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Shaping the Cosmos: Mergers, Black Hole Dynamics, and the Transformation of Spiral Galaxies

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Galaxy mergers play a pivotal role in shaping the structure and evolution of galaxies. This study investigates how spiral galaxies morphologically transform after merging with companion galaxies, focusing on the relationship between initial merger conditions and the resulting structures. Observational data from SDSS and HST archives will be integrated with high-resolution simulations like IllustrisTNG, EAGLE, GADGET, and RAMSES. Universe Sandbox will be used to illustrate merger dynamics.

Key factors such as mass ratios, angular momentum, gas content, and collision geometry will be correlated with final galaxy morphologies: elliptical, lenticular, irregular, or transitional. The study also examines the behavior of central black holes during mergers. As galaxies collide, their supermassive black holes are expected to interact and merge, pulling in matter and generating gravitational waves critical for detectors like LISA. This process also helps assess black hole mass, spin, and effects on the remnant core.

To quantify morphological evolution, Python tools like AstroPy, NumPy, Pandas, and Matplotlib will be used, along with indices like Gini-M20 and CAS metrics. This research aims to improve understanding of how mergers influence both visible and dark matter, contributing to broader insights in galaxy formation and cosmic structure evolution.

Keywords: Galaxy Mergers, Spiral Galaxies, Galaxy Morphology, Astrophysical Simulations, Cosmic Structure, Dark Matter Dynamics, Supermassive Black Hole Mergers.

Author: GANDHI, Anmol (Independent Researcher)

Presenter: GANDHI, Anmol (Independent Researcher)

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