

# Matthew Travis Eiles

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## Curriculum Vitae

### Education

- 2013–2018 **Ph.D.**, *Purdue University*, West Lafayette IN, *GPA – 3.88.*  
2017 **Masters**, *Purdue University*, West Lafayette IN, *GPA – 3.88.*  
2009–2013 **Bachelor of Science**, *Hope College*, Holland MI, *GPA – 3.8.*  
Double major in Math and Physics, HONORS

### Ph.D. Thesis

- Title *Highly excited states of small molecules and atomic molecular ions*  
Advisor Chris H. Greene  
Description A theoretical study of the formation and manipulation of Rydberg molecules and photodetachment of negative atomic ions.

### Experience

#### Research

- January 2021–Present **Group Leader**, *Finite Systems Division of the Max Planck Institute for the Study of Complex Systems.*
- March 2020–December 2020 **MPI-PKS Distinguished Postdoctoral Fellow**, *Max Planck Institute for the Study of Complex Systems.*
- July 2019–July 2020 **Alexander von Humboldt Postdoctoral Fellow**, *Max Planck Institute for the Study of Complex Systems.*  
In collaboration with Prof. Dr. Peter Schmelcher at the University of Hamburg
- July 2018–July 2019 **Guest Scientist**, *Max Planck Institute for the Study of Complex Systems.*  
Working in collaboration with Prof. Dr. Jan-Michael Rost and Dr. Alexander Eisfeld in the Finite Systems group.
- January 2015–June 2018 **Research Assistant**, *Purdue University.*  
Graduate research assistant under Prof. Chris H. Greene
- Theoretical atomic and molecular physics, focusing on Rydberg atoms and molecules, negative ion photodetachment, and highly correlated two-electron systems.
  - Used R-matrix theory, multichannel quantum defect theory, frame transformation methods, and pseudopotential techniques to perform nearly *ab initio*, non-perturbative calculations.
  - Developed analytical theory and utilized computationally demanding numerical methods with Mathematica, Fortran 90, and parallel computing with openMP.

#### Teaching

2013–2014 **Teaching Assistant**, *Purdue University*.

Lab and recitation instructor for introductory physics courses

- (Fall 2013-Summer 2014) Recitation leader for introductory Electricity and Magnetism. Led homework help room, review sessions, and prepared weekly lectures.
- (Fall 2014) Lab instructor for Modern Mechanics Lab. Taught VPython coding, supervised undergraduate teaching assistants, and guided laboratory experiments.
- (Summer - Fall 2014) Private tutoring for introductory mechanics and electricity and magnetism.

2010–2013 **Teaching Assistant**, *Hope College*.

Lab instructor, tutor, and grader for introductory and advanced physics courses

- Tutored for the academic support center and led homework help sessions.
- Lab assistant for introductory mechanics and electricity/magnetism labs.
- Grader for statistics, multivariable calculus, and introductory and advanced classical mechanics courses.

## Awards

- 2019 Raman Prize for outstanding thesis, Purdue University.
- 2019 Finalist for the APS DAMOP Deborah Jin Thesis Award.
- 2019–2021 Alexander von Humboldt Postdoctoral Fellowship.
- 2018 Shortlisted for the ITAMP postdoctoral fellowship.
- 2018 Travel support, DAMOP 2018
- 2017 Graduate Student International Travel Grant, Purdue University
- 2017 Travel support, ICPEAC XXX
- 2016 Gordon and Betty Moore Foundation Grant, KITP
- 2016 Edward S. Akeley award, Purdue University
- 2013 Phi Beta Kappa
- 2013 Yntema Prize, Outstanding student in physics, Hope College
- 2012 Michigan Space Grant Consortium Fellowship Award
- 2011 Dean's Science Division Research Award, Hope College

