

The Growth of Large-Scale Structure: Dark Energy's Imprint on Galaxy Distribution

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Level: BSc. Hons Project

Background

Our current understanding of the Universe reveals that it is dominated by two mysterious components: Dark Matter and Dark Energy. While Dark Matter acts as gravitational glue holding galaxies together, Dark Energy drives the accelerated expansion of the Universe, pushing galaxies apart.

Gravity naturally drives the condensation of matter into stars, galaxies, and clusters of galaxies through gravitational collapse. However, Dark Energy works against this process, slowing down the growth of cosmic structures. By studying how structures grow over time, we can learn about the properties of Dark Energy and test our cosmological models.

The Square Kilometre Array (SKA), being built primarily in South Africa, along with other surveys like DESI, Euclid, and LSST, will provide unprecedented high-precision observations of galaxy distributions across cosmic time, allowing us to probe Dark Energy with remarkable accuracy.

Project Aims

This Honours project will focus specifically on understanding how Dark Energy affects the growth rate of large-scale structure in the Universe. Students will develop a qualitative understanding of structure formation in cosmology, learn to calculate growth rates for different Dark Energy models, analyze how galaxy distribution statistics encode information about Dark Energy, and connect theoretical predictions to current observational constraints and future survey capabilities.

Expected Outcomes

By the end of this project, you will understand the theoretical framework of structure formation and Dark Energy, and be able to calculate and plot growth rates for different Dark Energy models. You will understand how the galaxy power spectrum and clustering statistics probe Dark Energy, and appreciate the role of current and future surveys (especially SKA) in constraining Dark Energy. You will also gain experience with cosmological computation and Fisher forecast techniques.

Students should have completed undergraduate courses in: (Introduction to General Relativity or Cosmology, and Computational Physics (basic programming in Python or similar). Familiarity with differential equations, statistical methods and Fourier analysis will be helpful but not essential.