Dr. Selim Can Hotinli

Personal details

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Professional

P. J. E. Peebles Senior Postdoctoral Fellow October 2023—2028
Perimeter Institute for Theoretical Physics

Horizon Fellow in Cosmology and Gravitation February 2021—2023
Johns Hopkins University

Postdoctoral Fellow* October 2020—2021
Imperial College London
*A post-doctorate position until my delayed start at Johns Hopkins due to COVID19 travel restrictions.

Education

Imperial College London 2016—2020
PhD in Physics, Thesis Advisor: Andrew Jaffe
Thesis Subject: Modern Cosmology in the post-Planck era.

Imperial College London 2014—2016
MSc in Physics (Distinction), Thesis Advisor: Andrew Jaffe and Carlo Contaldi
Thesis Subject: On the signatures of disorder in the early Universe.

Bosphorus University 2009-2014
BSc in Physics (First Class), Advisor: Prof. Veysi Erkcan Ozcan (CERN)

Activities

Organizer

Speaker selection, invitations and local contact

Seminars & Colloquia, Perimeter Institute, Canada	2023—
Theory Group Seminars, Johns Hopkins University, USA	2021—2023
Astrophysics Colloquia, Space Telescope Institute, Baltimore, USA	2022, 2023

Research group leadership

Cosmology arXiv discussions, Perimeter Institute, Canada	2023—
Astro-ph arXiv discussions, Johns Hopkins University, USA	2021—2023

Visitor

Aspen Centre of Physics, Aspen CO 81611, United States

New Discoveries in the Era of High-Resolution, Low-Noise CMB Experiments	2021
Groups and Clusters of Galaxies at the Crossroad between Astrophysics and Cosmology	2023
Toward a Holistic Understanding of the Multi-scale, Multiphase CGM	2024
New Cross-Correlation Perspectives on Cosmic Baryons	[2026, TBD]

KITP UC Santa Barbara, California 93106-4030, United States

Exploring New Boundaries in Cosmology and Astrophysics: CMB and LSS Surveys [2026]

Lead Representative: EDI-related Committees
Johns Hopkins University, USA 2021—2023
Perimeter Institute for Theoretical Physics, Canada 2023—

Visiting Graduate/Research Fellow
Canadian Institute for Astrophyiscs (CITA) 2017
Center for Computational Astrophysics, Flatiron Institute, USA 2017, 2018
Theory group, Johns Hopkins University, USA 2018
Perimeter Institute for Theoretical Physics, Canada 2019

Undergraduate Research Assistant or Group Member
Atomic, Mesoscopic and Optical Physics Group, Cavendish Laboratory, UK 2012
ATLAS Experiment group, Deutch Electron Synchrotron (DESY), Germany 2013
Astrophysics group, Imperial College London, UK 2015

Notable Awards and Grants

Principle Organizer of the 'Cosmic Ecosystems' conference 2025
A successful, large (> 120 people) conference happened in Summber 2025.
My personal application was granted with a funding of over 65000CAD at the Perimeter Institute.

P. J. E. Peebles Senior Postdoctoral Fellowship 2023—
Perimeter Institute's 5-year Prize Fellowship

Johns Hopkins Horizon Fellowship 2020—2023
Johns Hopkins University's Prize Postdoctoral Fellowship

Aspen Center of Physics 2021, 2023, 2024
stipend and *coverage*

Balzan Foundations Fellowship 2019
stipend from New-College-Oxford/Johns-Hopkins Centre for Cosmological Studies

Imperial College President's Scholarship 2016-2020
Imperial College's Prize PhD Scholarship.

