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Cosmological analysis of the DESI data to constrain general relativity and modified gravity models

- Thèses, Stages, Formation et Enseignement - Propositions de thèses 2021 -

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Title: Cosmological analysis of the DESI data to constrain general relativity and modified gravity models

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

Description:

Context: <\br> The late-time acceleration of the expansion of the universe has been discovered in the late 90's and has been confirmed by several independent cosmological probes since then which are more and more robust. However, its mechanism is still a major unknown in modern cosmology. In our current model, we assume a cosmological constant in the equations of general relativity that acts as a fluid whose equation of state is constant. But a time-dependent dark energy would still be compatible with observations. Moreover, tracking modifications of general relativity could also offer a solution, although the joint detection of gravitational and light waves has already ruled out several modified gravity models. One of the main probes for dark energy and gravity is the study of the three-dimensional clustering of galaxies using statistical tools. Important sky surveys are just starting in order to obtain a precision on the dark energy equation of state of about a few percent and to constrain the nature of gravity and see whether modifying general relativity is necessary at cosmological scales. One direct test of the theory of gravity consists in measuring the rate at which matter clusters to form galaxies, which is called the growth rate of structure.

Topic: <\br> The cosmology group of the LPNHE is involved in several of these international projects, including the Dark Energy Spectroscopic Instrument (DESI) which uses the 4m Mayall telescope at Kitt Peak in Arizona. After a few-month period of survey validation, DESI will start its scientific survey and will obtain 35 million spectra of galaxies over 5 years. The sample of 10 million galaxies at low redshifts (Bright Galaxy Survey, BGS) will probe the local universe when it is currently dominated by the cosmic acceleration. Together with it is high density sampling, it makes it the ideal dataset to study modifications of general relativity. The precision on the cosmological parameters will not be limited by statistics but by cosmic variance, meaning the fact that we observe only one universe. A multi-tracer method has been proposed to get rid of it which consists in splitting the sample into two sub-samples by colour (blue and red galaxies) whose clustering properties are different and perform a joint analysis. The technique could improve the precision on the growth rate of structure up to 20%, which would thus improve the constraints on the nature of gravity.

Proposed work: <\br> The candidate will contribute to the cosmological analysis of the DESI Y1 BGS data. He/she will develop the pipeline for the multi-tracer technique and perform a detailed study of potential systematics that could affect the measurement. He/She will test the method on simulated mock catalogues first and then apply it to real data in order to measure the growth rate of structure. This analysis on simulated and real data should lead to two publications and will be complementary to the standard analysis of the DESI Y1 data which has been identified as one of the key projects by DESI (Key Project 5). In parallel and depending on the progress, the candidate will contribute to the development of mock catalogues for the DESI BGS using the numerical simulations within the modified gravity framework. For this work, he/she will work with our colleagues, Prof. Shaun Cole and Prof. Baojiu Li at the Institute for Computational Cosmology (ICC) at Durham University in the UK in order to use one of the only cosmological simulations in modified gravity that exist. The candidate will be a member of several working groups in DESI (BGS, Galaxy and Quasar Clustering and Key Project 5) where he/she will attend weekly telecons and present his/her work.

Expected skills: <\br> The candidate is expected to have a strong background in cosmology with a M2 diploma (or equivalent). Interest in cosmological data analysis and numerical simulations, together with skills in statistical methods and computing, in particular in python, are also very appreciated.

Possible trips:

The candidate will have the opportunity to visit our collaborators Prof. Shaun Cole and Prof. Baojiu Li at the ICC at Durham University in the UK. He/She will also attend the DESI collaboration meetings which usually occur in the US and he/she will participate to the data taking, either on site at Kitt Peak or remotely from the LPNHE.

Contact:

- Pauline Zarrouk
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Documentations:

- https://www.desi.lbl.gov/
- https://lpnhe.in2p3.fr/spip.php?rubrique335
- http://www.icc.dur.ac.uk/