## Publications

19. G. Abumwis, C. W. Wächtler, **M. T. Eiles**, and A. Eisfeld *Coherently delocalized states in dipole interacting Rydberg ensembles: The role of internal degeneracies* Phys. Rev. A **104**, 013311 (2021).
18. F. Hummel, **M. T. Eiles**, and P. Schmelcher *Synthetic Dimension-Induced Conical Intersections in Rydberg Molecules* Phys. Rev. Lett. **127**, 023003 (2021).
17. P. Giannakeas, **M. T. Eiles**, F. Robicheaux, and J. M. Rost *Dressed ion-pair states of an ultralong-range Rydberg molecule* Phys. Rev. Lett. **102**, 123401 (2020).
16. P. Giannakeas, **M. T. Eiles**, F. Robicheaux, and J. M. Rost *Generalized local frame transformation theory for ultralong-range Rydberg molecules* Phys. Rev. A **102**, 033315 (2020).
15. A. L. Hunter, **M. T. Eiles**, A. Eisfeld and J. M. Rost *Rydberg Composites* Phys. Rev. X **10**, 031046 (2020).
14. G. Abumwis, **M. T. Eiles**, A. Eisfeld *Delocalization in two- and three-dimensional Rydberg gases*. J. Phys. B: At. Mol. Opt. Phys. **53**, 124003 (2020)
13. G. Abumwis, **M. T. Eiles**, A. Eisfeld *Extended coherently delocalized states in a frozen Rydberg*

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2/5

- gas Phys. Rev. Lett. **124**, 193401 (2020).
12. **M. T. Eiles**, C. Fey, F. Hummel, and P. Schmelcher *Triatomic butterfly molecules* J. Phys. B: At. Mol. Opt. Phys. **53**, 054001 (2020).
  11. **M. T. Eiles**, A. L. Hunter, and J. M. Rost *Ring Rydberg composites* J. Phys. B: At. Mol. Opt. Phys. **53**, 054001 (2020).
  10. **M. T. Eiles**, *Trilobites, butterflies, and other exotic specimens of long-range Rydberg molecules*. J. Phys. B: At. Mol. Opt. Phys. **52**, 113001 (2019).
  9. **M. T. Eiles**, *Formation of long-range Rydberg molecules in two-component ultracold gases* Phys. Rev. A **98**, 042706 (2018).
  8. **M. T. Eiles** and C. H. Greene, *Extreme correlation and repulsive interactions in highly excited atomic alkali anions* Phys. Rev. Lett. **121**, 133401 (2018).
  7. **M. T. Eiles**, Z. Tong, and C. H. Greene, *Theoretical prediction of the creation and observation of a ghost trilobite chemical bond* Phys. Rev. Lett. **121**, 113203 (2018). *This letter was selected to be featured in physics and as an editor's suggestion, and was featured on as a PRL cover image*
  6. **M. T. Eiles**, H. Lee, J. Pérez-Ríos, and C. H. Greene, *Anisotropic blockade using long-range Rydberg molecules*, Phys. Rev. A **95**, 052708 (2017). *Figure chosen for Kaleidoscope feature.*
  5. **M. T. Eiles** and C. H. Greene, *Hamiltonian for the inclusion of spin effects in long-range Rydberg molecules*, Phys. Rev. A **95**, 042515 (2017).
  4. J. Pérez-Ríos, **M. T. Eiles**, and C. H. Greene, *Mapping trilobite state signatures in atomic hydrogen*, J. Phys. B: At. Mol. Opt. Phys. **49**, 14LT01 (2016). *(2016 Highlight and IOP select collection; figure chosen for journal cover image)*
  3. **M. T. Eiles**, J. Pérez-Ríos, F. Robicheaux, and C. H. Greene, *Ultracold molecular Rydberg physics in a high density environment*, J. Phys. B: At. Mol. Opt. Phys. **49**, 114005 (2016). *(2016 Highlight; figure chosen for journal cover image)*
  2. **M. T. Eiles** and C. H. Greene, *Ultracold long-range Rydberg molecules with complex multi-channel spectra*, Phys. Rev. Lett. **115**, 193201 (2015).
  1. P. L. Gonthier, M. G. Baring, **M. T. Eiles**, Z. Wadiasingh, C. A. Taylor, and C. J. Fitch, *Compton scattering in strong magnetic fields: Spin-dependent influences at the cyclotron resonance*, Phys. Rev. D **90**, 043014 (2014).

