

Patrick Dean Mullen

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EDUCATION

- University of Illinois at Urbana-Champaign** Urbana, IL
Doctor of Philosophy in Astronomy (GPA: 4.00/4.00) Aug. 2016 – July 2021 (Expected)
Thesis: “Magnetized Models of Moon-forming Giant Impacts.”
Advisor: Charles F. Gammie
- University of Georgia** Athens, GA
Bachelor of Science in Physics, Minor in Chemistry (GPA: 3.95/4.00) Aug. 2012 – May 2016
Senior Thesis: “Charge Exchange: Atomic Data of Astronomical Significance.”
Advisor: Phillip C. Stancil

RESEARCH INTERESTS

I am a computational astrophysicist working on topics related to the formation of the Moon, particularly in simulating planetary scale giant impacts. I have developed and implemented numerical algorithms for modeling astrophysical flows subject to resistive magnetohydrodynamics and self-gravity.

RESEARCH EXPERIENCE

- Graduate Research Assistant** Nov. 2016 – Present
University of Illinois at Urbana-Champaign Urbana, IL
- Designed 3D numerical models to investigate the role of (i) magnetic fields in the Moon-forming giant impact and (ii) supersonic shear instabilities in the Earth–protolunar disk boundary layer.
 - Developed and implemented a fully-conservative numerical algorithm for self-gravitating (magneto)hydrodynamics in the **Athena++** framework.
- Graduate Research Intern** Sept. 2018 – Dec. 2018
Los Alamos National Laboratory Los Alamos, NM
- Implemented a super-time-stepping module in the **Athena++** framework for integrating diffusive physics, including Ohmic resistivity, ambipolar diffusion, viscosity, and thermal conduction.
- Undergraduate Research Assistant** Aug. 2013 – May 2016
University of Georgia Athens, GA
- Calculated state-resolved charge exchange cross sections for application to astrophysical modeling of XMM-Newton observations of Comet C/2000 WMI (linear).

TEACHING/MENTORING EXPERIENCE

- Graduate Teaching Assistant** Aug. 2016 – May 2018
University of Illinois at Urbana-Champaign Urbana, IL
- ASTR 121 (“Solar System and Worlds Beyond”) and ASTR 122 (“Stars and Galaxies”).
- Undergraduate Student Mentor** Sept. 2017 – Sept. 2018
University of Illinois at Urbana-Champaign Urbana, IL
- Mentored an undergraduate student for one year. Oversaw a project that analyzed 1D shock tube solutions when applying the M-ANEOS equation of state for forsterite.
- Young Scholars Mentor** June 2018 – July 2018
University of Illinois at Urbana-Champaign Urbana, IL
- Mentored a high school scholar for six weeks. Taught programming skills that enabled 3D visualizations of giant impact simulations with **yt**.

TECHNICAL SKILLS

Programming: C/C++, Python, Mathematica, MPI, OpenMP, FORTRAN, L^AT_EX

Software: Athena++, VisIt, yt

Workflow Tools: Git, Jupyter, Valgrind, GDB

HONORS AND AWARDS

Astrofest 2019 Poster Award Recipient	May 2019
Multiple Appearances in the <i>List of Teachers Ranked Outstanding by Their Students</i>	2016 – 2018
Charles H. Wheatley Award, Excellence in Physics at Senior Level	May 2016
UGA Presidential Scholar (3 semesters) and Dean’s List Honoree	2012–2016
Zell Miller Scholarship	2012–2016

INVITED TALKS

Mullen, P. D. (Oct. 2020), “A Magnetized, Moon-forming Giant Impact,” IAS Astro Coffee Seminar, Institute for Advanced Study

Mullen, P. D. (Dec. 2019), “Magnetized Models of Moon-Forming Giant Impacts,” ITC Seminar, Harvard-Smithsonian Center for Astrophysics

Mullen, P. D. (Mar. 2019), “Super-Time-Stepping with Athena+,” Athena++ Workshop 2019, University of Nevada at Las Vegas

