Groundbreaking research on our early universe earns the prestigious Second Prize at the 2023 Buchalter Cosmology Awards

- **Lucas Pinol of the Laboratoire de Physique de l'École Normale Supérieure (ENS-CNRS-UPSL-SU-UPC), Instituto de Física Teórica (UAM-CSIC), and IAP-CNRS-Sorbonne Université has been acknowledged along with his colleagues Denis Werth and Sébastien Renaux-Petel of the Institut d'Astrophysique de Paris (IAP-CNRS-Sorbonne Université).**

- **The study "Cosmological Flow of Primordial Correlators" unveils a new method for determining the observational consequences of any theory of the primordial universe.**

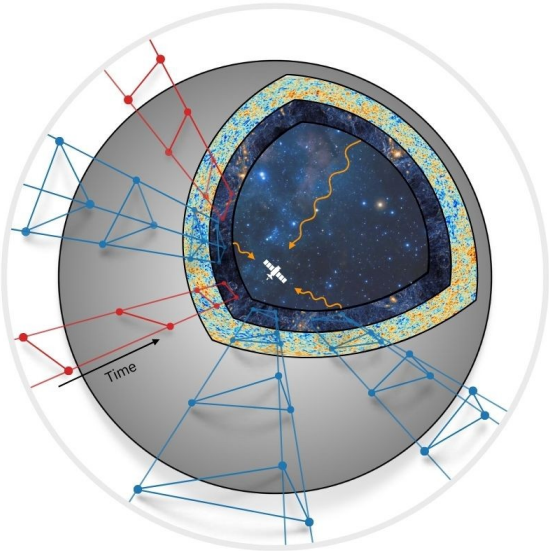
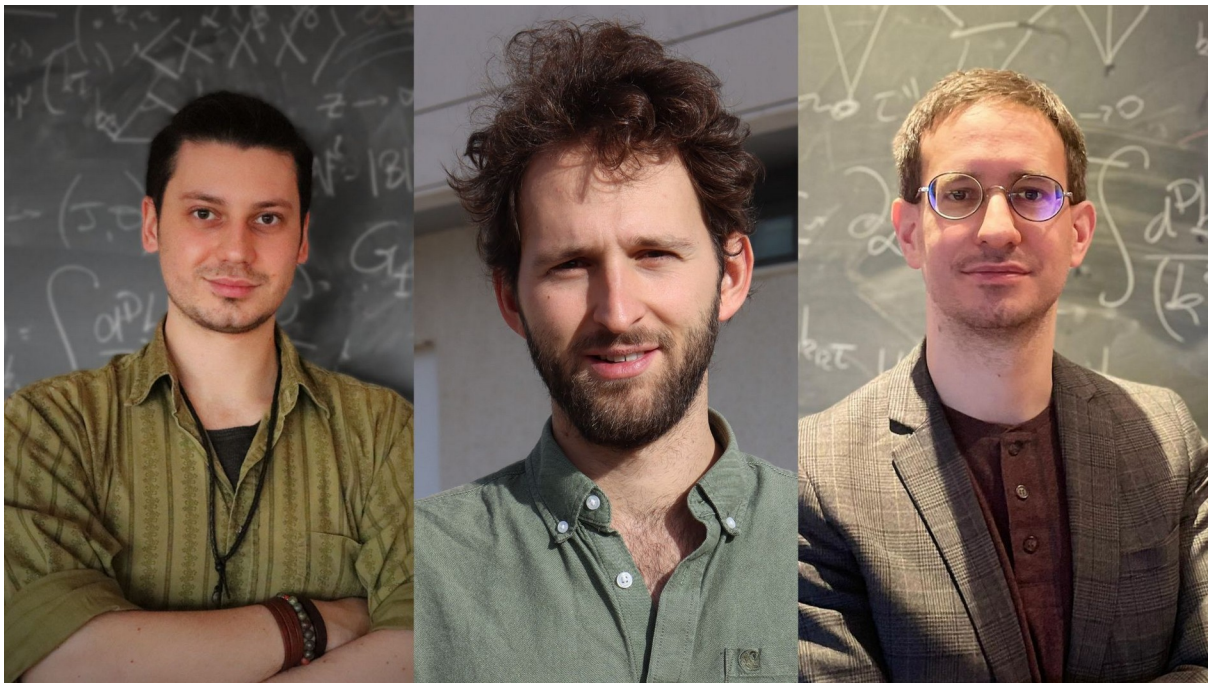


Figure I: Illustration of the cosmological flow. From initial quantum fluctuations, cosmological correlators evolve over time (represented by the black arrow) until reaching the end of inflation, subsequently shaping the distribution of matter in our Universe. The traces left in the sky by these correlators offer the opportunity to explore new, yet-unexplored physical theories that the next generation of cosmological surveys could decode.

