学位申請論文公開講演会

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場所：物理会議室（C207）　およびオンライン
題目：Machines to Learn the Multi-scale Physics of Galaxies
（データ科学的方法によるマルチスケール銀河物理の解明）

主論文の要旨

Galaxies are an aggregation of stars, gas, dust, and dark matter that evolve through external interactions (merging, gas accretion) and internal processes (star formation, feedback). These processes extend over a vast length-scale range, from AU scales ($\sim 10^{11}$m) to hundreds of Megaparsec scales ($\sim 10^{24}$m). Therefore, a comprehensive multi-scale theory that combines cosmology and baryonic physics is necessary to understand the working of galaxies. In this thesis, we explore the use of machines to get a step closer to such an understanding of multi-scale galaxy physics.

Astronomical observations are often incomplete. The challenge is that inference from incomplete observations is often ill-posed, meaning that no one unique solution exists that satisfies the observation. We focused on two cases. Firstly, astronomical images are smeared with unnecessary foreground objects, artifacts, or bad pixels. In Cooray et al. (2020), we introduced a flexible, cost-effective algorithm for treating incomplete images of the CO Multi-line Imaging of Nearby Galaxies (COMING) Project. Secondly, we developed CRAFT (Cooray et al. 2021) and CRAFT+WS (Cooray et al. 2022a), which solves the Faraday tomography problem with the highest fidelity. Successful Faraday tomography will deepen our understanding of the magnetized Universe.

Growing astronomical data may also be over-complete. The key idea is that all the high-dimensional data we obtain of the Universe should derive from a much lower-dimensional process or a physical theory. Therefore, dimensionality reduction provides a natural way for machines to extract physical information from data by transforming the high-dimensional data into a lower-dimensional representation. In Cooray et al. (2022b), we reported the discovery of a two-dimensional Galaxy Manifold within the 11-dimensional luminosity space provided in the RCSED (Chilingarian et al. 2017) catalog. Considering that the manifold represents the possible parameter space, we analyzed the evolutionary tracks. We found that gas accretion onto galaxies may be the driver for the existence of the Galaxy Manifold.

Through data scientific methods, we have built a comprehensive picture of multi-scale galaxy physics that combines cosmological gas inflow, galaxy evolution, and cosmic magnetism.