OTHER PRESENTATIONS

Mullen, P. D. (Apr. 2019), “Numerical Models of Giant Impacts,” Astrofest 2019, University of Illinois at Urbana-Champaign, *Poster*

Mullen, P. D. (Mar. 2018), “Numerical Models of Giant Impacts,” Les Houches Winter School 2018: Volatiles Elements in the Solar System, École de Physique des Houches, *Poster*

Mullen, P. D., Cumbee, R. S., Lyons, D., Gu, L., Kaastra, J., Shelton, R. L., Stancil, P. C. (June 2016), “Cometary Solar Wind Charge Exchange Line Ratios: Source of X-rays in Comet C/2000 WM1 (linear),” American Astronomical Society 228, *Poster*

Mullen, P. D., Cumbee, R. S., Lyons, D., Stancil, P. C., Shelton, R. L., Gu, L., Kaastra, J., Schultz, D. R. (Apr. 2016), “Charge Exchange: Atomic Data of Astronomical Significance,” CURO Symposium 2016, University of Georgia, *Poster*

Mullen, P. D., Cumbee, R. S., Lyons, D., Stancil, P. C., Wargelin, B. J. (Jan. 2015), “Charge Exchange Induced X-ray Emission of Fe XXVI and Fe XXV,” American Astronomical Society 225, *Talk*

Mullen, P. D., Cumbee, R. S., Lyons, D., Stancil, P. C., Allen, W. D., Shelton, R. L., Kharchenko, V., Schultz, D. R. (Aug. 2015), “Solar Wind Charge Exchange Induced X-ray Emission of Comets,” Chandra Workshop 2015, Chandra X-ray Center, *Poster*

Mullen, P. D. (Aug. 2015), “Charge Exchange Induced X-ray Emission of Comets,” AtomDB Workshop 2015, Harvard-Smithsonian Center for Astrophysics, *Talk*

Mullen, P. D., Cumbee, R. S., Lyons, D., & Stancil, P. C. (Apr. 2015), “Streamlined Multi-Channel Landau-Zener Charge Exchange Calculations,” ITAMP Workshop 2015, Harvard-Smithsonian Center for Astrophysics, *Poster*

Mullen, P. D., Hanawa, T., & Gammie, C. F. (*submitted* Oct. 2020), “An Extension of the Athena++ Framework for Fully Conservative Self-Gravitating Hydrodynamics,” ApJS

Mullen, P. D., & Gammie, C. F. (Nov. 2020), “A Magnetized, Moon-forming Giant Impact,” ApJL, 903, L15, <https://doi.org/10.3847/2041-8213/abbffd>

Cumbee, R. S., **Mullen, P. D.**, Lyons, D., Shelton, R. L., Fogle, M., Schultz, D. R., Stancil, P. C. (Jan. 2018), “Charge Exchange X-ray Emission due to Highly Charged Ion Collisions with H, He, and H₂: Line Ratios for Heliospheric and Interstellar Applications,” ApJ, 852, 7, <https://doi.org/10.3847/1538-4357/aa99d8>

Mullen, P. D., Cumbee, R. S., Lyons, D., Gu, L., Kaastra, J., Shelton, R. L., Stancil, P. C. (July 2017), “Line Ratios for Solar Wind Charge Exchange with Comets,” ApJ, 844, 7, <https://doi.org/10.3847/1538-4357/aa7752>

Mullen, P. D., Cumbee, R. S., Lyons, D., Stancil, P. C. (June 2016), “Charge Exchange-induced X-ray Emission of Fe XXV and Fe XXVI via a Streamlined Model,” ApJS, 224, 31, <https://doi.org/10.3847/0067-0049/224/2/31>

Gu, L., Kaastra, J., Raassen, A. J. J., **Mullen, P. D.**, Cumbee, R. S., Lyons, D., Stancil, P. C. (Nov. 2015), “A novel scenario for the possible X-ray line feature at ~ 3.5 keV—Charge exchange with bare sulfur ions,” A&A, 584, L11, <https://doi.org/10.1051/0004-6361/201527634>

For an updated list of publications, visit my [Google Scholar](#) profile.