Dark energy constraints from Lyman-alpha absorption data with DESI

- Thèses, Stages, Formation et Enseignement - Propositions de thèses 2020 -

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Title: Dark energy constraints from Lyman-alpha absorption data with DESI

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Team: Cosmology and dark energy; group: eBOSS/DESI

Description:

The origin of the accelerated expansion of the Universe, discovered in the late 1990s thanks to distant supernovae data, remains mysterious today. Is it due to a modified theory of gravity, or caused by â€œdarkâ€• energy with properties surprisingly similar to Einstein's cosmological constant? Accurately measuring the history of expansion helps constrain the properties of dark energy, and thereby better understand its nature.

One of the main probe of dark energy today is the measurement of the caracteristic scale imprinted in the matter distribution at the time of photon decoupling, about 300,000 years after the Big Bang, by primordial acoustic waves. Measuring this so-called standard BAO scale in the distribution of different populations of objects tracing the matter density field provides invaluable insights on the state of expansion at different times.

This scale, initially measured in 2005 by the SDSS collaboration in the correlation function of galaxies at a redshift z 0.35, then by the BOSS experiment (Baryonic Oscillation Spectroscopic Survey) in 2012 for galaxies at z 0.6, is nowdays also measured in the distribution of quasars, as well as in the distribution of material between the quasars and us. This matter produces in the spectrum of quasars a compact series of absorptions corresponding to the Lyman-alpha transition, called Lyman-alpha forest. For quasars at z> 2, these "forests" are shifted in the visible range and can be observed from the ground. The Lyman-alpha forest correlation function has a correlation peak around 150 Mpc, corresponding to the BAO scale.

The thesis is part of the large international DESI (Dark Energy Spectroscopic Instrument) project. This experiment uses the 4m Mayall telescope at Kitt Peak in Arizona. The signals from the 5000 fibers of its focal plane are sent to ten spectrographs, where they are dispersed in three arms (blue, red and near infrared). The science data collection starts in 2020 and will continue until 2025. The candidate will measure in the DESI data the correlation function of the Lyman-alpha absorptions in the lines of sight of the quasars, as well as the cross correlation function between the position of quasars and the absorptions of other quasars. He or she will study the still poorly understood systematic effects associated with these analyzes (distortion introduced by determining the continuum of quasar spectra, contamination by metals, effects of systems with high column density, etc.). Extracting the BAO scale from the correlation functions studied will constrain the dark energy models with unprecedented precision to these redshifts. The work can be extended to higher-order statistics, such as the 3-point Lyman-alpha correlation function.

Missions: <\br> The Dark Energy Spectroscopic Instrument (DESI) experiment is a major experiment in observational cosmology aiming at puting new constraints on the equation of state of Dark Energy from the measurement of the scale of acoustic baryon oscillations (BAO) in the correlation functions of different targets observed by DESI (emission line galaxies, red luminous galaxies, quasars and quasar absorption regions). DESI will obtain the spectra of 35 million of these targets. The commissioning of the instrument started in October 2019 and was completed in March 2020. After a validation period of a few months, the data collection of science should start in autumn 2020 and will last 5 years. The objective of the thesis is, through the development of new algorithms and an in-depth analysis of systematic effects, to make the most of the unprecedented spectroscopic data obtained by DESI to constrain the history of the expansion of the Universe to redshits of the order of 2.3 using the absorption lines of intergalactic neutral hydrogen in the line of sight of distant quasars.

Activities: <\br> The doctoral student will participate in data analysis activities from data obtained at the Mayall telescope at Kitt Peak as part of the international DESI collaboration. He / she will use and develop numerical analysis tools as part of open source code development on GitHub. He / she will be integrated into different working groups of the DESI collaboration (Lyman-alpha group and Data group among others) and will participate in weekly teleconferences where he / she will be required to present his work on a regular basis. He / she will also be involved in taking data, either directly on site or remotely from the LPNHE.

Requirements: <\br> The candidate must have an M2 master degree (or equivalent) in particle physics or astrophysics. A taste for the analysis of cosmological data and a mastery of programming, especially in python, are highly desirable. Fluency in English is required.

Work context:

The subject of the thesis is part of a large international collaboration (DESI). Part of the work will be carried out within the DESI team of LPNHE, a joint CNRS / IN2P3 unit on the Sorbonne University campus in Paris 5th district. This team brings together BAO Lyman-alpha analysis experts and is made up of four permanent researchers / teacher-researchers (including two CEA visitors), a postdoctoral student and a doctoral student. This team is itself a component of the Cosmology group of LPNHE, a world expert in observational cosmology. Our team has been forging close ties with the DESI team at Irfu (CEA) for 2 years and the doctoral student will participate in regular joint meetings. In addition, several trips lasting between 1 and 3 months will take place during the thesis at the Pierre Binetruy Center in Berkeley where the student will work with our many collaborators on DESI.

Possible trips:

The successful candidate will be required to travel between France and the United States for stays ranging from 1 to three months in Berkeley.

PhD proposal:

https://emploi.cnrs.fr/Offres/Doctorant/UMR7585-MARCAR-012/Default.aspx?lang=EN

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