Memberships

CMB-S4 2021—2025
Member

Simons Observatory 2018—
Member

Dark Energy Spectroscopic Instrument (DESI) 2025—
External member

Co-Advisor [Academic]

Julius Adolff (PSI student, Perimeter) 2025—
Now PhD candidate at UC Berkeley with Uros Seljak
`juliusadolff@berkeley.edu`

Jordan Krywonos (PhD candidate, Perimeter) 2024—
Applying for postdocs in 2025
`jkrywonos@perimeterinstitute.ca`

Amalia Madden (PhD candidate, Perimeter) 2023, 2024
Now postdoctoral fellow at UC Santa Barbara
amadden@perimeterinstitute.ca

Nanoom Lee (PhD candidate NYU) 2022—2024
Now postroctoral fellow at Johns Hopkins University with Marc Kamionkowksi
nanoom.lee@nyu.edu

Neha Anil Kumar (PhD candidate, JHU) 2022—
Applying for postdocs in 2025
nanilku1@jhu.edu

Mesut Caliskan (PhD candidate, JHU) 2022—
Applying for postdocs in 2025
caliskan@jhu.edu

Avery Tishue (PhD, Dartmouth) avery.tishue.gr@dartmouth.edu 2022—2025
Now postdoctoral fellow at University of Illinois, Urbana Champaign with Gil Holder

Jaxon North (Undergraduate student, JHU) 2022
Now in private sector with a government contract, Washington DC

Please feel free to contact me for a more up-to-date list, or a complete list of my mentees.

Talks and Seminars

Selected Conferences 2022—2025
Contributions. 'Simons Observatory F2F', Manchester University, UK [Online] 2025
Research talk. 'The mm-Universe' Conference, University of Chicago, USA 2025
Contributions. 'Cosmology Summer Fest, Marc Kamionkowski's 60th', JHU, USA 2025
Talks/Contributions. 'Simons Observatory F2F', KICP, Chicago University, USA 2025
Principal organizer. 'Cosmic Ecosystems', Perimeter Institute, Canada 2025
Invited review talk. 'Stage-5 Galaxy Survey', LBNL, UC Berkeley, USA 2024
Invited review talk. Reionization Conference, IAS, Paris, France 2024
Research talk. 'Baryons In the Universe', IPMU, Tokyo, Japan 2024
Talks/Contributions. Simons Observatory F2F, University of California, San Diego 2023
Invited review/research talk. 'New Physics from Old Light', Cambridge University, UK 2023
Research talk. 'Future Science with CMB x LSS', Yukawa Institute, Kyoto, Japan 2023
Research talk. Conference on cosmology, CCA, Flatiron Institute, NY, USA 2022
Invited research talk. Conference on reionization, McGill University, Montreal, Canada 2022

Shortlisted Job Talks (Tenure-Track Assistant Professor)
Invited colloqium and interview. Boston University, USA February 2023

Over 20 *Invited* Talks 2019-2025
Including LBNL & CCCP UC Berkeley, Perimeter Institute, Canadian Institute for Theoretical Astrophysics, Imperial College London, Johns Hopkins University, Flatiron Institute, Kavli Institute for Particle Astrophysics and Cosmology (KIPAC) and SLAC at Stanford, Max Planck Institute, Munich, Cornell University, University of Maryland College Park, University of Southern California, Columbia University, New York University, University of Sussex, NanoGrav Meeting, DAMTP and The Kavli Institute at Cambridge.

13 seminars given in Europe, USA and Canada February-September 2019

8 seminars given in Canada and United Kingdom 2017-2019

***Coding languages.* C/C++, Python, Fortran, Mathematica, Julia** Advanced

Public codes

kszx 2025—
The goal of the kszx package is to make a unified framework for different kSZ pipelines/projects which use a *3D Cartesian* approach. The code aimed to be used by ongoing and upcoming cosmological surveys analysis groups such as Simons Observatory.

ReCCO (Reconstruction Code for Cosmological Observables). 2022—
Consists on a collection of tools to calculate CMB secondary anisotropies (kSZ,tSZ,moving lens, CMB lensing) and reconstruct cosmological fields on our past lightcone (radial velocity fields and transverse velocity field)

CLASS_delens 2021—
Code produces delensed CMB spectra (TT, TE, EE and BB) and lensing-reconstruction noise for given CMB experiment specifications and cosmology.
FisherLens 2021—
This code provides a wrapper for the CLASS_delens code to facilitate Fisher forecasting of cosmological parameter constraints from CMB spectra.

