

# Curriculum Vitae, M. Haque

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Masudul Haque  
Max-Planck Institute for Physics of  
Complex Systems (MPI-PKS)  
Nöthnitzer Strasse 38  
01187 Dresden, Germany.

haque@pks.mpg.de  
Tel. office +49-351-871-1113  
Tel. mobile +31-6-1116-0834  
<http://www.pks.mpg.de/~haque/>  
ResearcherID: C-4861-2011

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## Employment & Education

- **Current institute:** (since October 2006)  
Max-Planck Institute for Physics of Complex Systems (MPI-PKS), Dresden, Germany.  
Currently Staff Scientist (fixed-term) at MPI-PKS, directing a group of  $\approx 5$  researchers.  
Former position title: *Distinguished PKS Postdoctoral Fellow*.  
Held one of three such fellowships at MPI-PKS, until September 2009.
- Nov. 2003 to Sept. 2006: Postdoctoral researcher, Utrecht University, the Netherlands. Employed in cold-atom theory group led by H. T. C. Stoof.
- Ph.D., October 2003. Rutgers, State University of New Jersey.  
Advisor: Andrei E. Ruckenstein.  
Thesis title: *Interaction Effects in the Weakly Repulsive Bose Gas*.
- Graduate student and teaching assistant, 1997 to 2003.  
Rutgers, State University of New Jersey; Department of Physics & Astronomy.
- Lecturer, 1996-97. Physics Department, Shahjalal University, Bangladesh.
- M.Sc., 1996; B.Sc., 1995. Shahjalal University, Bangladesh.

## Research Topics

- **Area:** Condensed Matter Theory.

Collective phenomena in electronic, nanoscale and cold-atom systems.

Focus on non-equilibrium quantum dynamics.

- **Specific topics of published research:**

*Citations refer to publication list.*

Non-equilibrium phenomena; collective quantum dynamics; quenches & ramps [1, 2, 4, 6, 7, 11–14, 19, 21, 22, 25, 26, 29, 30, 34, 42, 45, 49–51].

Trapped atomic fermions and bosons:

- Bose-Hubbard (optical lattice) dynamics [6, 7, 14, 25, 26, 29].
- polarized fermion pairing [39–41];
- strongly interacting one-dimensional bosons [12, 17];
- Bose condensate dynamics [7, 13, 21, 34, 44, 51];
- Feshbach resonances [39, 40, 45];
- BCS-BEC crossover [39–41];
- vortex dynamics in Bose condensates [21, 34, 44];

Cross-discipline application of concepts from *Quantum Information Theory* (e.g., entanglement measures) to condensed matter issues [5, 10, 15, 18, 23, 24, 27, 28, 30, 33, 37, 38].

Topological order and unconventional states in many-particle systems [8, 23, 24, 28, 35–38].

Fractional quantum Hall states [8, 23, 24, 28, 37, 38].

Frustrated magnets [30]. Spin chains [4, 9, 11, 15, 18, 22, 30].

Bethe ansatz and integrability [2, 9, 50].

Wigner crystallization [46]. Single-impurity physics [1, 3, 5]. Pomeranchuk instabilities [35, 36]. Laser-excited semiconductors; excitons [42]. Nonlinear dynamics and pattern formation [13, 34, 42]. The uniform Bose gas [43, 52, 53].

