

Julian B. Muñoz, Ph.D.

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RESEARCH INTERESTS

I am a broadly trained astrophysicist working at the intersection of cosmology, astronomy, and particle physics. I am interested in using astrophysical data-sets, like the 21-cm line of hydrogen, the large-scale structure, or fast radio bursts, to learn about dark matter and dark energy. I am proud to have discovered a new velocity-based standard ruler to measure the expansion rate of the universe at high redshifts. My research also involves understanding outstanding astrophysical events, such as gravitational waves from black-hole mergers and the formation of the first galaxies during cosmic dawn and the epoch of reionization.

RESEARCH EXPERIENCE

- 2020-** **Clay Fellow**, Harvard-Smithsonian Center for Astrophysics, Cambridge, MA.

- 2017-20** **Postdoctoral Fellow**, Department of Physics, Harvard University, Cambridge, MA.
Faculty Advisors: Cora Dvorkin and Abraham Loeb, Professors.

- 2013-17** **Graduate Student**, Physics & Astronomy Department, JHU, Baltimore, MD.
Faculty Advisor: Marc Kamionkowski, Professor.

- 2013** **Research Assistant**, Complutense University of Madrid, Spain.
Faculty Advisor: Gabriel Álvarez Galindo, Professor.

- 2012** **Research Intern**, Instituto Astrofísico de Canarias, Tenerife, Spain.
Faculty Advisors: Carlos Allende and Andrés Asensio, Professors.

EDUCATION

- 2017** **Ph.D. in Physics**, Johns Hopkins University.
Thesis: “*New Cosmological Probes for Old Fundamental Questions*”.
Ph.D. Advisor: Marc Kamionkowski, Professor.

- 2013** **Graduado en Física** (B.A. in Physics), Complutense University of Madrid.

SELECTED INVITED TALKS

“*Searching for new physics with the 21-cm line*”, Colloquium at ETH Zurich (2020), seminar at Cornell, KIAS, CERN, YITP, PSU, Perimeter, Yale, NYU, IFT, Weizmann, MIT, USC, BGU, Cambridge, Geneva (2019-20).
“*Velocity-induced Acoustic Oscillations*”, 234th AAS, 21-cm at Pisa, Hera Meeting UK, Tokyo (2019).
“*Searching for dark matter at cosmic dawn*”, Seminar at Fermilab, Mainz, TUM, Dartmouth, UCR, Elusives network. Plenary talk at IDM Brown, DM18 Santander, CIPANP18, and Aspen Winter (2018).
“*Has LIGO detected dark matter?*” Harvard BHI Colloquium (2017).

TEACHING & ADVISING EXPERIENCE

Teaching Assistant

Responsibilities included grading, supervising group discussions and laboratories, holding office hours, and developing assignments and exams.

- Physics 103. Fall 2013 (taught by David E. Kaplan), Johns Hopkins University.
- Physics 104. Spring 2014 (taught by Tim Heckman), Johns Hopkins University.
- Graduate Quantum Mechanics. Fall 2015 (taught by Marc Kamionkowski), JHU.
- Stars and the Universe. Spring 2016 (taught by Adam Riess), Johns Hopkins University.

Guest lecturer

Basics of 21-cm cosmology, Ay98 at Harvard, Fall 2018 and 2019.

Substitute lectures for Quantum Mechanics and Cosmology at JHU and Harvard, respectively.

Advising Experience

W. Linda Xu (graduate student at Harvard), since 2018, 2 papers.

Nick Deporzio (graduate student at Harvard), since 2018, 2 papers.

Nash Sabti (graduate student at King's College London), since 2019, 1 paper.

Pedagogical Training and Outreach

As a member of the graduate-student outreach group at JHU I participated in several outreach events, including the physics fair at JHU, demonstrations at Coppin State, and lectures at Pikesville High.

Recently I have contributed to the Boston non-profit Science for the Public, and Astronomy on Tap.

FELLOWSHIPS & AWARDS

Fellowships

NASA Hubble Fellowship (declined), MIT Kavli Fellowship (declined), 5-year Clay Fellowship.