Refereed Journals: PRL, PRD, JCAP, APJ, OJA, MRAS

References*

Prof. Simone Ferraro sferraro@lbl.gov
Senior Scientist, Physics Division, LBNL

Prof. Gilbert P. Holder gholder@illinois.edu
Brand & Monica Fortner Endowed Chair in Theoretical Astrophysics

Prof. Andrew H. Jaffe a.jaffe@imperial.ac.uk
Director of the Imperial Centre for Inference and Cosmology

Prof. Matthew Johnson mjohnson@perimeterinstitute.ca
Perimeter Institute & York University - Department of Physics and Astronomy

Prof. Marc Kamionkowski kamion@jhu.edu
William R. Kenan, Jr. Professor of Physics and Astronomy at Johns Hopkins University

Prof. Joel Meyers joelmeyers@utexas.edu
Associate professor at Southern Methodist University

Prof. Kendrick Smith kmsmith@perimeterinstitute.ca
The Daniel Family James Peebles Chair in Theoretical Physics

*In alphabetical order.

Publications

As of October 2025, h-index = 22 (19) total (published).

*: Supervised graduate student (below). **: Supervised undergraduate student (below).

Leading or major contribution:

[1] J. Adolff*, **S. C. Hotinli** and N. Dalal, "Probing Dark Energy Microphysics with kSZ Tomography," [arXiv:2511.05653 [astro-ph.CO]] [Submitted to OJAp].

- This work (below) exemplifies my recent efforts to identify new and powerful methods for accessing astrophysical information from cosmological data. The project was conceptualized, and the calculations and scope were clearly defined and drafted by me for the students I advise to lead.

[2] N. Anil Kumar*, M. Çalışkan*, **S. C. Hotinli**, K. Smith and M. Kamionkowski, "Electrons Everywhere, All at Once: A Novel kSZ Estimator for Electron-Electron Correlations," [arXiv:2509.18249 [astro-ph.CO]] [Submitted to PRL].

- This work (below) best represents the research projects I will lead in the coming years. Note that the scientific results here are more centered on cosmology; however, my future efforts will focus much more directly on astrophysics using similar methods.

[3] **S. C. Hotinli**, K. M. Smith and S. Ferraro, "Velocity Reconstruction from KSZ: Measuring f_{NL} with ACT and DESILS," [arXiv:2506.21657 [astro-ph.CO]] [Submitted to JCAP].

[4] N. Anil Kumar*, M. Çalışkan*, **S. C. Hotinli**, M. Kamionkowski, S. Ferraro and K. Smith, "Patchy Helium and Hydrogen Reionization from the Kinetic Sunyaev-Zel'dovich Effect and Galaxies," [arXiv:2506.11188 [astro-ph.CO]] [Submitted to PRD].

[5] A. J. Tishue*, **S. C. Hotinli**, P. Adshead, E. D. Kovetz and M. S. Madhavacheril, "Neutrino mass constraints from kinetic Sunyaev Zel'dovich tomography," Phys. Rev. D **111**, no.12, 123556 (2025) doi:10.1103/6vyw-k3k9 [arXiv:2502.05260 [astro-ph.CO]].

[6] J. Krywonos*, **S. C. Hotinli** and M. C. Johnson, "Constraints on cosmology beyond ΛCDM with kinetic Sunyaev Zel'dovich velocity reconstruction," [arXiv:2408.05264 [astro-ph.CO], Submitted to PRL].

[7] **S. C. Hotinli** and G. P. Holder, "Probing the optical depth with galaxy number counts," [arXiv:2404.10825 [astro-ph.CO]] [Submitted to PRD].

[8] B. Buncher*, G. Holder and **S. C. Hotinli**, "Gravitational Lensing of Galaxy Clustering," doi:10.33232/001c.132332 [arXiv:2402.07988 [astro-ph.CO]].

