

# Ludwig G. Mathey

---

Zentrum für Optische Quantentechnologien  
Institut für Laserphysik  
Universität Hamburg  
Luruper Chaussee 149, Gebäude 90  
D-22761 Hamburg

Phone: 040/8998-6505  
Fax: 040/8998-6503  
lmathey@physnet.uni-hamburg.de  
photon.physnet.uni-hamburg.de/ilp/mathey/

## Employment

Professor  
Zentrum für Optische Quantentechnologien  
Institut für Laserphysik  
University of Hamburg  
April 2017–Present

Junior Professor  
Zentrum für Optische Quantentechnologien  
Institut für Laserphysik  
University of Hamburg  
April 2011–March 2017

Post-doctoral Fellow  
National Institute for Standards and Technology  
University of Maryland  
Joint Quantum Institute  
2007– March 2011

## Education

PhD in Physics  
Cambridge, MA  
Supervisor: Prof. Antonio H. Castro Neto (Boston University)  
Harvard University  
June 2007

Diploma in Physics  
Heidelberg, Germany  
Heidelberg University  
May 2001

## Research Interests

*Condensed Matter Theory, Quantum Theory, Atomic Physics.* I study many-body physics of ultracold atoms and solid state systems. The interests of my group range from investigating conceptual questions to working in direct collaboration with experimental groups, as evidenced by my publications. A recent focus of my group has been emergent phenomena of driven many-body systems. In optical lattices, these include inducing a synthetic gauge field for neutral atoms, and creating an effectively frustrated lattice, resulting in a chiral superfluid forming therein. In solid state systems, these include light-induced dynamics in superconductors and graphene. This research focus is part of our broader agenda to investigate many-body dynamics, dynamic and equilibrium phase transitions, and collective phenomena such as superfluidity. Methodically we employ numerous techniques, ranging from analytical renormalization approaches to numerical simulations.

## Teaching/Mentoring Experience

I currently supervise one post-doctoral researcher in my group, seven graduate students and five undergraduates. The studies that are given as Refs. 1, 2, 4-8, 10-17 were performed by undergraduate and graduate students, and by post-doctoral scientists under my supervision since 2011.

## Ludwig G. Mathey

---

During my time as a professor, I have held a graduate seminar on ultra-cold atoms and solid state physics every term. In each summer term I hold an undergraduate seminar, in which Bachelor and Master students give presentations on statistical physics, many-body theory and quantum physics. In the winter term of 2012, I taught 'Introduction to Theoretical Physics 1', which is the required theory class for physics freshmen. In the summer term of 2015 and in the current summer term, I am teaching 'Condensed matter and ultra-cold atoms', a theory class that is aimed at Master students, and which is well-received. In the winter semester of 2015, I taught a freshman seminar for scientific computing, and supervised the student projects that are performed as part of our 'Computing in Science' curriculum. In addition, I have taught numerous sections since 2011.

During my post-doctoral employment at the Joint Quantum Institute, I mentored a graduate student from the University of Maryland, which lead to three publications, Refs. 24, 26, 28, listed below.

During my PhD studies, I worked as a Teaching Fellow at Harvard University for numerous undergraduate and graduate classes. These range from *Introductory Mechanics and Relativity, Electricity, Magnetism, and Waves* and *Introductory Electromagnetism*, to the graduate classes *Modern Optics and Quantum Electronics*, by Prof. L. Hau, *Quantum Theory of Solids*, by Prof. P. Martin, and *Statistical Physics*, by Prof. S. Sachdev.

