

# Philip Mocz

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**Research Interests** computational fluid dynamics • magnetohydrodynamics • turbulence • quantum dark matter • galaxy evolution & feedback • black hole physics • cosmological simulations • star formation

**Current Position** **Princeton University** 2017 - present  
Einstein Fellow

**Education** **Harvard University** 2017  
Ph.D. Astrophysics  
Secondary Field in Computational Science and Engineering (2015)  
*Moving mesh magnetohydrodynamics: magnetic processes in star formation and cosmology*  
(advisor: Lars Hernquist)

**Harvard University** 2012  
A.B. Mathematics and Astrophysics, *Summa Cum Laude* w/ highest honors

**Fellowships and Awards**

Einstein Fellowship	2017 - 2020
Eric Keto Prize	2017
Harvard Merit Fellowship	2016
NASA Earth and Space Science Fellowship (NESSF)	2015 - 2017
NSF Graduate Research Fellowship	2012 - 2015
Peirce Fellowship (Harvard)	2012
Derek Bok Center Certificate of Distinction in Teaching (Harvard)	2012
John Harvard Scholar	2008 - 2012
Phi Beta Kappa (Harvard)	2011
Leo Goldberg Prize for Astronomy Junior Thesis (Harvard)	2011
CAS vacation Scholarship (Swinburne Univ. of Technology)	2011
Weissman International Internship Program Scholarship	2010
Detur Prize (Harvard)	2009
Harvard College Program for Research in Science and Engineering	2009

**Refereed Publications**

27. **First star-forming structures in fuzzy cosmic filaments**  
[Mocz, P.](#); Fialkov A.; Vogelsberger, M.; Becerra, F.; Amin, M.; Bose, S.; Boylan-Kolchin, M.; Chavanis, P.H.; Hernquist, L.; Lancaster, L.; Marinacci, F.; Robles, V.; Zavala J.; 2019 PRL submitted
26. **Formation, Gravitational Clustering and Interactions of Non-relativistic Solitons in an Expanding Universe**  
Amin, M.; [Mocz, P.](#); 2019 Phys. Rev. D accepted
25. **The Self-gravitating Gas Fraction and The Critical Density for Star Formation**  
Burkhart, B.; [Mocz, P.](#); 2019 ApJ accepted
24. **Heating of Milky Way disc Stars by Dark Matter Fluctuations in Cold Dark Matter and Fuzzy Dark Matter Paradigms**  
Church, B.; Ostriker, J.; [Mocz, P.](#); 2019 MNRAS 485, 2861

23. **Star formation from dense shocked regions in supersonic isothermal magneto-turbulence**  
[Mocz, P.](#); Burkhardt, B.; 2018 MNRAS 480, 3916
22. **Evolution of the Black Hole Mass Function in Star Clusters from Multiple Mergers**  
 Christian, P.; [Mocz, P.](#); Loeb, A.; 2018 ApJL 858, 8
21. **Schrödinger-Poisson–Vlasov-Poisson correspondence**  
[Mocz, P.](#); Lancaster, L.; Fialkov, A.; Becerra, F.; Chavanis, P.-H.; 2018 Phys. Rev. D 97, 3519
20. **Non-ideal magnetohydrodynamics on a moving mesh**  
 Marinacci, F.; Vogelsberger, M.; Kannan, R.; [Mocz, P.](#); Pakmor, R.; Springel, V.; 2018 MNRAS, 476, 2476
19. **Galaxy Formation with BECDM: I. Turbulence and relaxation of idealised haloes**  
[Mocz, P.](#); Vogelsberger, M.; Robles, V.; Zavala J.; Boylan-Kolchin, M.; Fialkov A.; Hernquist, L.; 2017 MNRAS, 471, 4
18. **Unveiling the role of the magnetic field at the smallest scales of star formation**  
 Hull C.L.H.; [Mocz, P.](#); Burkhardt, B.; Goodman, A.A.; Girart, J.M.; Cortés, P.C.; Hernquist, L.; Li, Z.-Y.; Lai, S.-P.; Springel, V.; 2017 ApJL, 842, 9
17. **Moving mesh simulations of star forming cores in magneto-gravo-turbulence**  
[Mocz, P.](#); Burkhardt, B.; Hernquist, L.; McKee, C.; Springel, V.; 2017 ApJ, 838, 1
16. **Integer lattice dynamics for Vlasov-Poisson**  
[Mocz, P.](#); Succi, S.; 2017 MNRAS, 465, 3154
15. **Correspondence between constrained transport and vector potential methods for MHD**  
[Mocz, P.](#); 2017 J. Comp. Phys., 328, 221
14. **A moving mesh unstaggered constrained transport scheme for MHD**  
[Mocz, P.](#); Pakmor, R.; Springel, V.; Vogelsberger, M.; Marinacci, F.; Hernquist, L.; 2016 MNRAS, 463, 477
13. **Improving the convergence properties of the moving-mesh code AREPO**  
 Pakmor, R.; Springel, V.; Bauer, A.; [Mocz, P.](#); Munoz, D.J.; Ohlmann, S.T.; Schaal, K.; Zhu, C.; 2016 MNRAS, 455, 1134
12. **The large-scale properties of simulated cosmological magnetic fields**  
 Marinacci, F.; Vogelsberger, M.; [Mocz, P.](#); Pakmor, R.; 2015 MNRAS, 453, 3999
11. **Reducing noise in moving-grid codes with strongly-centroidal Lloyd mesh regularization**  
[Mocz, P.](#); Vogelsberger, M., Pakmor, R., Genel, S., Springel, V., Hernquist, L.; 2015 MNRAS, 452, 3853
10. **Numerical solution to the non-linear Schrödinger equation using smoothed-particle hydrodynamics**  
[Mocz, P.](#); Succi, S.; 2015 Phys. Rev. E, 91, 053304
9. **Interpreting MAD within multiple accretion regimes**  
[Mocz, P.](#); Guo, X.; 2015 MNRAS, 447, 1498
8. **A constrained transport scheme for MHD on unstructured static and moving meshes**  
[Mocz, P.](#); Vogelsberger, M.; Hernquist, L. 2014 MNRAS, 442, 43
7. **Do high-redshift quasars have powerful jets?**  
 Fabian, A.C.; Walker, S.A.; Celotti, A.; Ghisellini, G.; [Mocz, P.](#); Blundell, K.M.; McMahon, R.G. 2014 MNRAS, 442L, 81