[9] **S. C. Hotinli** and E. Pierpaoli, "On the detectability of the moving lens signal in CMB experiments," JCAP **06**, 076 (2024) doi:10.1088/1475-7516/2024/06/076 [arXiv:2401.12280 [astro-ph.CO]].

[10] C. Trendafilova, **S. C. Hotinli** and J. Meyers, "Improving constraints on inflation with CMB delensing," JCAP **06**, 017 (2024) doi:10.1088/1475-7516/2024/06/017 [arXiv:2312.02954 [astro-ph.CO]].

[11] M. Çalışkan*, N. Anil Kumar*, **S. C. Hotinli** and M. Kamionkowski, "Reconstructing patchy helium reionization using the cosmic microwave background and large-scale structure," JCAP **10**, 034 (2024) doi:10.1088/1475-7516/2024/10/034 [arXiv:2312.00118 [astro-ph.CO]].

[12] E. Vanzan*, M. Kamionkowski and **S. C. Hotinli**, "Phenomenology of a vector-field-induced and possibly parity breaking compensated isocurvature perturbation," Phys. Rev. D **109**, no.8, 8 (2024) doi:10.1103/PhysRevD.109.083510 [arXiv:2311.18121 [astro-ph.CO]].

[13] N. Lee* and **S. C. Hotinli**, "Probing light relics through cosmic dawn," Phys. Rev. D **109**, no.4, 043502 (2024) doi:10.1103/PhysRevD.109.043502 [arXiv:2309.15119 [astro-ph.CO]].

[14] **S. C. Hotinli**, N. Sabti, J. North** and M. Kamionkowski, "Unveiling neutrino halos with CMB lensing," Phys. Rev. D **108**, no.10, 103504 (2023) doi:10.1103/PhysRevD.108.103504 [arXiv:2306.15715 [astro-ph.CO]].

[15] **S. C. Hotinli**, E. Pierpaoli, S. Ferraro and K. Smith, "Transverse velocities and matter gradient correlations: A new signal and a new challenge to moving-lens analyses," Phys. Rev. D **108**, no.8, 083508 (2023) doi:10.1103/PhysRevD.108.083508 [arXiv:2305.15462 [astro-ph.CO]].

[16] **S. C. Hotinli** and K. Ahn, "Probing the Global 21 cm Background by Velocity-induced Dipole and Quadrupole Anisotropies," Astrophys. J. **964**, no.1, 21 (2024) doi:10.3847/1538-4357/ad2209 arXiv:2305.01672 [astro-ph.CO].

[17] **S. C. Hotinli**, "Cosmological probes of helium reionization," Phys. Rev. D **108**, no.4, 043528 (2023) doi:10.1103/PhysRevD.108.043528 [arXiv:2212.08004 [astro-ph.CO]].

[18] S. Foreman, **S. C. Hotinli**, M. S. Madhavacheril, A. van Engelen and C. D. Kreisch, "Subtracting the kinetic Sunyaev-Zeldovich effect from the cosmic microwave background with surveys of large-scale structure," Phys. Rev. D **107**, no.8, 083502 (2023) doi:10.1103/PhysRevD.107.083502 [arXiv:2209.03973 [astro-ph.CO]].

[19] N. A. Kumar*, **S. C. Hotinli** and M. Kamionkowski, "Uncorrelated compensated isocurvature perturbations from kinetic Sunyaev-Zeldovich tomography," Phys. Rev. D **107**, no.4, 043504 (2023) doi:10.1103/PhysRevD.107.043504 [arXiv:2208.02829 [astro-ph.CO]].

- The work (below) is one of my projects that started new programs in cosmology and astrophysics.

[20] **S. C. Hotinli**, S. Ferraro, G. P. Holder, M. C. Johnson, M. Kamionkowski and P. La Plante, "Probing helium reionization with kinetic Sunyaev-Zel'dovich tomography," Phys. Rev. D **107**, no.10, 103517 (2023) doi:10.1103/PhysRevD.107.103517 [arXiv:2207.07660 [astro-ph.CO]].