### Publications

1. Junichi Okamoto, Ludwig Mathey, Wen-Min Huang, *Influence of electron-phonon coupling on low temperature phases of metallic single-wall carbon nanotubes*, Phys. Rev. B **98**, 205122 (2018).
2. Ilias M. H. Seifie, Vijay Pal Singh, Ludwig Mathey, *Squeezed field path integral description of second sound in Bose-Einstein condensates*, cond-mat/1807.07214.
3. Ali Sanayei, Pascal Naidon, Ludwig Mathey, *Electron trimer states in conventional superconductors*, cond-mat/1807.05440.
4. Christoph Georges, Jayson G. Cosme, Ludwig Mathey, Andreas Hemmerich, *Light-induced coherence in an atom-cavity system*, cond-mat/1807.02577.
5. Jayson G. Cosme, Christoph Georges, Andreas Hemmerich, Ludwig Mathey, *Dynamical control of order in a cavity-BEC system*, Phys. Rev. Lett. **121**, 153001 (2018).
6. Koen Sponselee, Lukas Freystatzky, Benjamin Abeln, Marcel Diem, Bastian Hundt, Andre Kochanke, Thomas Ponath, Bodhaditya Santra, Ludwig Mathey, Klaus Sengstock, Christoph Becker, *Dynamics of Ultracold Quantum Gases in the Dissipative Fermi-Hubbard Model*, Quantum Science and Technology **4**, 014002 (2018).
7. Junichi Okamoto, Wen-Min Huang, Robert Hppner, Ludwig Mathey, *Critical behavior of a chiral superfluid in a bipartite square lattice*, New. J. Phys. **20**, 015012 (2018).
8. Junichi Okamoto, Wanzheng Hu, Andrea Cavalleri, Ludwig Mathey, *Transiently enhanced interlayer tunneling in optically driven high  $T_c$  superconductors*, Phys. Rev. B **96**, 144505 (2017).
9. S. Rajasekaran, J. Okamoto, L. Mathey, M. Fechner, V. Thampy, G.D. Gu, A. Cavalleri, *Probing optically silent superfluid stripes in cuprates*, Science **359**, 6375 (2018).
10. M. Lahrz, C. Weitenberg, L. Mathey, *Implementing supersymmetric dynamics in ultracold atom systems*, Phys. Rev. A **96**, 043624 (2017).
11. Matthias Tarnowski, Marlon Nuske, Nick Flschner, Benno Rem, Dominik Vogel, Lukas Freystatzky, Klaus Sengstock, Ludwig Mathey, Christof Weitenberg, *Observation of topological Bloch-state defects and their merging transition*, Phys. Rev. Lett. **118**, 240403 (2017).
12. Vijay Pal Singh, Christof Weitenberg, Jean Dalibard, Ludwig Mathey, *Superfluidity and relaxation dynamics of a laser-stirred 2D Bose gas*, Phys. Rev. A **95**, 043631 (2017).