6. **A discontinuous Galerkin method for solving the fluid and magnetohydrodynamic equations in astrophysical simulations**  
[Mocz, P.](#); Vogelsberger, M.; Sijacki, D.; Pakmor, R.; Hernquist, L. 2014 MNRAS, 437, 397
5. **Cosmological growth and feedback from supermassive black holes**  
[Mocz, P.](#); Fabian, A.C.; Blundell, K.M.; 2013 MNRAS, 432, 3381
4. **The Tully-Fisher relation for 25,000 Sloan Digital Sky Survey galaxies as a function of environment**  
[Mocz, P.](#); Green A.; Malacari M.; Glazebrook, K.; 2012 MNRAS, 425, 296
3. **Inverse-Compton ghosts and double-lobed radio sources in the X-ray sky**  
[Mocz, P.](#); Fabian, A.C.; Blundell, K.M.; 2011 MNRAS, 413, 1107
2. **The inverse-Compton ghost HDF 130 and the giant radio galaxy 6C 0905+3955: matching an analytic model for double radio source evolution**  
[Mocz, P.](#); Fabian, A.C.; Blundell, K.M.; Goodall, P.T.; Chapman, S.C.; Saikia, D.J.; 2011 MNRAS 417, 1576
1. **A Detection of an X-ray Wind and an Ionized Disk in the Chandra HETGS Observation of the Seyfert 2 Galaxy IRAS 18325-5926**  
[Mocz, P.](#); Lee, J.C.; Iwasawa, K.; Canizares, C.R.; 2011 ApJ, 729, 30

**Presentations Ultralight Dark Matter**

Cosmo Cruise, Aug 2019. *Invited*

**First star-forming structures in fuzzy cosmic filaments**

University of Hawaii, Jun 2019.

**Structure formation and turbulent processes in the Universe**

UW-Madison colloquium, Feb 2019. *Invited*

**Shock structures in magnetized supersonic isothermal turbulence**

CCA Big Apple Magnetic Fields conference, Jan 2019. *Invited*

**Small-scale features in fuzzy dark matter**

Columbia Physics theory seminar, Dec 2018. *Invited*

**Quantum Wave Dark Matter and the Classical Limit**

MX Dark Matter Conference, Cancun, Mexico, Nov 2018. *Invited*

**Small-scale structure in fuzzy dark matter and the classical limit**

Rice theory seminar, Oct 2018. *Invited*

**Small-scale features in fuzzy dark matter cosmology**

Einstein Symposium, Oct 2018.

**Small-scale structure in fuzzy dark matter and the classical limit**

CITA theory seminar, Sept 2018. *Invited*

**Galaxy Formation with Bose-Einstein Condensate Dark Matter**

Ringberg Computational Galaxy Formation, Mar 2018. *Invited*

**Magneto- and turbulent regimes of star formation**

ALMA NA Taiwan Joint Workshop: Magnetic Fields or Turbulence?, Feb 2018

**Solving Vlasov-Poisson dynamics on an integer lattice**

CIRM Collisionless Boltzmann (Vlasov) Equation and Modeling of Self-Gravitating Systems and Plasmas, Oct 2017.

**The role of magneto-turbulence in star formation**

Einstein Symposium, Oct 2017.

**Galaxy Formation with Axion Dark Matter**

CCA NY Area Computational Hydro Workshop, Sept 2017.