[21] N. Lee*, **S. C. Hotinli** and M. Kamionkowski, "Probing cosmic birefringence with polarized Sunyaev-Zel'dovich tomography," Phys. Rev. D **106**, no.8, 083518 (2022) doi:10.1103/PhysRevD.106.083518 [arXiv:2207.05687 [astro-ph.CO]].

[22] N. Anil Kumar*, G. Sato-Polito, M. Kamionkowski and **S. C. Hotinli**, "Primordial trispectrum from kinetic Sunyaev-Zel'dovich tomography," Phys. Rev. D **106**, no.6, 063533 (2022) doi:10.1103/PhysRevD.106.063533 [arXiv:2205.03423 [astro-ph.CO]].

[23] **S. C. Hotinli**, G. P. Holder, M. C. Johnson and M. Kamionkowski, "Cosmology from the kinetic polarized Sunyaev Zel'dovich effect," JCAP **10**, 026 (2022) doi:10.1088/1475-7516/2022/10/026 [arXiv:2204.12503 [astro-ph.CO]].

[24] **S. C. Hotinli**, D. J. E. Marsh and M. Kamionkowski, Phys. Rev. D **106**, no.4, 043529 (2022) doi:10.1103/PhysRevD.106.043529 [arXiv:2112.06943 [astro-ph.CO]].

[25] **S. C. Hotinli**, J. Meyers, C. Trendafilova, D. Green and A. van Engelen, "*The benefits of CMB delensing,*" JCAP **04** (2022) no.04, 020 doi:10.1088/1475-7516/2022/04/020 [arXiv:2111.15036 [astro-ph.CO]].

[26] J. Cayuso*, R. Bloch*, **S. C. Hotinli**, M. C. Johnson and F. McCarthy, "*Velocity reconstruction with the cosmic microwave background and galaxy surveys,*" [arXiv:2111.11526 [astro-ph.CO]].

[27] L. Ji*, **S. C. Hotinli** and M. Kamionkowski, "*Cross-correlation of the Polarizations of the 21-cm and Cosmic Microwave Backgrounds,*" [arXiv:2110.01619 [astro-ph.CO]]. (to be published at PRD)

[28] **S. C. Hotinli**, K. M. Smith, M. S. Madhavacheril and M. Kamionkowski, "*Cosmology with the moving lens effect,*" Phys. Rev. D **104**, no.8, 083529 (2021) doi:10.1103/PhysRevD.104.083529 [arXiv:2108.02207 [astro-ph.CO]].

[29] **S. C. Hotinli**, T. Binnie, J. B. Muñoz, B. R. Dinda and M. Kamionkowski, "*Probing compensated isocurvature with the 21-cm signal during cosmic dawn,*" Phys. Rev. D **104**, no.6, 063536 (2021) doi:10.1103/PhysRevD.104.063536 arXiv:2106.11979 [astro-ph.CO].

[30] **S. C. Hotinli** and M. C. Johnson, Phys. Rev. D **105**, no.6, 063522 (2022) doi:10.1103/PhysRevD.105.063522 arXiv:2012.09851 [astro-ph.CO].

[31] **S. C. Hotinli**, "*New directions in cosmology and astrophysics,*". doi:10.25560/85382.

[32] **S. C. Hotinli**, M. C. Johnson and J. Meyers, "*Optimal filters for the moving lens effect,*" Phys. Rev. D **103**, no.4, 043536 (2021) doi:10.1103/PhysRevD.103.043536 arXiv:2006.03060 [astro-ph.CO].

[33] **S. C. Hotinli**, James B. Mertens, Matthew C. Johnson and Marc Kamionkowski, "*Probing correlated compensated isocurvature perturbations using scale-dependent galaxy bias*," doi:10.1103/PhysRevD.100.103528, arXiv:1908.08953 [astro-ph.CO].

