

Evolution and Spatial Distribution of Stellar [Mg/Fe] Trends in Massive Galaxies in cosmological simulations

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Building upon the foundational Honours project which characterizes global [Mg/Fe] ratios at $z = 0$, this Master's level research track investigates the **spatially resolved evolution** of chemical enrichment in group and cluster central galaxies. Modern Integral Field Unit (IFU) observations, such as *MaNGA*, reveal complex radial gradients in stellar populations that challenge simple “monolithic collapse” scenarios.

This project utilises the various cosmological simulations, such as *Simba-C* and *IllustrisTNG* to track the progenitors of today's massive galaxies across cosmic time. By examining the interplay between star formation histories, AGN feedback, and the chemical enrichment modules, this study seeks to determine the physical drivers behind the observed alpha-enhancement and how these chemical signatures are distributed spatially within the galaxy halos.

Key Objectives

- **Radial Gradient Analysis:** Map the stellar [Mg/Fe] and metallicity gradients within central galaxies to distinguish between in-situ star formation and ex-situ stellar accretion.
- **Cosmic Time Evolution:** Trace the evolution of the $[Mg/Fe] - \sigma$ relation from $z = 2$ to the present day to identify when the observed, “downsizing” signatures emerge.
- **Feedback Impact:** Evaluate how different AGN feedback modes (jet vs. wind) truncate star formation and freeze the [Mg/Fe] ratios.
- **Synthetic Observation Comparison:** Generate mock radial profiles to perform a direct comparison with IFU survey data.

Special Requirements

The student should have a strong proficiency in Python and experience with large-scale data analysis. Prior experience with hydrodynamical simulations or galactic chemical enrichment models is highly advantageous.

This is a Master's level project and serves as a direct physics-based extension of the Honours-level Simba-C stellar properties track.

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