## Ludwig G. Mathey

---

13. Junichi Okamoto, Ludwig Mathey, Wen-Min Huang, *Fermion pairing in mixed-dimensional atomic mixtures*, Phys. Rev. A **95**, 053633 (2017).
14. Nick Fläschner, Dominik Vogel, Matthias Tarnowski, Benno S. Rem, Dirk-Sören Lhmann, Markus Heyl, Jan Carl Budich, Ludwig Mathey, Klaus Sengstock, Christof Weitenberg, *Observation of a dynamical topological phase transition*, cond-mat/1608.05616.
15. Jun-ichi Okamoto, Ludwig Mathey, Rainer Härtle, *Hierarchical equations of motion approach to transport through an Anderson impurity coupled to interacting Luttinger liquid leads*, cond-mat/1608.05399.
16. Jun-ichi Okamoto, Andrea Cavalleri, Ludwig Mathey, *Theory of enhanced interlayer tunneling in optically driven high  $T_c$  superconductors*, cond-mat/1606.09276.
17. Marco T. Manzoni, Ludwig Mathey, Darrick E. Chang, *Designing exotic many-body states of atomic spin and motion in photonic crystals*, cond-mat/1606.05582.
18. B. Zhu, T. Rexin, L. Mathey, *Magnus expansion approach to parametric oscillator systems in a thermal bath*, Zeitschrift für Naturforschung A, **71**, 921 (2016).
19. Marlon Nuske, L. Mathey, Eite Tiesinga, *Detecting the BCS pairing amplitude via a sudden lattice ramp in a honeycomb lattice*, Phys. Rev. A **94**, 023607 (2016).
20. Amy C. Mathey, L. Mathey, *Realizing and optimizing an atomtronic SQUID*, New J. Phys. **18**, 055016 (2016).
21. Peter Janzen, Wen-Min Huang, L. Mathey, *Bose-Einstein condensation in a frustrated triangular optical lattice*, cond-mat/1510.00380.
22. Vijay Pal Singh, Wolf Weimer, Kai Morgener, Jonas Siegl, Klaus Hueck, Niclas Luick, Henning Moritz, L. Mathey, *Probing superfluidity of Bose-Einstein condensates via laser stirring*, Phys. Rev. A **93**, 023634 (2016).
23. Marlon Nuske, Eite Tiesinga, L. Mathey, *Optimization of collisional Feshbach cooling of an ultracold nondegenerate gas*, Phys. Rev. A **91**, 043626.
24. M. Lahrz, Mikhail Lemeshko, L. Mathey, *Exotic roton excitations in quadrupolar Bose-Einstein condensates*, New J. Phys. **17**, 045005.
25. T. Kock, M. Ölschläger, A. Ewerbeck, W.-M. Huang, L. Mathey, and A. Hemmerich, *Observation of chiral superfluid order by matter wave heterodyning*, Phys. Rev. Lett. **114**, 115301.
26. J. Klinder, H. Keßler, M. Wolke, L. Mathey, and A. Hemmerich, *Dynamical phase transition in the open Dicke model*, PNAS **112**, 3290.
27. Wolf Weimer, Kai Morgener, Vijay Pal Singh, Jonas Siegl, Klaus Hueck, Niclas Luick, Ludwig Mathey, and Henning Moritz, *The critical velocity in the BEC-BCS crossover*, Phys. Rev. Lett. **114**, 095301.
28. R. Höppner, B. Zhu, T. Rexin, A. Cavalleri and L. Mathey, *Redistribution of phase fluctuations in a periodically driven cuprate superconductor*, Phys. Rev. B **91**, 104507.
29. Martin Lahrz, Mikhail Lemeshko, Klaus Sengstock, Christoph Becker, L. Mathey, *Detecting quadrupole interactions in ultracold Fermi gases*, Phys. Rev. A **89**, 043616 (2014).
30. Vijay Pal Singh and L. Mathey, *Noise correlations of two-dimensional Bose gases*, Phys. Rev. A **89**, 053612 (2014).
31. Wen-Min Huang, Martin Lahrz, L. Mathey, *Quantum phases of quadrupolar Fermi gases in coupled one-dimensional systems*, Phys. Rev. A **89**, 013604 (2014).
32. M. Ojekhile, R. Höppner, H. Moritz, L. Mathey, *Sudden and slow quenches into the antiferromagnetic phase of ultracold fermions*, cond-mat/1308.5680.
33. J. Struck, M. Weinberg, C. Ölschläger, P. Windpassinger, J. Simonet, K. Sengstock, R. Höppner, P. Hauke, A. Eckardt, M. Lewenstein, L. Mathey, *Engineering Ising-XY spin models in a triangular lattice via tunable artificial gauge fields*, Nature Physics **9**, 738 (2013).