[34] **S. C. Hotinli**, M. Kamionkowski and A. H. Jaffe, "*The search for anisotropy in the gravitational-wave background with pulsar-timing arrays*," doi:10.21105/astro.1904.05348, arXiv:1904.05348 [astro-ph.CO].

- The work (below) is one of my projects that started new programs in cosmology and astrophysics.

[35] **S. C. Hotinli** and Meyers, Joel and Dalal, Neal and Jaffe, Andrew H. and Johnson, Matthew C. and Mertens, James B. and Münchmeyer, Moritz and Smith, Kendrick M. and van Engelen, Alexander, "*Transverse Velocities with the Moving Lens Effect*," Phys. Rev. Lett. **123**, no. 6, 061301 (2019) doi:10.1103/PhysRevLett.123.061301, arXiv:1812.03167 [astro-ph.CO].

[36] **S. C. Hotinli**, J. Frazer, A. H. Jaffe, J. Meyers, L. C. Price and E. R. M. Tarrant, "*Effect of reheating on predictions following multiple-field inflation*,". Phys. Rev. D **97**, no. 2, 023511 (2018) doi:10.1103/PhysRevD.97.023511, arXiv:1710.08913 [astro-ph.CO].

Significant contribution:

[37] N. Dachlythra, K. Wolz, S. Azzoni, D. Alonso, A. J. Duivenvoorden, A. E. Adler, J. E. Gudmundsson, C. Baccigalupi, A. Carones and G. Coppi, *et al.* "The Simons Observatory: Quantifying the impact of beam chromaticity on large-scale B-mode science," JCAP **10**, 005 (2025) doi:10.1088/1475-7516/2025/10/005 [arXiv:2503.01791 [astro-ph.CO]].

[38] S. Aiola *et al.* [CMB-HD], "*Snowmass2021 CMB-HD White Paper,*" [arXiv:2203.05728 [astro-ph.CO]].

[39] J. J. Renk *et al.* [GAMBIT Cosmology Workgroup], "*CosmoBit: A GAMBIT module for computing cosmological observables and likelihoods,*" JCAP **02**, 022 (2021) doi:10.1088/1475-7516/2021/02/022 [arXiv:2009.03286 [astro-ph.CO]].

Minor contribution:

[40] M. Abitbol *et al.* [Simons Observatory], JCAP **08**, 034 (2025) doi:10.1088/1475-7516/2025/08/034 [arXiv:2503.00636 [astro-ph.IM]].

[41] C. L. Chang, K. M. Huffenberger, B. A. Benson, F. Bianchini, J. Chluba, J. Delabrouille, R. Flauger, S. Hanany, W. C. Jones and A. J. Kogut, *et al.* "*Snowmass2021 Cosmic Frontier: Cosmic Microwave Background Measurements White Paper,*" [arXiv:2203.07638 [astro-ph.CO]].

[42] K. Abazajian *et al.* [CMB-S4], "*Snowmass 2021 CMB-S4 White Paper,*" [arXiv:2203.08024 [astro-ph.CO]].

[43] S. S. AbdusSalam, F. J. Agocs, B. C. Allanach, P. Athron, C. Balázs, E. Bagnaschi, P. Bechtle, O. Buchmueller, A. Beniwal and J. Bhom, *et al.* "*Simple and statistically sound strategies for analysing physical theories,*" [arXiv:2012.09874 [hep-ph]].

[44] P. Stöcker *et al.* [GAMBIT Cosmology Workgroup], "*Strengthening the bound on the mass of the lightest neutrino with terrestrial and cosmological experiments,*" Phys. Rev. D **103**, no.12, 123508 (2021) doi:10.1103/PhysRevD.103.123508 [arXiv:2009.03287 [astro-ph.CO]].

[45] W. R. Coulton, P. D. Meerburg, D. G. Baker, S. Hotinli, A. J. Duivenvoorden and A. van Engelen, "Minimizing gravitational lensing contributions to the primordial bispectrum covariance," Phys. Rev. D **101**, no.12, 123504 (2020) doi:10.1103/PhysRevD.101.123504 [arXiv:1912.07619 [astro-ph.CO]].