Spanish Ministry of Education Research Fellowship 2012 (€4k).

Summer Fellowship at the Instituto Astrofísico de Canarias 2012 (€2k).

Academic Recognition

Dan David Prize Scholar 2017 (\$15k).

Travel awards

EJ Rhee travel award 2016 (\$1k) and Pitt PACC travel award 2017 (\$500).

PROFESSIONAL SERVICE

Refereeing

PRL, PRD, ApJ, ApJ Lett., JCAP, MNRAS, Phys. Dark Univ., Nature Astronomy & Communications.

Grant reviewer for ERC Synergy (EU) and FONDECYT (Chile).

White Papers

Contributor to the CMB-S4 science book and thirteen Astro2020 decadal papers.

Contact person for four LOIs, one RFI, and speaker in the community meeting of Snowmass 2021.

Professional Duties

Organizer of the high-energy physics seminar at Harvard (2018-2019).

Develop and maintain the codes 21cmvFAST, RelicFast, and develop 21cmFASTv3.

External collaborator of the hydrogen epoch of reionization array (HERA) experiment.

PUBLICATIONS

Total number of publications: 34

Number of first-author publications: 18

Total number of citations: 1816 (including preprints: 2942)

h-index: 23

Most-cited first-author publication: Muñoz and Loeb, Nature 2018 (174 citations)

Selected

1. **J. B. Muñoz**
Robust Velocity-induced Acoustic Oscillations at Cosmic Dawn
Phys.Rev. D100, 063538 (2019). [ArXiv: 1904.07881](#) – **Editor’s Choice.**
2. **J. B. Muñoz**
A Standard Ruler at Cosmic Dawn
Phys. Rev. Lett. 123, 131301 (2019). [ArXiv: 1904.07868](#) – **Editor’s Choice.**
3. **J. B. Muñoz**, C. Dvorkin and A. Loeb
21-cm Fluctuations from Charged Dark Matter.
Phys. Rev. Lett. 121, 121301 (2018). [ArXiv: 1804.01092](#).
4. **J. B. Muñoz** and A. Loeb
A small amount of mini-charged dark matter could cool the baryons in the early Universe.
Nature 557 no.7707, 684 (2018). [ArXiv: 1802.10094](#).
5. **J.B. Muñoz**, E.D. Kovetz, L. Dai, and M. Kamionkowski.
Lensing of Fast Radio Bursts as a Probe of Compact Dark Matter.
Phys. Rev. Lett. 117, 091301 (2016). [ArXiv: 1605.00008](#) – **Editor’s Choice.**

Other Research

6. A. Ray, R. Laha, **J. B. Muñoz**, and R. Caputo.
Closing the gap: Near future MeV telescopes can discover asteroid-mass primordial black holes
Submitted to PRD. [ArXiv: 2102.06714](#)
7. **J. B. Muñoz**, S. Bohr, F.Y. Cyr-Racine, J. Zavala, and Mark Vogelsberger
ETHOS: Impact of Dark Acoustic Oscillations on Cosmic Dawn
PRD 103 4, 043512 (2021). [ArXiv: 2011.05333](#).
8. S. Murray, B. Greig, A. Mesinger, **J. B. Muñoz**, Y. Qin, J. Park, and C. Watkinson,
21cmFASTv3: A Python-integrated C code for 3D realizations of the cosmic 21cm signal.
JOSS 5(54), 2582. [ArXiv: 2010.15121](#).
9. N. Sabti*, **J. B. Muñoz**, and D. Blas,
First Constraints on Small-Scale Non-Gaussianity from UV Galaxy Luminosity Functions.
JCAP 01 010 (2021). [ArXiv: 2009.01245](#).

* Student co-supervised.

