Simulating the Dynamics, Collisions, and Morphology of Galactic Ultralight Dark Matter Haloes

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Approximately 80% of the gravitating matter in the universe has been determined to be "dark" (or non-baryonic) matter. Dark matter's gravitational interactions with baryonic (luminous) matter have been critical to the evolution of galaxies, galaxy clusters, and interstellar gas clouds. Galaxies would not be able to form without a halo of dark matter particles, and producing models to understand how these haloes behave under various constraints and interact with one another is vital to understanding the development of the universe. There are several theories of dark matter; this project explores an appealing candidate: ultralight dark matter (ULDM). ULDM proposes that dark matter is made up of ultralight axion-like particles, each of which is approximately one ten-billionth the mass of an electron. This project aims to simulate the behavior of dark matter haloes in collisional galaxies, interstellar gas clouds, and during accretion events to improve understanding of their dynamics and role in shaping the distribution of baryonic matter over galactic and intergalactic space. I use PyUltraLight, a pseudo-spectral solver that can model ULDM halo behavior. To calibrate the models, I revisit prior simulations of colliding galaxies established in other literature. Then, I simulate the accretion of dark matter haloes around a central mass. Although the density distributions of the dark matter haloes were often faint, the simulations conformed to prior observations of baryonic matter, in addition to producing feasible simulations of dark matter halo accretion in young galaxies.

Awards Won:
Fourth Award of $500