## Presentations

47. *Coherent delocalization in a frozen Rydberg gas* Presentation APS DAMOP, Orlando, FL. May , 2022.
46. *Coherent delocalization in a frozen Rydberg gas* Presentation DPG SAMOP, Online. Mar 14-18, 2022.
45. *Synthetic dimension-induced conical intersections in Rydberg molecules* Hot Topic Talk Workshop on Cold Rydberg Chemistry, Online. November 22-23, 2021.
44. *Ghostly molecules and the Droste effect* Hope College Physics Seminar, invited, Online. October 29, 2021.
43. *Anderson localization of a Rydberg electron* Invited talk DPG SAMOP spring meeting, Online. September 20-24, 2021.
42. *Topological States in a Rydberg Composite*. Presentation APS DAMOP meeting, Online. June 1-4, 2021.
41. *Exploring the Droste effect and Anderson localization in Rydberg atoms*. Invited Colloquium, University of Texas San Antonio. April 16, 2021.

40. *Exciton States in a Rydberg Gas*. Presentation APS March Meeting (virtual). March 15-19, 2021.
39. *Anderson Localization in a Rydberg Composite*. Presentation. 51st Annual DAMOP meeting, Online. June 1 - 5, 2020.
38. *Pandora's little box of Rydberg Molecules*. Presentation. GiRyd Status Workshop, Mainz, Germany, Mar. 25, 2020.
37. *Rydberg molecules*. Invited talk, PIER workshop on Ultra-long-range Rydberg molecules, Lauenburg, Germany, Feb. 5 2020.
36. *Anderson Localization in a Rydberg composite*. Invited talk, International Workshop on Atomic Physics, Dresden, Germany, Nov. 21 2019.
35. *Anderson Localization in a Rydberg composite*. Invited talk, Task-Force Meeting on "Cold Ions and Rydberg Atoms in Atomic Gases", Stuttgart, Germany, Nov. 12 2019.
32. *Localization, scarring, and the effects of disorder on Rydberg atoms and other excited systems*. Poster presentation, 50th Annual DAMOP meeting, Milwaukee, WI. May 27-May 31, 2019
31. *Highly excited states of small molecules and atomic negative ions*. Invited thesis prize talk, 50th Annual DAMOP meeting, Milwaukee, WI. May 27-May 31, 2019
30. *Spatial Confinement And Geometric Effects In The Electronic Structure Of A Rydberg Atom Embedded In A Neutral Medium*. Poster Presentation, ECAMP13. Florence, Italy. Apr. 11, 2019.
29. *Rydberg states in a two-dimensional monolayer*. Presentation. GiRyd Status Workshop, Kaiserslautern, Germany. Mar. 25, 2019.
28. *Exploring electron-neutral interactions in "trilobites", "butterflies", and anions*. Invited Seminar. Purdue University, West Lafayette, IN. Mar 21 2019.
27. *Localization, scarring, and the effects of disorder on Rydberg atoms and other excited systems*. Presentation. DPG Spring meeting. Rostock, Germany. Mar 13, 2019.
26. *Using heteronuclear Rydberg dimers and trimers to probe ultracold mixtures*. Poster Presentation. DPG Spring Meeting. Rostock, Germany. Mar. 12, 2019.
25. *Extreme Correlation and Repulsive Interactions in Highly Excited Atomic Alkali Anions*. Presentation. Extreme Atomic Physics workshop, Riezlern. Feb. 20, 2019.
24. *Atom-electron collisions in negative ion photodetachment and Rydberg molecule photoassociation*. Invited Presentation. University of Hamburg. Dec. 20, 2018.
23. *Rydberg atoms and their interactions with other atoms, with electrons, and even with nothing*. Invited Presentation. University of Rostock. Sept. 18, 2018.
22. *Rydberg atoms and their interactions with other atoms, with electrons, and even with nothing*. Presentation. MPI-PKS Finite Systems Group Meeting. July 23, 2018.
21. *Recent adventures with Rydberg atoms and molecules*. Poster Presentation. GiRyd Status Workshop, Hamburg, DE. July 4 - July 6, 2018.
20. *New types of trilobite-like states in hydrogen atoms and negative ions*. Poster Presentation. 49th Annual DAMOP meeting, Ft. Lauderdale, FL. May 28-June 1, 2018.
19. *Photodetachment of  $K^-$  into highly polarizable excited states*. Presentation. 49th Annual DAMOP meeting, Ft. Lauderdale, FL. May 28-June 1, 2018.
18. *Degenerate states in Rydberg atoms and negative ions*. Seminar. Hope College, Holland, MI. April 20, 2018.
17. *Degenerate states in Rydberg atoms and negative ions*. Seminar. Physics Graduate Student Association, Purdue University, West Lafayette, IN. April 19, 2018.
16. *Effects of degenerate energy levels in long-range Rydberg molecules and doubly excited negative*