## Ludwig G. Mathey

---

34. J. Heinze, J. S. Krauser, N. Fläschner, B. Hundt, S. Götzke, A. P. Itin, L. Mathey, K. Sengstock, C. Becker, *Intrinsic Photoconductivity of Ultracold Fermions in Optical Lattices*, Phys. Rev. Lett. **110**, 085302 (2013).
35. S. G. Bhongale, L. Mathey, Erhai Zhao, Susanne F. Yelin, Mikhail Lemeshko, *Quantum Phases of quadrupolar Fermi gases in optical lattices*, Phys. Rev. Lett. **110**, 155301 (2013).
36. S. G. Bhongale, L. Mathey, Shan-Wen Tsai, Charles W. Clark, Erhai Zhao, *Unconventional Spin Density Waves in Dipolar Fermi Gases*, Phys. Rev. A **87**, 043604 (2013).
37. Amy C. Mathey, Charles W. Clark, L. Mathey, *Decay of a superfluid current of ultra-cold atoms in a toroidal trap*, Phys. Rev. A **90**, 023604 (2014).
38. Ipei Danshita, L. Mathey, *Counterflow superfluid of polaron pairs in Bose-Fermi mixtures in optical lattices*, Phys. Rev. A **87**, 021603 (2013).
39. L. Mathey, Kenneth J. Günter, Jean Dalibard, A. Polkovnikov, *Dynamic Kosterlitz-Thouless transition in 2D Bose mixtures of ultra-cold atoms*, cond-mat/1112.1204.
40. S. G. Bhongale, L. Mathey, Shan-Wen Tsai, Charles W. Clark, Erhai Zhao, *Bond order solid of two-dimensional dipolar fermions*, Phys. Rev. Lett. **108**, 145301, (2012).
41. Anzi Hu, L. Mathey, Eite Tiesinga, Ipei Danshita, Carl J. Williams, Charles W. Clark, *Detecting paired and counterflow superfluidity via dipole oscillations*, Phys. Rev. A **84**, 041609 (2011).
42. L. Mathey, A. Ramanathan, K. C. Wright, S. R. Muniz, W. D. Phillips, Charles W. Clark, *Phase fluctuations in anisotropic Bose condensates: from cigars to rings*, Phys. Rev. A **82**, 033607 (2010).
43. Anzi Hu, L. Mathey, Carl J. Williams, Charles W. Clark, *Noise correlations of one-dimensional Bose mixtures in optical lattices*, Phys. Rev. A **81**, 063602 (2010).
44. L. Mathey and A. Polkovnikov, *Light cone dynamics and reverse Kibble-Zurek mechanism in two-dimensional superfluids following a quantum quench*, Phys. Rev. A **81**, 033605 (2010).
45. Anzi Hu, L. Mathey, Ipei Danshita, Eite Tiesinga, Carl J. Williams, Charles W. Clark, *Counterflow and paired superfluidity in one-dimensional Bose mixtures in optical lattices*, Phys. Rev. A **80**, 023619 (2009).
46. L. Mathey and A. Polkovnikov, *A supercritical superfluid and vortex unbinding following a quantum quench*, Phys. Rev. A **80**, 041601(R) (2009).
47. L. Mathey, Eite Tiesinga, Paul S. Julienne, and Charles W. Clark, *Collisional Cooling of ultra-cold atom ensembles using Feshbach resonances*, Phys. Rev. A **80**, 030702(R) (2009).
48. L. Mathey, A. Vishwanath, and E. Altman, *Noise Correlations in low-dimensional systems of ultra-cold atoms*, Phys. Rev. A **79**, 013609 (2009).
49. L. Mathey, Ipei Danshita, and Charles W. Clark, *Creating a supersolid in one-dimensional Bose mixtures*, Phys. Rev. A **79**, 011602 (2009).
50. L. Mathey, A. Polkovnikov, and A. H. Castro Neto, *Phase-locking transition of coupled low-dimensional superfluids*, Europhysics Letters **81** (2008) 10008.
51. L. Mathey, S.-W. Tsai, and A. H. Castro Neto, *Exotic Superconducting Phases of Ultracold Atom Mixtures on Triangular Lattices*, Phys. Rev. B **75**, 174516 (2007).
52. L. Mathey, S.-W. Tsai, and A. H. Castro Neto, *Competing Types of Orders in two-dimensional Bose-Fermi Mixtures*, Phys. Rev. Lett. **97**, 030601, (2006).
53. L. Mathey, *Commensurate Mixtures of ultra-cold atoms in one dimension*, Phys. Rev. B **75**, 144510 (2007).
54. L. Mathey, and D.-W. Wang, *Phase Diagrams of one-dimensional Bose-Fermi mixtures of ultra-cold atoms*, Phys. Rev. A **75**, 013612 (2007).