10. J. Flitter, **J. B. Muñoz**, and E. Kovetz,
Outliers in the LIGO Black Hole Mass Function from Coagulation in Dense Clusters.
Submitted to PRD. [ArXiv: 2008.10389](#)
11. W.L. Xu^{*}, N. Deporzio^{*}, **J. B. Muñoz**, and C. Dvorkin,
Accurately Weighing Neutrinos with Cosmological Surveys.
Phys.Rev.D 103 2, 023503 (2021). [ArXiv: 2006.09395](#).
12. N. Deporzio^{*}, W.L. Xu^{*}, **J. B. Muñoz**, and C. Dvorkin,
Finding eV-scale Light Relics with Cosmological Observables.
Phys.Rev.D 103 2, 023504 (2021). [ArXiv: 2006.09380](#).
13. **J. B. Muñoz** and F.Y. Cyr-Racine.
Cosmic Variance of the 21-cm Global Signal.
Phys.Rev.D 103 2, 023512 (2021). [ArXiv: 2005.03664](#).
14. R. Laha, **J. B. Muñoz**, and T. Slatyer.
INTEGRAL constraints on primordial black holes and particle dark matter
Phys.Rev. D101, 123514 (2020). [ArXiv: 2004.00627](#). – **INTEGRAL picture of the month.**
15. Y. Qin, A. Mesinger, J. Park, B. Greig, and **J. B. Muñoz**.
A tale of two sites I: Inferring the properties of minihalo-hosted galaxies from current observations.
MNRAS 495 1, 123 (2020) [ArXiv: 2003.04442](#).
16. **J. B. Muñoz**, C. Dvorkin, and F.Y. Cyr-Racine.
Probing the Small-Scale Matter Power Spectrum with Large-Scale 21-cm Data.
Phys.Rev. D101, 063526 (2020). [ArXiv: 1911.11144](#).
17. **J. B. Muñoz**, V. Ravi, and A. Loeb.
Periodic Fast Radio Bursts from Young Neutron Stars.
ApJ 890 162 (2020), [ArXiv: 1909.00004](#).
18. D. Jyoti, **J. B. Muñoz**, R. Caldwell, and M. Kamionkowski
Cosmic Time Slip: Testing Gravity on Supergalactic Scales with Strong-Lensing Time Delays
Phys.Rev. D100, 043031 (2019). [ArXiv: 1906.06324](#).
19. C. Zeng, E.D. Kovetz, X Chen, Y. Gong, **J. B. Muñoz**, and M. Kamionkowski
Searching for Oscillations in the Primordial Power Spectrum with CMB and LSS Data
Phys.Rev. D99, 043517 (2019). [ArXiv: 1812.05105](#).
20. **J. B. Muñoz** and A. Loeb
Finding the Missing Baryons with FRBs and Sunyaev-Zeldovich Maps
Phys.Rev. D98, 103518 (2018). [ArXiv: 1809.04074](#).
21. **J. B. Muñoz** and C. Dvorkin
Efficient Computation of Galaxy Bias with Neutrinos and Other Relics.
Phys.Rev. D98, 043503 (2018). [ArXiv: 1805.11623](#).

