Philip Mocz  0000-0001-6631-2566

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Research Interests scalar field dark matter • turbulence • computational fluid dynamics • magnetohydrodynamics • star formation • galaxy evolution & feedback • black hole physics • cosmology

Current Position

Princeton University 2017 - present
NASA 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 & Astrophysics, *summa cum laude* w/highest honors, Phi Beta Kappa

Fellowships and Awards

NASA 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 Fellow	2009
Intel Science Talent Search Scholarship	2008

Refereed Publications

30. **Dynamical Friction in a Fuzzy Dark Matter Universe**
Lancaster, L.; Giovanetti, C.; **Mocz, P.**; Kahn, Y.; Lisanti, M., Spergel, D.; 2019 JCAP submitted.

29. **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 **(Editors' Suggestion)**, accepted.

28. **Fuzzy Dark Matter Soliton Cores around Supermassive Black Holes**
Davies E.Y.; **Mocz, P.**; 2019 MNRAS submitted

27. **A Markov model for non-lognormal density distributions in compressive isothermal turbulence**
Mocz, P.; Burkhart, B.; 2019 ApJL 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 879, 129

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.; Burkhart, 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. **Non-ideal magnetohydrodynamics on a moving mesh**
Marinacci, F.; Vogelsberger, M.; Kannan, R.; **Mocz, P.**; Pakmor, R.; Springel, V.; 2018 MNRAS, 476, 2476

20. **Schrödinger-Poisson–Vlasov-Poisson correspondence**
Mocz, P.; Lancaster, L.; Fialkov, A.; Becerra, F.; Chavanis, P.-H.; 2018 Phys. Rev. D 97, 3519

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.**; Burkhart, 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.; Burkhart, 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. **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
2. **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
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

Grants and Proposals

6. Co-PI of TACC *Stampede2* computing grant "Cosmology with Bose Einstein Condensate Dark Matter: Cosmic Web and First Galaxies" TG-AST170020 (2017). 60,750 node-hours ($\sim$ 3M cpu core-hrs; est. value $\$18,000$)
5. PI of TACC *Stampede2* computing grant "The Formation of First Stars in Bose-Einstein Condensate Dark Matter" TG-AST170015 (2017). 50,000 CPU core-hrs (est. value $\$1,800$)
4. PI of NASA Einstein Fellowship award "Moving mesh magnetohydrodynamics: understanding the role of magneto-turbulence in cosmological structure formation and star formation" PF7-180164 (2017). Total budget: $300,000. (host Jim Stone)
3. Co-PI of Gauss Centre for Supercomputing grant "Predicting galaxy formation in a representative volume of the Universe" (2015). 92M cpu core-hrs on *Hornet* in Stuttgart. (PI: Volker Springel)
2. Co-PI of NASA NESSF award "Moving Mesh Cosmology with Magnetohydrodynamics" NNX15AR88H (2015). Total budget: $100,000. (admin PI: Lars Hernquist)
1. PI of NSF GRFP award "Jet dynamics and kinetic feedback from supermassive black holes" DGE-1144152 (2012). Total budget: $100,000.

Presentations

Ultralight Dark Matter
Rutgers astronomy seminar, Sep 2019. *Invited*

Ultralight Dark Matter
Cosmo Cruise, Aug 2019. *Invited*

First structures in ultralight dark matter
UCSC Galaxy Workshop, Aug 2019.

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, Sep 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, Sep 2017.

Galaxy Formation with Axion Dark Matter
Brown BASS talk, Sep 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, Sep 2016.

Moving mesh magnetohydrodynamics
Astronum 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

Astronomy 151. Astronomical Fluid Dynamics. *Teaching Fellow*, Spring 2016
- student evaluation score 5.0/5.0, 5 students
- duties: office-hours, special topics sections, grading, homework solutions

Applied Computation 274. Computational Fluid Dynamics. *Section leader*, Fall 2014
• student evaluation score 4.5/5.0, 6 students
• duties: lectures, office-hours, course material and homework development, grading, final project supervision

Applied Computation 274. Computational Fluid Dynamics. *Section leader*, Spring 2014
• student evaluation score 4.0/5.0, 6 students
• duties: office-hours, course material and homework development, grading, final project supervision

Applied Mathematics 205. Advanced Scientific Computing: Numerical Methods. *Section leader*, Fall 2012
• student evaluation score 4.7/5.0, 56 students
• duties: weekly section, office-hours, course material and homework development, final project supervision

Skills

Programming: C/C++, Python, Matlab, Mathematica, Javascript, MPI, CUDA, SQL
Web: HTML5, CSS

Mentoring

Elliot Davies (undergraduate, Physics, Princeton, 2019)
Cara Giovanetti (undergraduate, Physics, Princeton, 2019)
Ben Church (undergraduate, Mathematics & Physics, Columbia, 2018)
Lachlan Lancaster (graduate, Astrophysics, Princeton, 2017-2019)
Alex Gurvich (undergraduate, Physics & Astronomy, Carnegie Mellon University, 2016)
Sruthi Narayanan (undergraduate, Computer Science, MIT, 2016)

Outreach and Service

Princeton Astrophysics Undergraduate Summer Research Program Mentor. 2019. Advised physics student summer research project on interaction of black holes and scalar field dark matter.

Harvard Astronomy Department Peer Mentor. 2015 - 2017. Served as a guide and resource for first and second year graduate student mentees.

Library Committee Graduate Student Representative, Harvard-Smithsonian CfA. 2015 - 2017. Helped advise head librarian and committee of 8 scientists on the future of the library, new digital services, journal subscriptions, educational services, and resources for graduate students.

Einstein in the Classroom. 2015. Engaged with Pierce Middle School in the greater Boston area to offer physics activities in the classroom covering relativity, spacetime curvature, the life cycles of stars, and the relative sizes of the objects in the observable Universe.

Guest Lecture. 2019. Taught graduate students about moving mesh computational fluid dynamics with interactive coding demos in Princeton graduate seminar course AST 542.

Peer Review. *Monthly Notices of the Royal Astronomical Society*, *Astrophysical Journal*, *Journal of Computational Physics*, *Frontiers Computational Physics*, *French National Research Agency (ANR)*, NESSF.