## Ludwig G. Mathey

---

55. L. Mathey, A. Vishwanath, and E. Altman, *Noise Correlations in one-dimensional systems of ultra-cold fermions*, Phys. Rev. Lett. **100**, 240401 (2008).
56. L. Mathey, D.-W. Wang, W. Hofstetter, M. Lukin, and E. Demler, *Luttinger Liquid of Polarons in one-dimensional boson-fermion mixtures*, Phys. Rev. Lett. **93**, 120404, (2004).
57. L. Mathey, *Universal Properties of Amorphous Solids: The Microscopic Approach*, Diploma thesis, (2001).

### Book contributions

L. Mathey, S.-W. Tsai, and A. H. Castro Neto, *Ultracold Atomic Gases: Novel States of Matter*, Encyclopedia of Complexity and Systems Science, Dr. R. A. Meyers (Ed.) (Springer Heidelberg, 2009).

### Talks and Posters

*Control of many-body systems via external driving* DESY colloquium, Hamburg, 2016 (talk).

*Effective field theories in ultra-cold atom systems* Holography workshop, Hamburg, 2016 (talk).

*Bose-Einstein condensation in frustrated lattices* DPG Meeting, Hannover, 2016 (talk).

*Probing superfluidity via laser stirring* UMD seminar, College Park, 2015 (talk); Sant Feliu, 2015 (poster); Oldenburg seminar, 2015 (talk); Utrecht workshop, 2015 (talk); Imperial college, 2016 (talk).

*Noise correlations in ultra-cold atom systems* Hannover seminar, 2015, (talk).

*Redistribution of phase fluctuations in a periodically driven cuprate superconductor* Nice, 2014 (talk); Benasque, 2014 (talk); Ustron, 2014 (talk); CFEL workshop, Hamburg, 2015 (talk); PIER Workshop, 2015 (talk).

*Wolfgang Pauli Lecture: Topological Defects in Condensed Matter and Cosmology* (with Marc Hindmarsh) Hamburg University, 2014 (talk).

*Dynamic and equilibrium phase transitions* Rice University, 2014 (talk); SFB Workshop, 2013 (talk).

*Condensation in frustrated optical lattices* DPG Meeting, 2014 (talk); ICAP, Washington, 2014 (poster).

*Artificial gauge fields and photoconductivity* CUNY Workshop, 2013 (talk); Princeton, 2013 (talk); Hanover, 2013 (talk).

*Quantum Phases of strongly correlated Bose-Fermi mixtures* Weizmann Institute, 2012 (talk).

*Dynamic vortex unbinding following a quantum quench in bosonic mixtures* Joint Quantum Institute, University of Maryland, 2011 (talk); BEC 2011, Sant Feliu (poster); Lexi Symposium, 2011 (talk); CUNY Workshop, 2012 (talk), Lyon Conference, 2012 (talk); ICAP Conference Paris, 2012 (poster); Caltech, 2012 (talk); UC Riverside, 2012 (talk); Technion, 2012, KITP Santa Barbara, 2012 (talk); Krakow, 2012 (talk); Heidelberg, 2012 (talk); Katowice, 2012 (talk); Aarhus, 2012 (talk);

*Many-Body Physics of Bosonic Mixtures in 1D* Stony Brook University, 2010 (talk); GRK Colloquium, University of Hamburg, 2011 (talk).

*Phase-fluctuating regime of ring-shaped condensates* APS April Meeting, Washington, 2010 (talk); APS March Meeting, Portland, 2010 (talk).