## Research Supervision

*Citations refer to publication list.*

- **Publication Record of Supervision:** Supervised or co-supervised junior researchers for papers [1–7, 9, 10, 12–18, 26–30, 32–34, 37, 38, 51].
- **Recent Group Members:** Researchers in my group during 2012-2014:
  - postdocs: *W. Beugeling, S. Ghosh, E. Quinn, A. Soori*;
  - MPI-PKS PhD students *S. Roy, W. Tschischik*;
  - visiting PhD students *Y. Shchadilova, K. Saha*.
  - Details below.
- **PhD students and postdocs:**
  - Wladimir Tschischik.* PhD student with me at MPI-PKS since April 2012. Pursuing research on non-equilibrium dynamics in Bose-Hubbard systems ([6, 14]+ongoing). (R. Moessner, the Department Director, is the formal supervisor.)
  - Oleksandr Zozulya.* Former PhD student of K. Schoutens at University of Amsterdam. I supervised his PhD research closely; all his PhD publications are coauthored with me [27, 28, 33, 37, 38].
  - Wouter Beugeling.* Postdoc under my supervision at MPI-PKS (Oct. 2012 – present). Working on non-equilibrium issues related to the Eigenstate Thermalization Hypothesis ([2]+ongoing).
  - Shreyoshi Ghosh.* Postdoc under my supervision at MPI-PKS (Sep. 2012 – Dec. 2013). Working on non-equilibrium dynamics of the ‘Kondo’ screening cloud ([5]+ongoing).
  - Yulia Shchadilova.* PhD student in Moscow. Frequent visitor at MPI-PKS; e.g., visited my group Dec. 2012 to Feb. 2013. Exploring non-equilibrium evolution in a model designed to show interplay of binding, itinerancy, and impurity (Kondo) physics ([1, 3]+ongoing).
  - Sthitadhi Roy.* PhD student with me at MPI-PKS since August 2013. Pursuing research on non-equilibrium dynamics in topological Chern insulators. (R. Moessner, the Department Director, is the formal supervisor.)
  - Eoin Quinn.* Postdoc under my supervision at MPI-PKS (Sep. 2013 – present). Working on oscillatory driving of many-body systems.
  - Abhiram Soori.* Postdoc under my supervision at MPI-PKS (Oct. 2013 – March 2014). Worked on real-time dynamics at unconventional superconductor interfaces.
  - Vincenzo Alba.* Postdoc at MPI-PKS (Oct. 2010 – Sep. 2012). Joint supervision with A. M. Läuchli. Research on the nature of entanglement spectra in 1D and 2D systems [10, 15, 18].

*Weibin Li.* Former postdoc at MPI-PKS. Worked with me on vortex dynamics [34].

*Ivana Vidanovic.* During PhD studies (in Belgrade), worked with me on non-equilibrium dynamics in spinor condensates [13].

*Auditya Sharma.* While a postdoc in Natal (Brazil) in 2012-2013, worked with me on spectral structures and dynamics in the open-boundary Heisenberg chain [4].

*Kush Saha.* During PhD studies (in India), visited MPI-PKS Sep.–Nov. 2012 to work with me. Explored the Bethe ansatz description of edge-related eigenstates of the open-boundary Heisenberg chain [9].

*Alexey Mikaberidze.* PhD student at MPI-PKS until 2011. Worked with me on an ecology-motivated calculation [32]. Based on this work, Mikaberidze moved to a career in theoretical ecology after his PhD in atomic/laser physics.

*Frank Zimmer.* Former postdoc at MPI-PKS (2009-2011). Worked with me on non-equilibrium dynamics (non-adiabatic ramps in trapped gases) [7, 51].

*V. Ravi Chandra & J. Bandyopadhyay.* Former postdocs at MPI-PKS. Worked with me on entanglement and dynamics in frustrated spin chains [30].

*Ricardo Pinto.* Former PhD student at MPI-PKS. Worked with me on non-equilibrium dynamics in 1D lattice models (interaction-induced edge effects) [29].

- **Undergraduate Research Supervision (longer project):**

*April 2011 – March 2012:* Wladimir Tschischik, student from Technische Universität Chemnitz, performed one-year ‘Diplomarbeit’ research with me at MPI-PKS.

Defended ‘Diplomarbeit’ thesis in March 2012.

Research on non-equilibrium dynamics in Bose-Hubbard ladders [14].

Tschischik is continuing his research with me as PhD student.

- **Undergraduate Research Supervision (short projects):**

Supervising summer research projects for visiting undergraduates.

*Summer 2009:* T. Venumadhav, visited Dresden from I.I.T. (Kanpur, India); 10 weeks.

Research on non-equilibrium dynamics, led to publication; paper [26].

Venumadhav went on to pursue doctoral studies at Caltech.

*February–July 2009:* S. Piatecki, visited Dresden from ENS Paris; 5 months.

Research on geometrically frustrated itinerant systems, later completed with additional collaborators [16, 20]. Piatecki went on to pursue doctoral studies at ENS Paris.

*Summer 2010:* A. Balram, visited Dresden from ISERC (Pune, India); 3 months.

Research on non-equilibrium dynamics in Bose-Hubbard rings.

Balram went on to pursue doctoral studies at Penn State.

*Summer 2011:* S. Chatterjee, visited Dresden from I.I.T. (Kanpur, India); 10 weeks.

