Investigating the Stellar Mg/Fe Trends in Group and Cluster Central Galaxies Using the Simba-C Cosmological Simulation

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Observations show that central galaxies in groups and clusters have higher [Mg/Fe] ratios with increasing mass, suggesting a rapid early burst of star formation dominated by Type II supernovae before delayed Type Ia enrichment. Traditional models with a fixed IMF struggle to match this trend without assuming a variable or top-heavy IMF. Recent studies (DOI: 10.1111/j.1365-2966.2009.15924.x and DOI: 10.48550/arXiv.2407.07971) propose that refining star formation histories, feedback, and chemical yields can resolve these issues. Simba-C's updated enrichment models offer an excellent testbed.

Problem Statement: This honours project will assess whether the Simba-C simulation reproduces the observed trends in stellar chemical abundances—especially $[Mg/Fe]$—in group and cluster central galaxies by exploring the relation between stellar velocity dispersion and chemical properties, and determining if rapid early star formation and quenching emerge without extreme IMF variations.

1 Objectives

- **Data Exploration**: Extract and analyse the relevant simulation data (e.g., stellar velocity dispersion and chemical abundances) for group/cluster central galaxies.
- **Trend Investigation**: Investigate any emerging correlations between stellar properties and chemical abundances.
- **Model Evaluation**: Assess how well the Simba-C simulation reproduces the observed chemical abundance trends.

This hands-on investigation is expected to provide insights into the processes driving chemical enrichment in massive galaxies, allowing the student to compare simulation trends with observational data and critically evaluate the role of star formation history, feedback, and enrichment models in reproducing the steep Mg/Fe–σ relation.

Special requirements - The student should have experience in programming in Python.

This can become a Master's level project.