute of Fundamental Research (TIFR), Mumbai, India: December 5, 2013 - February 4, 2016.

Visiting Scholar (postdoctoral) in School of Physical Sciences, Jawaharlal Nehru University, New Delhi, India: July 15, 2013 - November 30, 2013.

Research associate (postdoctoral) in JNCASR, Bangalore, India: December 7, 2011 - July 12, 2013.

Research Interests

Research area: Theoretical condensed matter physics.
Research topics:

Metal-insulator transition in presence of electronic correlations and disorder, particularly in transition metal oxides.

Non-Hermitian quantum mechanics and application to non-equilibrium physics.

Electronic properties at the interface of different correlated materials.

Developing efficient numerical methods for solving many-body Hamiltonians, specifically using the dynamical mean field theory (DMFT).

Correlated topological insulators.

Publications

Published

1. H. Barman, *Local moment approach as a quantum impurity solver for the Hubbard model*, Phys. Rev. B 94, 045106 (2016), doi: 10.1103/PhysRevB.94.045106, arxiv.org link: `http://arxiv.org/abs/1412.4434`.

   Highlights: Zero temperature study of the particle-hole asymmetric Hubbard model using local moment approach (LMA) as a quantum impurity solver (QIS) within the DMFT framework; First time observed Mott-transition using LMA as QIS; LMA promises more efficient and numerically less expensive semianalytical tool as it obeys the spectral moment

sum-rule very well; Fermi liquid scaling universality in spectral densities and optical properties found.

2. V. Tripathi, A. Galda, H. Barman, V. M. Vinokur *Parity-time symmetry-breaking mechanism of dynamic Mott transitions in dissipative systems*, Phys. Rev. B **94**, 041104(R) (2016), doi: 10.1103/PhysRevB.94.041104, arxiv.org link: http://arxiv.org/abs/1510.08355.

   Highlights: Critical behavior of electric field-driven (dynamic) Mott insulator-to-metal transitions in dissipative Fermi and Bose systems in terms of non-Hermitian Hamiltonians invariant under simultaneous parity (P) and time-reversal (T) operations discussed in 1D and 2D interacting fermionic and bosonic systems; the renormalization and collapse of the Mott gap due to electric field derived analytically using Bethe ansatz for 1D and numerically using dynamical field theory (DMFT) in 2D; critical behavior near the Mott transition found with agreement in experiments.

3. H. Barman and N. S. Vidhyadhiraja, *Transport and spectra in the half-filled Hubbard model: a dynamical mean field study*, Int. J. Mod. Phys. B **25** 2461-2479 (2011), doi: 10.1142/S0217979211100977, arxiv.org link: http://arxiv.org/abs/1011.4478.

   Highlights: Direct real frequency implementation (avoiding analytical continuation) of the iterated perturbation theory (IPT); detailed study of the optical conductivity at zero and finite temperature; universal features, e.g. the isosbestic points and analysis of the temperature-driven resistivity hysteresis with analytical calculation; experiments on V_2O_3 and $NiS_{2-x}Se_x$ compounds compared.

Submitted/in preparation

1. H. Barman, M. S. Laad, S. R. Hassan, *Realization of a "Two Relaxation Rates" in the Hubbard-Falicov-Kimball Model* arxiv.org link: https://arxiv.org/abs/1611.07594.

   Abstract: A single transport relaxation rate governs the decay of both, longitudinal and Hall currents in Landau Fermi Liquids (LFL). Breakdown of this fundamental feature, first observed in cuprates and subsequently in other *three-dimensional* correlated systems close to (partial

or complete) Mott metal- insulator transitions, played a pivotal role in emergence of a non-Landau Fermi liquid paradigm in higher dimensions $D(> 1)$. Motivated hereby, we explore the emergence of this "two relaxation rates" scenario in the Hubbard-Falicov-Kimball model (HFKM) using the dynamical mean-field theory (DMFT). Specializing to $D = 3$, we find, beyond a critical FK interaction, that two distinct relaxation rates governing distinct temperature (T) dependence of the longitudinal and Hall currents naturally emerges in the non-LFL metal. We rationalize thissurprising finding by an analytical analysis of the structure of charge and spin correlations in the underlying impurity problem, and point out good accord with observations in the famed case of $V_{2-y}O_3$ near the MIT.