Research on non-equilibrium dynamics; continued Balram’s work.

Chatterjee went on to pursue doctoral studies at Harvard.

## Organization & Editorial activities

### Workshop in August 2013

*Title:* Quantum many body systems out of equilibrium (QSOE13)

*Co-organizers:* J. S. Caux (Amsterdam); C. Kollath (Geneva); T. Esslinger (Zürich).

*Format:* Three-week programme (August 12–30, 2013).

*Location & Funding:* Max Planck Institute (MPI-PKS), Dresden, Germany.

*Website:* <http://www.pks.mpg.de/~qsoe13/>

### Workshop in November 2012

*Title:* Entanglement Spectra in Complex Quantum Wavefunctions (ESiCQW12)

*Co-organizers:* Andrei Bernevig (Princeton); Andreas Läuchli (Innsbruck).

*Format:* One-week high-intensity workshop (November 12–16, 2012).

*Location & Funding:* Max Planck Institute (MPI-PKS), Dresden, Germany.

*Website:* <http://www.pks.mpg.de/~esicqw12/>

### Workshop in June 2010

*Title:* Quantum information concepts for condensed matter problems (QICCMP10)

*Co-organizers:* Ian Affleck (UBC, Canada); Ulrich Schollwöck (LMU, Munich).

*Format:* Two-week programme (June 14–25, 2010). 100<sup>+</sup> participants.

*Location & Funding:* Max Planck Institute (MPI-PKS), Dresden, Germany.

*Website:* <http://www.pks.mpg.de/~qiccmp10/>

### Special Issue in J. STAT. MECH (2013/2014)

*Title:* Quantum Entanglement in Condensed Matter Physics

*Co-editors:* Stephan Rachel (T.U. Dresden); Andrei Bernevig (Princeton);  
Andreas Läuchli (Innsbruck); Eduardo Fradkin (UIUC, Illinois).

*Website:* <http://iopscience.iop.org/1742-5468/focus/extra.special4>

## Publication List

### • Published or Accepted:

1. *Quantum quenches and work distributions in ultra-low-density systems.*  
Y. E. Shchadilova, P. Ribeiro, and M. Haque; Phys. Rev. Lett. **112**, 070601 (2014).
2. *Finite-size scaling of eigenstate thermalization: Power-law dependence on Hilbert-space dimension,*  
W. Beugeling, R. Moessner, and M. Haque, Phys. Rev. E **89**, 042112 (2014).
3. *Single-impurity Kondo physics at extreme particle-hole asymmetry.*  
Y. E. Shchadilova, M. Vojta, and M. Haque, Phys. Rev. B **89**, 104102 (2014).
4. *Fine structures in the spectrum of the open-boundary Heisenberg XXZ chain at large anisotropies.*  
A. Sharma and M. Haque, Phys. Rev. A **89**, 043608 (2014).
5. *Real-space structure of the impurity screening cloud in the Resonant Level Model.*  
S. Ghosh, P. Ribeiro, and M. Haque, J. Stat. Mech., accepted (2014).  
Available as preprint: arXiv:1309.0027.
6. *Breathing mode in the Bose-Hubbard chain with a harmonic trapping potential.*  
W. Tschischik, R. Moessner, and M. Haque, Phys. Rev. A, **88**, 063636 (2013).
7. *Slow interaction ramps in trapped many-particle systems: universal deviations from adiabaticity.*  
M. Haque and F. E. Zimmer, Phys. Rev. A **87**, 033613 (2013).
8. *Viewpoint: Toward Fractional Quantum Hall Physics with Cold Atoms.*  
M. Daghofer and M. Haque, Physics **6**, 49 (2013).
9. *Bethe ansatz description of edge-localization in the open-boundary XXZ spin chain.*  
V. Alba, K. Saha, and M. Haque, J. Stat. Mech., P10018 (2013).
10. *Entanglement spectrum of the two dimensional Bose-Hubbard model.*  
V. Alba, M. Haque, and A. M. Läuchli; Phys. Rev. Lett. **110**, 260403 (2013).
11. *Linear quantum quench in the Heisenberg XXZ chain: time dependent Luttinger model description of a lattice system.*  
F. Pollmann, M. Haque, and B. Dora; Phys. Rev. B **87**, 041109 (2013).
12. *Strongly interacting bosons in multi-chromatic potentials supporting mobility edges: localization, quasi-condensation and expansion dynamics.*  
P. Ribeiro, M. Haque, and A. Lazarides; Phys. Rev. A **87**, 043635 (2013).
13. *Spin modulation instabilities and phase separation dynamics in trapped two-component Bose condensates.*  
I. Vidanovic, N. J. Van Druten, and M. Haque; New J. Physics, **15**, 035008 (2013).