**Galaxy Formation with Axion Dark Matter**

Brown BASS talk, Sept 2017. *Invited*

**Integer Lattice for Vlasov-Poisson**

Harvard ITC luncheon talk, May 2017.

**Quantum Turbulence in Bose-Einstein Condensate Dark Matter**

Harvard ITC luncheon talk, Mar 2017.

**Moving mesh simulations of star forming cores in magneto-gravo-turbulence**

Cosmic Rays, Astrophysical Turbulence and Magnetic Reconnection Conference, IIP, Natal, Brazil, Dec 2016. *Invited*

**Moving mesh simulations of star forming cores in magneto-gravo-turbulence**

Berkeley TAC seminar, Nov 2016.

**Moving mesh simulations of star forming cores in magneto-gravo-turbulence**

Harvard ITC luncheon talk, Sept 2016.

**Moving mesh magnetohydrodynamics**

Astronom Conference, Monterey, CA, Jun 2016.

**Moving mesh magnetohydrodynamics and applications to star forming cores**

Crutcher & Heiles Conference, Madison, WI, May 2016.

**Moving Mesh and Smoothed Particle Methods for Computational Fluid Dynamics**

Istituto per le Applicazioni del Calcolo “Mauro Picone”, Rome, Jan 2015. *Invited*

**A discontinuous Galerkin method for solving the fluid and MHD equations in astrophysical simulations**

Southern Cross Conference Series VI: Feeding, Feedback, and Fireworks: Celebrating Our Cosmic Landscape, Jun 2013.

**Tully-Fisher Relationships for SDSS Galaxies as a Function of Environment**

Centre for Astrophysics and Supercomputing, Swinburne Univ. of Technology, Aug 2011.

**Cosmological growth and feedback of massive black holes**

University of Cambridge, Institute of Astronomy X-Ray Group Talk, Jul 2011.

**SMA Observation of the Extended Emission in the High-Mass Star Forming Region AFGL 2591**

Harvard University, CfA, May 2011.

**X-ray spectroscopy of silicate dust in the ISM and environments around XRBs**  
Harvard University, CfA, Junior Thesis Presentations, Apr 2011.

**Laboratory and Astronomical Observations of the CN Radical**  
Harvard University, CfA, Mar 2011.

**Double radio sources and inverse-Compton ghosts in the X-ray sky**  
University of Cambridge, Institute of Astronomy X-Ray Group Talk, Aug 2010.

**A Search for X-Ray Winds and Strong Gravity Around a Supermassive Black Hole In A Distant Galaxy**  
PRISE Talk, Harvard University, Aug 2009.

Teaching	<b>Astronomy 151. Astronomical Fluid Dynamics.</b> <i>Teaching Fellow</i> , Spring 2016 <ul style="list-style-type: none"><li>• student evaluation score 5.0/5.0, 5 students</li><li>• duties: office-hours, special topics sections, grading, homework solutions</li></ul>
	<b>Applied Computation 274. Computational Fluid Dynamics.</b> <i>Section leader</i> , Fall 2014 <ul style="list-style-type: none"><li>• student evaluation score 4.5/5.0, 5 students</li><li>• duties: lectures, office-hours, course material and homework development, grading, final project supervision</li></ul>
	<b>Applied Computation 274. Computational Fluid Dynamics.</b> <i>Section leader</i> , Spring 2014 <ul style="list-style-type: none"><li>• student evaluation score 4.0/5.0, 6 students</li><li>• duties: office-hours, course material and homework development, grading, final project supervision</li></ul>
	<b>Applied Mathematics 205. Advanced Scientific Computing: Numerical Methods.</b> <i>Section leader</i> , Fall 2012 <ul style="list-style-type: none"><li>• student evaluation score 4.7/5.0, 56 students</li><li>• duties: weekly section, office-hours, course material and homework development, final project supervision</li></ul>
Skills	Programming: C/C++, Python, Matlab, Mathematica, Javascript, MPI, CUDA, SQL Web: HTML5, CSS
Mentoring	Elliot Davies (undergraduate student, Princeton, 2019) Ben Church (undergraduate student, Columbia, 2018) Lachlan Lancaster (graduate student, Princeton, 2017-2019) Alex Gurvich (undergraduate student, CMU, 2016) Sruthi Narayanan (undergraduate student, MIT, 2016)
Outreach and Service	<b>Princeton Astrophysics Undergraduate Summer Research Program Mentor.</b> 2019. Advised summer research project on interaction of black holes and scalar field dark matter  <b>Harvard Astronomy Department Peer Mentor.</b> 2015 - 2017  <b>Library Committee Graduate Student Representative, Harvard-Smithsonian CfA.</b> 2015 - 2017

**Einstein in the Classroom.** 2015. Engaging with Pierce Middle School in the greater Boston area, to offer physics activities in classroom covering relativity, spacetime curvature, the life cycles of stars, the relative sizes of the objects that occupy the observable universe.