

PhD in Physics and Nanoscience – XXXVIII cycle

First year report

Antonio Farina

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Research activity :

My Ph.D. research revolves around the Euclid experiment, a mission under the European Space Agency dedicated to Fundamental Cosmology and Astrophysics. The primary objective of Euclid is to establish constraints on the cosmological parameters that intricately characterize the evolution and composition of our Universe. This includes, in particular, unraveling the nature of Dark Energy, Dark Matter and inflation and obtaining a precise measurement of the cumulative neutrino mass. To attain these ambitious accomplishments, the Euclid mission is set to perform a redshift survey of an unprecedented extension (15.000 square degrees), mapping position and properties of more than 50 millions of galaxies in the visible and near-infrared bands. A notable portion of this sample of galaxies will also undergo analyses in spectroscopic mode, enabling a more precise determination of their redshifts and, subsequently, of their distances. This allows us to study the three-dimensional distribution of galaxies, whose build-up and statistical properties depend on the expansion history of the Universe, its matter-energy content and the nature of the gravitational interaction.

So far, the most widely used clustering statistical tools have been the so-called 2-point statistics. However, the non-Gaussian features that characterize primordial density fluctuations, their non-linear evolution and galaxy biasing (the non-trivial relation between luminous galaxies and the bulk of underlying Dark Matter) drive the shift of a substantial fraction of cosmological information towards density field's higher-order moments.

My doctoral activity primarily focuses on the characterization of these higher order statistics, including both theoretical and measurement aspects, with particular emphasis on the so-called galaxy 3-point correlation function (3PCF). On the modeling front, I have expanded the existing 3PCF model, which previously considered only the average over the line of sight direction, to encompass its complete redshift-space dependence. This extension will enable us to conduct, for the 1st time, a fully anisotropic joint 2 and 3PCF analysis, a task that is currently occupying my efforts. Two and 3-point statistics, indeed, are

highly complementary and, if combined, would allow us to significantly improve the accuracy with which we infer cosmological parameters, to break down degeneracies in their estimates and to trace the rate at which cosmic structures are evolving, which in turns depend on the nature of Dark Energy.

On the measurements front, I am working within the Euclid Level 3 Organizational Unit to test and optimize the algorithms that will be employed to estimate both isotropic and anisotropic versions of the 2 and 3PCF correlation functions.

Finally, I have recently embarked on a new endeavor more closely focused on systematic effects. In the context of the Euclid spectroscopic survey, systematic variations in the galaxy selection function are addressed by utilizing the so-called spectroscopic visibility mask (VMSP). This mask enables us to modulate the number density of the measured target correcting for effects like spectrophotometric zero-point calibration, Milky Way extinction, interlopers and so on. However, this correction could lead to the introduction of correlated errors if true density perturbations happen to align with foregrounds. The goal of this task is, then, that of propagating to the covariance matrix the errors coming from the VMSP and quantifying their effects on the measured galaxy clustering statistics.

Attended courses:

1. *The double trouble of the missing matter in the Universe* – PhD course by Prof. Enzo Branchini (course)
2. *Fisica delle strutture cosmiche* – Master degree course by Prof. Marco Raveri (course)

Conference presentations:

1. Speaker at the annual Euclid Consortium Galaxy Clustering meeting, 20-24 February 2023, Milano, Italy – **Modelling the 3-point correlation function in redshift space**, Fire Talk
2. Speaker at the 109^o National Congress of SIF (Italian Society of Physics), 11-15 September 2023, Fisciano (SA), Italy – **Modelling and estimation of the anisotropic galaxy 3-point correlation function**, Field: Astrophysics

Teaching activities:

1. Tutor of General Physics for 1st year Management Engineering students