14. *Non-equilibrium dynamics in Bose-Hubbard ladders.*  
W. Tschischik, M. Haque, and R. Moessner; Phys. Rev. A **86**, 063633 (2012).
15. *Boundary-locality and perturbative structure of entanglement spectra in gapped systems.*  
V. Alba, M. Haque, and A. M. Läuchli; Phys. Rev. Lett. **108**, 227201 (2012).
16. *Itinerant electrons in the Coulomb phase.*  
L. D. C. Jaubert, S. Piatecki, M. Haque, and R. Moessner;  
Phys. Rev. B **85**, 054425 (2012).
17. *Strongly interacting one-dimensional bosons in optical lattices of arbitrary depth: from the Bose-Hubbard to the sine-Gordon regime and beyond.*  
A. Lazarides and M. Haque, Phys. Rev. A **85**, 063621 (2012).
18. *Entanglement spectrum of the Heisenberg XXZ chain near the ferromagnetic point.*  
V. Alba, M. Haque, and A. M. Läuchli; J. Stat. Mech. P08011 (2012).
19. *Crossover from adiabatic to sudden interaction quench in a Luttinger liquid.*  
B. Dóra, M. Haque, and G. Zaránd; Phys. Rev. Lett. **106**, 156406 (2011).
20. *Analysis of a fully packed loop model arising in a magnetic Coulomb phase.*  
L. D. C. Jaubert, M. Haque, and R. Moessner; Phys. Rev. Lett. **107**, 177202 (2011).
21. *Three-vortex configurations in trapped Bose-Einstein condensates.*  
J. A. Seman, E. A. L. Henn, M. Haque, R. F. Shiozaki, E. R. F. Ramos,  
M. Caracanhas, P. Castilho, C. Castelo Branco, P. E. S. Tavares,  
F. J. Poveda Cuevas, G. Roati, K. Magalhaes, and V. S. Bagnato;  
Phys. Rev. A **82**, 033616 (2010).
22. *Self-similar spectral structures and edge-locking hierarchy in open-boundary spin chains.* — M. Haque, Phys. Rev. A **82**, 012108 (2010).
23. *Disentangling Entanglement Spectra of Fractional Quantum Hall States on Torus Geometries.* — A. M. Laeuchli, E. J. Bergholtz, J. Suorsa, and M. Haque;  
Phys. Rev. Lett. **104**, 156404 (2010).  
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24. *Entanglement Scaling of Fractional Quantum Hall states through Geometric Deformations.* — A. M. Laeuchli, E. J. Bergholtz, and M. Haque;  
New Journal of Physics **12**, 075004 (2010).
25. *Interaction induced fractional Bloch and tunneling oscillations.*  
R. Khomeriki, D. O. Krimer, M. Haque, and S. Flach;  
Phys. Rev. A **81**, 065601 (2010).
26. *Finite-rate quenches of site bias in the Bose-Hubbard dimer.*  
T. Venumadhav, M. Haque, and R. Moessner; Phys. Rev. B **81**, 054305 (2010).
27. *Entanglement between particle partitions in itinerant many-particle states.*  
M. Haque, O. S. Zozulya, and K. Schoutens;  
J. Phys. A: Math. Theor. **42**, 504012 (2009).