*A supercritical superfluid and vortex unbinding following a quantum quench* Condensed Matter Seminar at the University of Maryland, 2010 (talk); DAMOP, Houston, 2010 (talk); NIST Seminar, 2009 (talk); DAMOP, University of Virginia, 2009 (talk); University of Hamburg, 2010 (talk); Physics of Quantum Electronics, Snowbird, 2010 (talk); Ecole Normale Supérieure, Paris, 2010 (talk); Institut d'Optique, Palaiseau, 2010 (talk); Laboratoire de Physique Théorique, Toulouse, 2010 (talk); Joint Quantum Institute, University of Maryland, 2011 (talk).

## Ludwig G. Mathey

---

*Collisional Cooling of ultra-cold atom ensembles using Feshbach resonances* APS March Meeting, Pittsburgh, 2009 (talk); DAMOP, Pennsylvania State University, 2008 (talk); Physical Chemistry/Chemical Physics Seminar, College Park, 2010 (talk).

*Counterflow and paired superfluidity in one-dimensional Bose mixtures in optical lattices* APS March Meeting, New Orleans, 2008 (talk).

*Creating a supersolid in one-dimensional Bose mixtures* NIST Seminar, 2008 (talk); ICAP, University of Connecticut, 2008 (poster); Seminar at Georgetown University, 2008 (talk).

*Phase-locking transition of coupled low-dimensional superfluids* NIST Seminar, 2007 (talk); Seminar at Yale University, 2007 (talk); Seminar at George Mason University, 2007 (talk); APS March Meeting, Denver, 2007 (talk).

*Commensurate Mixtures of ultra-cold atoms in one dimension* ICAP, Innsbruck, 2006 (poster); Seminar at Boston University (talk).

*Competing Types of Orders in two-dimensional Bose-Fermi Mixtures* ICAP, Innsbruck, 2006 (poster); APS March Meeting, Baltimore, 2006 (talk).

*Noise Correlations in one-dimensional ultra-cold atom systems* Seminar at MIT (talk); APS March Meeting, Los Angeles, 2005 (talk).

*Luttinger Liquid of Polarons in one-dimensional Bose-Fermi mixtures* Seminar at MIT (talk); ICAP, Rio de Janeiro, 2004 (talk); DAMOP, Boulder, 2003 (poster); ICAP, MIT, 2002 (poster).

### Research funding

*SFB 925*. In my first year I successfully applied to join the Sonderforschungsbereich (SFB) 925. In 2015, I was instrumental in a successful renewal of this SFB, by providing substantial collaborative work and laying out key directions of study for the new funding period of the SFB.

*CUI*. During my time here, my colleagues and myself successfully applied for the German Excellence Initiative which resulted in the Centre for Ultrafast Imaging. Again, I contributed strong interconnectivity and key strategic directions, such as the emergence in driven systems, which establishes an intellectual interface of cold atom and solid state physics.

*DFG*. I have successfully applied for the financial support for PhD students, under a DFG 'Normalverfahren'.

*Stipends*. I have successfully applied for PhD stipends, in particular one from the China Scholarship Council.

### General audience presentations

*Superfluidity and Superconductivity* General audience talk ('Ringvorlesung') at the University of Hamburg.

*Christmas lecture* Christmas tradition of the Physics department of the University of Hamburg.

### Service

Organization of a workshop on 'Holography'

Wolfgang Pauli Topical Lecture on 'Topological Defects in Condensed Matter and Cosmology'

Organization of a workshop on 'Emergence in driven solid-state and cold-atom systems'

Serving on the PhD commission of the Hamburg Physics Department, 2013 – Present

Serving on a hiring commission of a junior faculty position, 2012

Organization of a student-run seminar on Condensed Matter Theory, Harvard University, 2004–2006

## Ludwig G. Mathey

---

### Awards and Honors

White Prize for Excellence in Teaching, Harvard University, 2004

German Merit Foundation (Studienstiftung des Deutschen Volkes), 1995–2004