NEW YORK CITY COLLEGE OF TECHNOLOGY

Physics Department

Center for Theoretical Physics

The Slime Mold Cosmic Web and What it Teaches Us about Galaxy Evolution

Presented by

Dr. Farhan Hasan

Space Telescope Science Institute, Baltimore, USA

Thursday, November 14 at 12:00 noon

In-person

Room 801N, NAAM Building

On the largest scales, the universe forms a vast "cosmic web" made up of filamentary strands connecting massive nodes, with vast, empty voids in between. While simulations have predicted this structure for decades, observing it directly has been challenging due to the faintness of the gas in the cosmic web. In this talk, I will present a novel method inspired by the growth patterns of the "slime mold" microorganism to model the cosmic web more effectively. Our Monte Carlo Physarum Machine (MCPM) model simulates galaxies as "food sources" and uses them to map out the cosmic matter distribution. Integrating MCPM with standard techniques improves our ability to identify large-scale filamentary structure substantially. Using the IllustrisTNG cosmological simulations, we find that MCPM reveals two types of filaments: dense, prominent ones and more diffuse, weaker ones. The density of these filaments influences galaxy evolution. In the nearby universe, galaxies near dense filaments are deprived of gas and stop forming stars, while galaxies near diffuse filaments remain gas-rich and actively star-forming. However, in the first ~2-4 billion years after the Big Bang, this effect of the cosmic web is absent. Furthermore, high filament gas density can also result in galaxies forming stars in their cores first, a process called "inside-out growth." Our findings suggest that inhospitable gaseous environments of dense filaments can result in physical mechanisms such as gas stripping from galaxies. Additionally, the environment plays a major role in halting star formation in low-mass and satellite galaxies, while internal processes dominate in high-mass and central galaxies. We also find that while dark matter in galaxies tends to align with nearby filaments, stars lose this alignment early in their evolution. Finally, I'll discuss ongoing efforts to test these predictions using state-of-the-art observatories, including the Sloan Digital Sky Survey and the Hubble Space Telescope.

Light refreshments will be served