Madrid, January 12th, 2024.- The research titled "Cosmological Flow of Primordial Correlators" has been honored with the esteemed Second Prize at the 2023 Buchalter Cosmology Awards, unveiled last week at the 243rd meeting of the American Astronomical Society.

Traditional methods to study these primordial patterns have been limited to specific scenarios, but the groundbreaking work of Denis Werth of the Institut d'Astrophysique de Paris (IAP-CNRS-Sorbonne Université), Lucas Pinol of the Laboratoire de Physique de l'École Normale Supérieure (ENS-CNRS-UPSL-SU-UPC), Instituto de Física Teórica (UAM-CSIC), and IAP-CNRS-Sorbonne Université, and Sébastien Renaux-Petel of the Institut d'Astrophysique de Paris (IAP-CNRS-Sorbonne Université), introduces a unique theoretical framework for determining the observational consequences of any theory of the primordial universe.



Denis Werth, Lucas Pinol and Sébastien Renaux-Petel.

Primordial inhomogeneities were created during a phase of accelerated expansion called cosmic inflation, and they provide the seeds that collapsed to form galaxies and the universe as we know it. Their knowledge can only be statistical and is contained in what is called "cosmological correlators", connecting theories to cosmological observations. While theoretically calculable, practical difficulties have historically hindered this, creating a bias between theories and theoretical predictions. The authors pioneered the development of the "cosmological flow" that addresses these issues, allowing for the systematic calculation of cosmological correlators. This method traces their temporal evolution from their origin as vacuum quantum fluctuations to the end of inflation, providing a deep understanding of the physical processes at play during this phase of the primordial universe. This breakthrough enables the scientific community to explore new processes in high-energy physics, i.e., energies much higher than those achievable in terrestrial experiments (e.g., in the Large Hadron Collider).

Much data is anticipated from major cosmological surveys like the Euclid space telescope or the ground-based Vera Rubin telescope. In this context, the cosmological flow method generates theoretical data ensuring unbiased interpretation of these observations. To expedite progress in this direction, in addition to publishing the formalism of the cosmological flow method, the study authors have made their code public.

Dr. Kyle Boone and Dr. Matthew McQuinn from the University of Washington secured the prestigious First Prize for their groundbreaking work titled "Solar System-scale interferometry on fast radio bursts could measure cosmic distances with sub-percent precision," published in The Astrophysical Journal Letters. Receiving the Third Prize was the collaborative effort of Dr. Gabriele Franciolini of CERN, Dr. Davide Racco of ETH Zurich and the University of Zurich, and Dr. Fabrizio Rompineve of Universitat Autònoma de Barcelona, IFAE, and BIST. Their work, titled "Footprints of the QCD Crossover on Cosmological Gravitational Waves at Pulsar Timing Arrays," presented a timely test for a potential early universe contribution to the stochastic background of gravitational waves.

Dr. Ari Buchalter, the founder of the Buchalter Cosmology Prize, remarked, "The 2023 prize winners each represent novel ideas that can test our understanding of the cosmos and potentially open up exciting new avenues of exploration."

The rotating judging panel for the prize, composed of leading theoretical physicists, included Dr. Cora Dvorkin of Harvard University, Dr. Lam Hui of Columbia University, and Dr. Rafael Porto of Deutsches Elektronen-Synchrotron DESY.-

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- Sébastien Renaux-Petel, CNRS researcher at the Institut d'Astrophysique de Paris (IAP, CNRS, and Sorbonne Université), lecturer at École Polytechnique, PI of the ERC GEODESI project in which the awarded work originated

Award-winning paper: Werth, Pinol, Renaux-Petel 2023, "Cosmological flow of primordial correlators," http://arxiv.org/abs/2302.00655

Companion paper: Pinol, Renaux-Petel, Werth 2023, "The Cosmological Flow: A Systematic Approach to Primordial Correlators," http://arxiv.org/abs/2312.06559

Buchalter Cosmology Prize: http://www.buchaltercosmologyprize.org/

IFT

The Institute for Theoretical Physics (IFT) UAM-CSIC was officially created in 2003 as a joint research center belonging to the Spanish National Research Council (CSIC) and the Autonomous University of Madrid (UAM). It is the only Spanish center dedicated entirely to research in Theoretical Physics. The IFT members develop research in the frontiers of Elementary Particle Physics, Astroparticles and Cosmology, in order to understand the fundamental keys of Nature and the Universe. They are also leading many research projects, both at the national and international level. The IFT is part of the strategic line `Theoretical Physics and Mathematics´ of the Campus of International Excellence (CEI) UAM+CSIC established in 2009. Since 2012, it is credited as Severo Ochoa Centre of Excellence. Besides purely scientific activity, in the IFT is also conducted intensive training tasks of young researchers and professionals through the graduate program in Theoretical Physics with mention of excellence from the CEI and the Ministry of Education. In addition, the Institute carries out the important task of transferring knowledge to society through several outreach programs.

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