ALMA MATER STUDIORUM
UNIVERSITÀ DI BOLOGNA

DIPARTIMENTO DI FISICA E ASTRONOMIA
DEPARTMENT OF PHYSICS AND ASTRONOMY - DIFA

Title of the Project: Big Data exploration with Artificial Intelligence: from Cosmology to practical applications (Alte competenze RER 2020)

Supervisors: Lauro Moscardini, Federico Marulli

Duration: 1 year

Scientific Case:

In the last decades, the exponential growth of data drastically changed the way we do science. This data tsunami led Astrophysics in the so-called Big Data Era. Standard cosmological analyses based on abundances, two-point and higher-order statistics of specific extra-galactic tracer populations – such as e.g. galaxies, galaxy clusters, voids - have been widely used up to now to investigate the properties of the Cosmic Web. However, these statistics can only exploit a sub-set of the whole information content available.

This project aims at improving the scientific exploitation of current and future galaxy surveys, taking advantage of the newest data analysis techniques to assess the properties of the large-scale structure of the Universe. Specifically, the goal is to develop a new Bayesian deep neural network for cosmological analyses. The implemented supervised machine learning infrastructure will be trained and tested on simulated catalogues in different cosmological frameworks, and then applied to current available datasets, such as e.g. VIPERS, XXL, BOSS. In the next future, the developed neural network will be used to analyse the data provided by the European Space Agency (ESA) Euclid satellite, which will be launched in 2022.

The primary scientific goals of this project are to provide independent constraints on the dark energy equation of state parameters and to test Einstein's General Theory of Relativity. The candidate will acquire high-level knowledges on the modern statistical techniques to analyse large extra-galactic datasets and extract cosmological information. Moreover, he/she will become familiar with the newest deep learning techniques for data mining, that will be investigated for the first time in a cosmological context. The new

VIALE BERTI PICHAT 6/2 - 40127 BOLOGNA - ITALIA
TEL. 051 20 95255 - FAX 051 252774
E-MAIL DIREZIONE.FISICA@UNIBO.IT
WWW.FISICA-ASTRONOMIA.UNIBO.IT

implemented algorithms will be included in the CosmoBolognaLib, a large set of free software C++/Python libraries for cosmological calculations.

Outline of the Project:

The project is organised in the following phases:

- Construction of a large set of dark matter mock catalogues in different cosmological frameworks using fast techniques, such as e.g. the ones based on Lagrangian Perturbation Theory.
- Application of subhalo abundance matching (SHAM) and/or halo occupation distribution (HOD) techniques to populate the dark matter catalogues with galaxies and galaxy clusters.
- Implementation of new standard and Bayesian deep neural network infrastructures.
- Training and testing of the neural networks on mock galaxy and cluster catalogues.
- Comparison of the cosmological constraints from neural network and standard probes, such as e.g. the two-point and three-point correlation functions of galaxy and galaxy clusters.
- Exploitation of the new machine learning tools on available datasets (e.g. VIPERS, XXL, BOSS) to provide independent cosmological constraints.
- Application of the tools on larger mock catalogues to provide forecasts for next-generation galaxy redshift surveys, such as Euclid and LSST.

Contacts:

Federico Marulli (federico.marulli3@unibo.it)
Lauro Moscardini (lauro.moscardini@unibo.it)