NASSP Honours Project Proposal: Probing Interacting Dark Energy with LoTSS DR2 Galaxy Density Fields

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The accelerated expansion of the universe remains one of the most profound mysteries in modern cosmology. While the standard ΛCDM model assumes non-interacting dark matter and dark energy, interacting dark energy (IDE) models propose that these components exchange energy through a coupling, altering the expansion history and growth rate of structure. Low-redshift galaxy surveys provide a unique opportunity to test these models by analyzing the clustering properties of galaxies, which are sensitive to modifications in the growth of structure. The LOFAR Two-Meter Sky Survey Data Release 2 (LoTSS DR2) offers a large catalog of radio galaxies, which trace large-scale structure and are less affected by dust extinction and photometric redshift uncertainties compared to optical surveys. This project uses LoTSS DR2 data to probe IDE models by analyzing the galaxy density field.

The Honours student recruited will:

- Analyze LoTSS DR2 catalogs to construct galaxy overdensity maps and compute the galaxy auto-power spectrum, which characterizes the clustering of galaxies in Fourier space.
- Compare the observed galaxy clustering signal with predictions from ΛCDM and IDE scenarios, focusing on interaction parameters such as the coupling strength (ξ).
- Investigate the scale dependence of the growth rate of structure under IDE models and assess whether the data favor deviations from ΛCDM.
- Explore how radio galaxies trace large-scale structure compared to optical surveys, providing insights into their astrophysical properties.

This project will produce:

- Constraints on interaction parameters such as the coupling strength (ξ) using LoTSS DR2 galaxy clustering data.

- Evidence for or against interactions between dark matter and dark energy based on the observed clustering signal.

- Insights into the astrophysical properties of radio galaxies and their role in tracing large-scale structure.

Requirements for the student:

- Basic familiarity with Python (for data processing and statistical analysis).

- Introductory knowledge of cosmology (e.g., structure formation, dark energy).

- Interest in learning numerical methods (e.g., power spectrum estimation, covariance analysis).

- Willingness to work with large datasets and cosmological tools (e.g., `HEALPix`, `Corrfunc`, or `CCL`).

Relevant literature (e.g., LoTSS DR2 data papers, IDE theory reviews) will be provided upon request.