28. *Entanglement signatures of Quantum Hall phase transitions.*  
O. Zozulya, M. Haque, and N. Regnault; Phys. Rev. B **79**, 045409 (2009).
29. *Edge-localized states in quantum one-dimensional lattices.*  
R. A. Pinto, M. Haque, and S. Flach; Phys. Rev. A **79**, 052118 (2009).
30. *Entanglement and level crossings in frustrated ferromagnetic rings.*  
M. Haque, J. N. Bandyopadhyay, and V. Ravi Chandra;  
Phys. Rev. A **79**, 042317 (2009).
31. *Probing topological order in quantum Hall states using entanglement calculations.*  
M. Haque; AMS Contemp. Math. **482**, 213 (2009).
32. *Survival benefits in mimicry: a quantitative framework.*  
A. Mikaberidze and M. Haque; J. Theor. Biol. **259**, 462 (2009).
33. *Particle partitioning entanglement in itinerant many-particle systems.*  
O. Zozulya, M. Haque, and K. Schoutens; Phys. Rev. A **78**, 042326 (2008).
34. *A vortex dipole in a trapped two-dimensional Bose condensate.*  
W. Li, M. Haque and S. Komineas; Phys. Rev. A **77**, 053610 (2008).
35. *Symmetry-breaking Fermi surface deformations from central interactions in two dimensions.*  
J. Quintanilla, M. Haque, and A. J. Schofield; Phys. Rev. B, **78**, 035131 (2008).
36. *Pomeranchuk instability: symmetry breaking and experimental signatures.*  
J. Quintanilla, C. Hooley, B. J. Powell, A. J. Schofield, and M. Haque;  
Physica B: Condensed Matter, **403**, 1279 (2008).
37. *Bipartite entanglement entropy in fractional quantum Hall states.*  
O. Zozulya, M. Haque, K. Schoutens, and E. H. Rezayi;  
Phys. Rev. B **76**, 125310 (2007).
38. *Entanglement entropy in fermionic Laughlin states.*  
M. Haque, O. Zozulya, and K. Schoutens; Phys. Rev. Lett. **98**, 060401 (2007).
39. *Trapped fermionic clouds distorted from the trap shape due to many-body effects.*  
M. Haque and H. T. C. Stoof; Phys. Rev. Lett., **98**, 260406 (2007).
40. *Deformation of a Trapped Fermi Gas with Unequal Spin Populations.*  
G. B. Partridge, Wenhui Li, Y. A. Liao, R. G. Hulet, M. Haque, and H. T. C. Stoof;  
Phys. Rev. Lett. **97**, 190407 (2006).
41. *Pairing of a trapped resonantly interacting fermion mixture with unequal spin populations.* — M. Haque and H. T. C. Stoof; Phys. Rev. A **74**, 011602 (2006).
42. *Ring-shaped luminescence pattern in biased quantum wells studied as a steady state reaction front.* — M. Haque; Phys. Rev. E **73**, 066207 (2006).
43. *Squeezing in the weakly interacting uniform Bose-Einstein condensate.*  
M. Haque and A. E. Ruckenstein; Phys. Rev. A, **74**, 043622 (2006).



44. *Ultracold superstring in atomic boson-fermion mixtures.*  
M. Snoek, M. Haque, S. Vandoren, and H. T. C. Stoof;  
Phys. Rev. Lett. **95**, 250401 (2005).
  45. *Dynamics of a molecular Bose-Einstein condensate near a Feshbach resonance.*  
M. Haque and H. T. C. Stoof; Phys. Rev. A **71**, 063603 (2005).
  46. *Structural Transition of Wigner Crystal on Liquid Substrate.*  
M. Haque, I. Paul and S. Pankov; Phys. Rev. B **68**, 045427 (2003).
  47. *Anomaly in the normalization constant of the ( $^3\text{He},p$ ) reaction.*  
M. Haque *et. al.*, Nuovo Cimento A, **111A**, 1131 (1998).
  48.  $^{64}\text{Cu}$  levels from the  $^{62}\text{Ni}(^3\text{He},p)$  reaction at 18 MeV.  
A. K. Basak *et. al.*, Phys. Rev. C **56**, 1983 (1997).
- **Publicly available preprints (under review or unpublished):**
49. *Non-smooth and level-resolved dynamics of a periodically driven tight binding model.* — J. M. Zhang and M. Haque, arXiv:1404.4280.
  50. *Quantum Bowling: Particle-hole transmutation in one-dimensional strongly interacting lattice models.*  
M. Ganahl, M. Haque, and H. G. Evertz; arXiv:1302.2667.
  51. *Non-adiabatic interaction ramps in a trapped Bose condensate.*  
F. E. Zimmer and M. Haque, arXiv:1012.4492.
  52. *Transition Temperature of Dilute Weakly Repulsive Bose Gas.*  
M. Haque and A. E. Ruckenstein, cond-mat/0212590.
  53. *Weakly Non-ideal Bose Gas: Comments on Critical Temperature Calculations.*  
M. Haque, cond-mat/0302076.