22. A.M. Dizgah, H. Lee, **J. B. Muñoz** and C. Dvorkin
Galaxy Bispectrum from Massive Spinning Particles.
JCAP 1805, 013 (2018). [ArXiv: 1801.07265](#).
23. **J. B. Muñoz** and A. Loeb
Constraints on Dark Matter-Baryon Scattering from the Temperature Evolution of the Intergalactic Medium.
JCAP 1711, 043 (2017). [ArXiv: 1708.08923](#).
24. **J.B. Muñoz** and M. Kamionkowski
Large-Distance Lens Uncertainties and Time-Delay Measurements of H_0 .
Phys.Rev. D96, 103537 (2017). [ArXiv: 1708.08454](#).
25. T. L. Smith, **J.B. Muñoz**, R. Smith, K. Yee, and D. Grin.
Baryons still trace dark matter: probing CMB lensing maps for hidden isocurvature.
Phys.Rev. D96, 083508 (2017). [ArXiv 1704.03461](#).
26. **J.B. Muñoz**, E. D. Kovetz, A. Raccanelli, M. Kamionkowski, and J. Silk.
Towards a measurement of the spectral runnings.
JCAP 1705, 032 (2017). [ArXiv 1611.05883](#).
27. P.D. Meerburg, M. Münchmeyer, **J.B. Muñoz**, and X. Chen.
Prospects for Cosmological Collider Physics.
JCAP 1703, 050 (2017). [ArXiv: 1610.06559](#).
28. I. Cholis, E.D. Kovetz, Y. Ali-Haïmoud, S. Bird, M. Kamionkowski, **J.B. Muñoz**, and A. Raccanelli.
Orbital eccentricities in primordial black holes binaries.
Phys. Rev. D94, 084013 (2016). [ArXiv: 1606.07437](#).
29. A. Raccanelli, E.D. Kovetz, S. Bird, I. Cholis, and **J.B. Muñoz**.
Determining the progenitors of merging black-hole binaries.
Phys. Rev. D94, 023516 (2016). [ArXiv: 1605.01405](#).
30. M. Shiraishi, **J.B. Muñoz**, M. Kamionkowski, and A. Raccanelli.
Violation of statistical isotropy and homogeneity in the 21-cm power spectrum.
Phys.Rev. D93, 103506 (2016) . [ArXiv: 1603.01206](#).
31. S. Bird, I. Cholis, **J.B. Muñoz**, Y. Ali-Haïmoud, M. Kamionkowski, E.D. Kovetz, A. Raccanelli, and A.G. Riess.
Did LIGO detect dark matter?
Phys. Rev. Lett. 116, 201301 (2016). [ArXiv: 1603.00464](#) – **Featured in Physics.**
32. **J.B. Muñoz**, D. Grin, L. Dai, M. Kamionkowski, and E.D. Kovetz.
Search for Compensated Isocurvature Perturbations with Planck Power Spectra.
Phys.Rev. D93, 043008 (2016). [ArXiv: 1511.04441](#).
33. **J.B. Muñoz**, E.D. Kovetz, and Y. Ali-Haïmoud.
Heating of Baryons due to Scattering with Dark Matter During the Dark Ages.
Phys.Rev. D92, 083528 (2015). [ArXiv: 1509.00029](#).

34. **J.B. Muñoz**, Y. Ali-Haïmoud, and M. Kamionkowski.
Primordial non-gaussianity from the bispectrum of 21-cm fluctuations in the dark ages.
Phys.Rev. D92, 083508 (2015). [Arxiv: 1506.04152](#) – **Editor’s Choice.**
35. **J.B. Muñoz** and M. Kamionkowski.
Equation-of-State Parameter for Reheating.
Phys.Rev. D91, 043521 (2015). [ArXiv: 1412.0656.](#)
36. **J. Muñoz Bermejo**, A. Asensio Ramos, and C. Allende Prieto.
A PCA approach to stellar effective temperatures.
Astronomy & Astrophysics 553, A95 (2013). [ArXiv: 1303.7218.](#)

Selected white papers

37. A. Loeb and **J.B. Muñoz**
The First Stars May Shed Light on Dark Matter (Invited viewpoint for PRL, [arXiv:1807.01531](#)).
38. K.A. Abazajian et al. (including **J.B. Muñoz**)
CMB-S4 Science Book, First Edition ([arXiv:1610.02743](#)).
39. V. Ravi et al. (including **J.B. Muñoz**)
Fast Radio Burst Tomography of the Unseen Universe ([arXiv:1903.06535](#)).
40. A. Liu et al. (including **J.B. Muñoz**)
Cosmology with the Highly Redshifted 21cm Line ([arXiv:1903.06240](#)).
41. S. Furlanetto et al. (including **J.B. Muñoz**)
Fundamental Cosmology in the Dark Ages with 21-cm Line Fluctuations ([arXiv:1903.06240](#)).
42. V. Gluscevic et al. (including **J.B. Muñoz**)
Cosmological Probes of Dark Matter Interactions: The Next Decade ([arXiv:1903.05140](#)).
43. C. Dvorkin et al. (including **J.B. Muñoz**)
Neutrino Mass from Cosmology: Physics Beyond the Standard Model ([arXiv:1903.03689](#)).
44. J.O. Burns et al. (including **J.B. Muñoz**)
Dark Cosmology: Investigating Dark Matter & Exotic Physics in the Dark Ages using the Redshifted 21-cm Global Spectrum ([arXiv:1902.06147](#)).