- ions. Seminar. Technical University of Kaiserslautern, Kaiserslautern, Germany. February 13, 2018.
15. *Effects of degenerate energy levels in long-range Rydberg molecules and doubly excited negative ions*. Seminar. University of Stuttgart, Stuttgart, Germany. February 12, 2018.
  14. *Effects of degenerate energy levels in long-range Rydberg molecules and doubly excited negative ions*. Seminar. University of Hamburg, Hamburg, Germany. February 5, 2018.
  13. *Long-range interactions in Rydberg molecules and atomic negative ions*. Poster presentation. Midwest Cold Atom Workshop, Ann Arbor, MI. November 11, 2017.
  12. *Anisotropic blockade using pendular long-range Rydberg molecules*. Poster presentation. ICPEAC XXX, Cairns, Australia, July 26-Aug. 1, 2017.
  11. *Anisotropic blockade using pendular Rydberg butterfly molecules*. Presentation. 48th Annual DAMOP meeting, Sacramento, CA. June 5-9, 2017.
  10. *Doubly excited states of atomic negative ions*. Poster presentation. 48th Annual DAMOP meeting, Sacramento, CA. June 5-9, 2017.
  9. *If I ran the quantum zoo*. Physics Seminar, Hope College, Holland, MI. Feb. 24, 2017.
  8. *New prospects in Rydberg molecules*. KITP Few Body Systems Workshop, Kavli Institute for Theoretical Physics, Santa Barbara, CA. Dec. 12, 2016.
  7. *New prospects in Rydberg molecules*. Midwest Cold Atom Workshop, Chicago, IL. Oct. 29, 2016.
  6. *Polyatomic Rydberg molecules in a high density environment*. Presentation. CUI Young researchers workshop: "From few- to many body physics in cold atomic quantum matter", Center for Optical Quantum Technologies University of Hamburg. June 27-29, 2016
  5. *Ultracold Long-Range Rydberg Molecules with Complex Multichannel Spectra*. Presentation. 47th Annual DAMOP meeting, Providence, RI. May 23-27, 2016.
  4. *If I ran the quantum zoo*. Seminar. Physics Graduate Student Association, Purdue University, West Lafayette, IN. April 20, 2016.
  3. *Compton Scattering Cross Sections in Strong Magnetic Fields: Advances for Neutron Star Applications*. Poster Presentation. AAS 13th Meeting of the High Energy Astrophysics Division, Monterey, CA. April 7-11, 2013.
  2. *Resonant Compton Up-scattering in High Field Pulsars and Magnetars*. Poster Presentation. 219th AAS Meeting, Austin, TX. January 8-12, 2012
  1. *Resonant Compton Up-scattering in High Field Pulsars and Magnetars*. Presentation. MSGC Annual Fall Conference, Ann Arbor, MI. November 12, 2011

## Professional service

- 2020–present **Group seminar organizer**, *MPI-PKS Finite Systems Division Group Seminar*.
- 2017–present **Referee**, *Physical Review X, Physical Review Letters, New Journal of Physics, Physical Review A, Journal of Physics B, Physics Letters A*.
- 2017–2018 **Graduate seminar organizer**, *Physics Graduate Student Association*, Purdue University.
- 2016–2017 **Vice President**, *Physics Graduate Student Association*, Purdue University.
- 2012–2013 **President**, *Society of Physics Students*, Hope College.

## Outreach

July 8, 2022. *Rydberg Moleküle: die kleinsten Riesen*. Public lecture for Dresden's Long Night of Sciences. Available on youtube.