2. M. Lankhorst, M. Stehno, A. Galda, V. Tripathi, H. Barman, F. Coneri, H. Hilgenkamp, A. Brinkman, T. Baturina, A. Golubov, V. M. Vinokur, *Vortex Mott phase transitions in proximity arrays.*

   Abstract: We use an array of superconducting nio- bium islands placed on a normal gold substrate to create the eggcrate potential in which magnetic field-induced vortices are frozen into a vortex Mott insulator. We observe temperature- and current-driven vortex Mott transitions and find that thermal- and current-driven transitions have the same critical behavior. We propose a parity-time (PT) symmetry-breaking mechanism of the dynamic Mott transi- tion yielding critical index that perfectly agrees with the experimen- tal results. Our findings experimentally establish an equivalence be- tween a quantum system and a classical system with an extra tempo- ral dimension and enable exploring non-trivial quantum many-body physics and critical phenomena by means of bench-top laboratory experiments on a classical system.

3. H. Barman, E. W. Carlson, K. A. Dahmen, J. M. Honig, D. E. Logan, N. S. Vidhyadhiraja, *Statistics of the resistivity avalanches across the Mott transition.*

   Highlights: Theoretical model proposed to explain the statistics of avalanches found in the resistivity hysteresis in correlated metal-insulator-transition systems; the model assumes a mapping of the random-field Ising model (RFIM) to a bimodal resistor network; a power law behavior in the avalanche size distribution observed and the depen-

dence of the exponent on several physical parameters studied. Reasonable agreement with experiments on VO_2 thin films found.

Scientific Skills

Programming Languages : Fortran 95/77, C/C++, Python, Matlab, Mathematica.

Operating Systems : Unix, Linux, MS DOS.

Scripting languages : Unix shell script, Perl, JavaScript.

Parallel computing : GPU computing, MPI, OpenMP.

Scientific packages : LMTO, VASP (Band structure calculations).

Other Professional Skills

HTML with Cascading Style Sheets (CSS3).

Scientific Journals Reviewed

Journal of Low Temperature Physics (2012).

Pramana - Journal of Physics (2012).

Teaching

Teaching assistant for (Quantum Mechanics -I) in TIFR (Jan-May, 2013)

Teaching assistant for the course *Mathematical Methods in Physics* in JNCASR (Aug.-Dec. 2008).

Tutor in the *Numerical Quantum Many-body Method* workshop in JNCASR (Dec. 2007).

Teaching assistant for the courses *Mathematical Methods in Physics* and *A first course in computational methods* in JNCASR (Aug.-Dec. 2007).

Pre-PhD Project Works

Heavy Fermions: An Overview with Prof. V. B. Shenoy, IISc, Bangalore, May 2006.

A Study of Relativistic Effects in Nanostructures, with Dr. P. Durganandini, Dept. of Physics, University of Pune, May 2005.

Topological (Chern-Simons) Quantum Mechanics in Reduced Form, with Dr. Biswajit Chakraborty, SNBNCBS, Kolkata, July 2004.

Conference and Seminar Presentations

Talks

Spin fluctuations on the verge of Mott localization, APS March meeting, 2013 (http://meetings.aps.org/Meeting/MAR13/Event/184816).

Transport and spectra in the half–filled Hubbard model, APS March meeting, 2011 (http://meetings.aps.org/Meeting/MAR11/Event/141098).

Posters

Zero temperature dynamics of the Hubbard model in infinite dimensions: A local moment approach, Advanced Numerical Algorithms for Strongly Correlated Quantum Systems, Würzburg, Germany (February 23-26, 2015).

An attempt to study magnetic and transport properties of Sr_2VO_4 *by unrestricted Hartree-Fock (UHF) approximation*, JNC research conference on the Chemistry of Materials, Alleppey, Kerala. (September 27-29, 2008).

Transport and Thermodynamics in the Hubbard Model and A visit to Mott transition, JNCASR In-house symposium, (November 19-20, 2007).

Specific Heat in Hubbard Model and Its Applications to Doped Mott Insulators, Symposium on Trends in Computational Material Sciences, JNCASR, Bangalore (February 16, 2007).