[46] K. Basu *et al.*, "A Space Mission to Map the Entire Observable Universe using the CMB as a Backlight," arXiv:1909.01592 [astro-ph.CO]. Science White Paper submitted in response to the ESA Voyage 2050 call, 20 pages + title page + references.
Contribution: Edited part of Section 2.1.3 titled '*Cosmic velocity fields with the kSZ and moving lens effects*'. Provided the analysis that produced Figure 4, and produced Figure 4.

Please see arXiv and inpsire for a more complete list.

Notable recent research activities and findings

- Led ACT × DESI-LS data analysis providing the tightest kSZ-based constraint on local-type primordial non-Gaussianity ($f_{\rm NL} = -39^{+40}_{-33}$) and measuring $b_v = 0.45^{+0.06}_{-0.05}$, revealing baryonic feedback suppression of the galaxy–electron correlation; results validated through extensive null tests and form the basis for upcoming Simons Observatory, DESI, and LSST studies [3].
- Co-developed the kszx software that makes a unified framework for different kSZ pipeline and projects [3]. The code is to be used by analysis groups of ongoing and upcoming cosmological surveys such as DESI, Simons Observatory and LSST and more widely by the cosmology and astrophysics communities.
- Co-led analysis using Planck and unWISE data that provided the tightest constraints on the rest frame of large-scale structure, ruling out nonlinear Gpc-scale voids, placing a < 14 km/s (68%) limit on the intrinsic dipole, excluding matter–radiation isocurvature explanations, and constraining amplitudes of primordial non-Gaussianity and isocurvature; co-led conceptualization, analysis, and writing, and co-advised a student collaborator [6].
- Initiated programs to uncover new astrophysical signals and methods.

  Example 1: My recent work (led by one of the students I advise) introduced the first practical method to directly measure the three-dimensional distribution of all ionized electrons in the Universe—the electron auto-power spectrum—using a novel kSZ estimator that combines CMB and galaxy-survey data [2]. By mapping the full electron distribution rather than just galaxy-traced gas, it opens a new avenue for probing baryonic feedback, missing baryons, and the interplay between cosmology and astrophysics with forthcoming surveys like the Simons Observatory and DESI.

  Example 2: I was the first to demonstrate the detectability and scientific importance of the moving-lens effect in the CMB—the redshifting of CMB photons caused by cosmic structures moving transverse to the line of sight. This effect uniquely enables unbiased measurements of the large-scale transverse velocities of dark matter halos [35]. I developed the foundational concept for this program and carried out detailed feasibility forecasts; I then subsequently created the methods for

its detection [32,26], built its scientific value [28], recently extending these efforts to tests with simulations [9]. In the process, I also uncovered a new related signal that emerged from this line of work [15]. I now lead a major effort within my experimental collaborations to achieve the first detection of the moving-lens effect.

Example 3: Demonstrated that joint analyses of CMB and large-scale structure (CMB×LSS) data can detect signatures of helium reionization [4,11,17,20], providing an independent observational probe of this key cosmic epoch and opening new possibilities to explore its connection to galaxy formation, quasar evolution, and the growth of cosmic structures. Doing so, I aim to renew community interest in helium reionization—an epoch I argue to be underexplored—as an astrophysical frontier and begun laying the groundwork for upcoming cross-correlation studies and the first detection with near-future CMB and LSS data. I also explore machine-learning and Bayesian hierarchical model building methods to fully capitalize on the existing complementary Lyman-alpha forest measurements of this epoch.

Example 4: I have led a campaign of forecasting projects that has built the science case for cross-correlation projects for both astrophysics and cosmology. Science topics include: Dark energy [1], electron density and baryonic feedback [2], primordial non-Gaussianity and isocurvature [19,22,23,29,33], parity violation [12], neutrino mass [12,13,4], cosmological growth rate [28], searches for ultra-light axions [24], cosmic birefringence [21] and probing helium and hydrogen reionization [4,11,17,20].