Marco Bonici PhD second year report

My PhD supervisor is Professor Nicola Maggiore.

Research Subject

My PhD research is focused on Cosmology, in particular on the study of Dark Energy and neutrino masses, both from a theoretical and a phenomenological point of view. On the theoretical side, I have studied, with my advisor Nicola Maggiore, the structure of the Einstein equations applied to the cosmological context, in a very general fashion: we did not make any assumption on the Dark Energy equation of state or the functional form of the interactions between Dark Energy and the other components of the universe. In particular, we have obtained a new observable which quantifies the deviations from the Standard Model of Cosmology. We have published our paper and now I am still working on this reasearch subject, preparing a Python code based on the Nested sampling algorithm, which will enable us to use different datasets to constrain the value of our observable.

My other PhD project is related to the Euclid Mission. Euclid is an ESA space mission, whose main scientific tasks are the nature of Dark Energy, Dark Matter and the neutrino masses. Euclid will observe about a billion galaxies obtaining a measure of the matter distribution in the Universe. Furthermore, from the shapes of the observed galaxies, it will also obtain an estimate of the gravitational lensing, the light distortion due to the underlying mass distribution. I am studying, cooperating with the Milan INAF section, the cross-correlation between lensing and the cosmic voids distribution. Cosmic voids are among the biggest large scale structures of the Universe and they are underdense regions; for this reason, their features are really sensitive to Dark Energy and neutrinos. In order to study this cross-correlation, I am writing a Python code divided in three parts. The first part of my code evaluates the observables I am interested in, the cross-correlation between lensing and cosmic voids, and is based on an open-source code, CAMB. This code numerically solves the Einstein-Boltzmann equations and hence gives us the evolution of the universe inhomogeneities. The second part of my code numerically evaluates the derivates of the observables with respect to the cosmological parameters. The third part of the code evaluates the Fisher Matrix, allowing use to forecast how precisely we will be able to measure the cosmological parameters using the voids lensing cross-correlation. Furthermore I wrote a Python script, together with the Genoa Euclid group, which automates the job submission to the local computing facility. This enables us to perform simulations with different values of the cosmological parameters in a fast and efficient way.

Courses attended during last year

- Cosmology (N.Maggiore)

List of given exams during my PhD

- Simulation methods applied to Physics (R. Ferrando)
- Very High Energy Astrophysics (F. Tavecchio)
- Summer School of Cosmology, International Center of Theoretical Physics, Trieste 18-29 June 2018
- Cosmology (N.Maggiore)

Attended Conferences and Meetings during last year

- Euclid Workshop INAF, Rome, 11/02/2019-14/02/2019: Annual collaboration meeting for the italian Euclid comunity
- Universum, Milan, 03/04/2019-05/04/2019: Conference about the state of the art of Cosmology research in Italy
- Euclid Annual Meeting, Helsinki, 04/06/2019-07/06/2019: Annual collaboration meeting for the ESA Euclid Mission

Published Papers

- ”Analysis of the Angular Dependence of Time Delay in Gravitational Lensing”; Nicola Alchera, Marco Bonici, Roberta Cardinale, Alba Domi, Nicola Maggiore, Chiara Righi, Silvano Tosi; Symmery 2018,10(7),246, https://doi.org/10.3390/sym100702466
- ”Towards a New Proposal for the Time Delay in Gravitational Lensing”; Nicola Alchera, Marco Bonici, Nicola Maggiore; Symmetry 2017, 9(10), 202; https://doi.org/10.3390/sym9100202
- “Constraints on Interacting Dynamical Dark Energy and a new test for ΛCDM”; Marco Bonici, Nicola Maggiore; Eur.Phys.J. C79 (2019) no.8, 672; https://doi.org/10.1140/epjc/s10052-019-7198-1