Conferences and Workshops Participated in

1. February 23-26, 2015: Advanced Numerical Algorithms for Strongly Correlated Quantum Systems, Würzburg, Germany.
2. February 9-21, 2015: School on Topological Quantum Matter, HRI, Allahabad.
3. February 10-16, 2014: School and Workshop on Physics of Cold Atoms, HRI, Allahabad.
4. January 6-17, 2014: Strongly correlated systems: From models to materials, ICTS, Bangalore.
5. March 18-22, 2013: American Physical Society (APS) March meeting, Baltimore, MD, USA.
6. January 03-05, 2013: Mini Winter School on Quantum Information and Quantum Computation, ICTS, Bangalore.
7. December 19-21, 2012: Discussion Meeting: Advances in Graphene, Majorana Fermions, Quantum Computation, ICTS, Bangalore.
8. December 16-18, 2012: Mini program on Dirac Material and Quantum Computation, ICTS, Bangalore.
9. March 19-21, 2012: K. S. Krishnan Discussion Meeting on Frontiers in Quantum Science 2012: Tensor Network States for Quantum Matter, IMSc, Chennai.
10. December 27, 2011 - January 11, 2012: International Nonequilibrium Winter School, IISER, Kolkata.
11. June 29 - July 13, 2011: International School on Topology in Quantum Matter, IISc, Bangalore.
12. March 21-25, 2011: American Physical Society (APS) March meeting, Dallas, TX, USA.
13. January 11-13, 2011: Multi-scale modeling and Simulations of Materials, JNCASR-UCL Workshop, JNCASR, Bangalore.
14. December 12 23, 2010: ICTS Condensed Matter Programme, Mysore.

15. December 21-22, 2009: Frontiers in Quantum Science 2009, IMSc, Chennai.
16. December 5-20, 2009: ICTS Condensed Matter Programme 2009, Mahabaleshwar.
17. October 6-8, 2009: School on Parallel Computation, The Advanced Material Research Unit, S N Bose National Centre For Basic Sciences, Kolkata .
18. March 5-7, 2009: School of Physics Symposium-2009, Jawaharlal Nehru University, New Delhi.
19. September 27-29, 2008: JNC research conference on the Chemistry of Materials, Alleppey, Kerala.
20. Oct. 29 Nov. 3, 2007: Numerical Quantum Many-body Method in Physics and Chemistry, JNCASR, Bangalore.
21. February 15-17, 2007 : Symposium on Trends in Computational Material Sciences, JNCASR, Bangalore.
22. January 16-18, 2007 : Workshop on Correlated and Novel Materials, Centre for Theoretical Studies, IIT Kharagpur, Kharagpur.
23. July 24-28, 2006 : Physics Near Mott Transition, IISc, Bangalore.
24. July 10-22, 2006 : Summer School on "Electronic Structure Methods and their Applications" in conjunction with Conference on Computational Materials Theory, JNCASR, Bangalore.
25. February 20-22, 2006 : India-European Thematic Meeting on Computational Material Science, IISc, Bangalore.

Professional Activities

Member, American Physical Society, 2010–Present.

Outreach and Other Activities

Jan 3 to Jan 12, 2017 : Participated and presented a demonstrative session titled "*Going Green : Energy that matters*" in the outreach program

named "It's a Materials World" organized by the outreach group VIGYANshaala and IMSc Chennai, targetting school children in Delhi and Tamilnadu states in India.

April 9, 2016 : Demonstrated "*Fold and one-cut theorem*" on Science Day, IMSc, Chennai.

April 24, 2015 : Volunteered in the workshop titled "*Women in Science and Beyond* organized by Science Outreach India (and outreach group supported by Schlumberger Foundation, Faculty of Future, University of Cambridge, United Kingdom).

Author of a science blog: Hbar's Page (https://reducedplanckconstant.wordpress.com).

Honors, Awards, and Fellowships

1. Best poster award in In-house symposium 2007, JNCASR, Bangalore, India.
2. Ranked 42nd in Joint Entrance Screening Test (JEST), India, 2006.
3. Qualified GATE examination 2006, India.
4. National Talent Search Examination (NTSE) award, India, 1997.

References

Prof. Vikram Tripathi

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Prof. S. R. Hassan

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