Probing the Galaxy Stellar Mass Function in SGR/eROSITA Clusters

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Abstract

Galaxy clusters are massive structures consisting of hundreds of galaxies bound by gravity. The Galaxy Stellar Mass Function (GSMF) quantifies the distribution of stellar masses in galaxies, providing essential insights into galaxy formation and evolution. By comparing the GSMF across different environments—such as within galaxy clusters and the field (less dense regions)—we can assess how these environments influence galaxy properties and evolution. This analysis sheds light on the efficiency of star formation and the role of feedback processes, including supernovae and active galactic nuclei (AGN), in regulating galaxy growth.

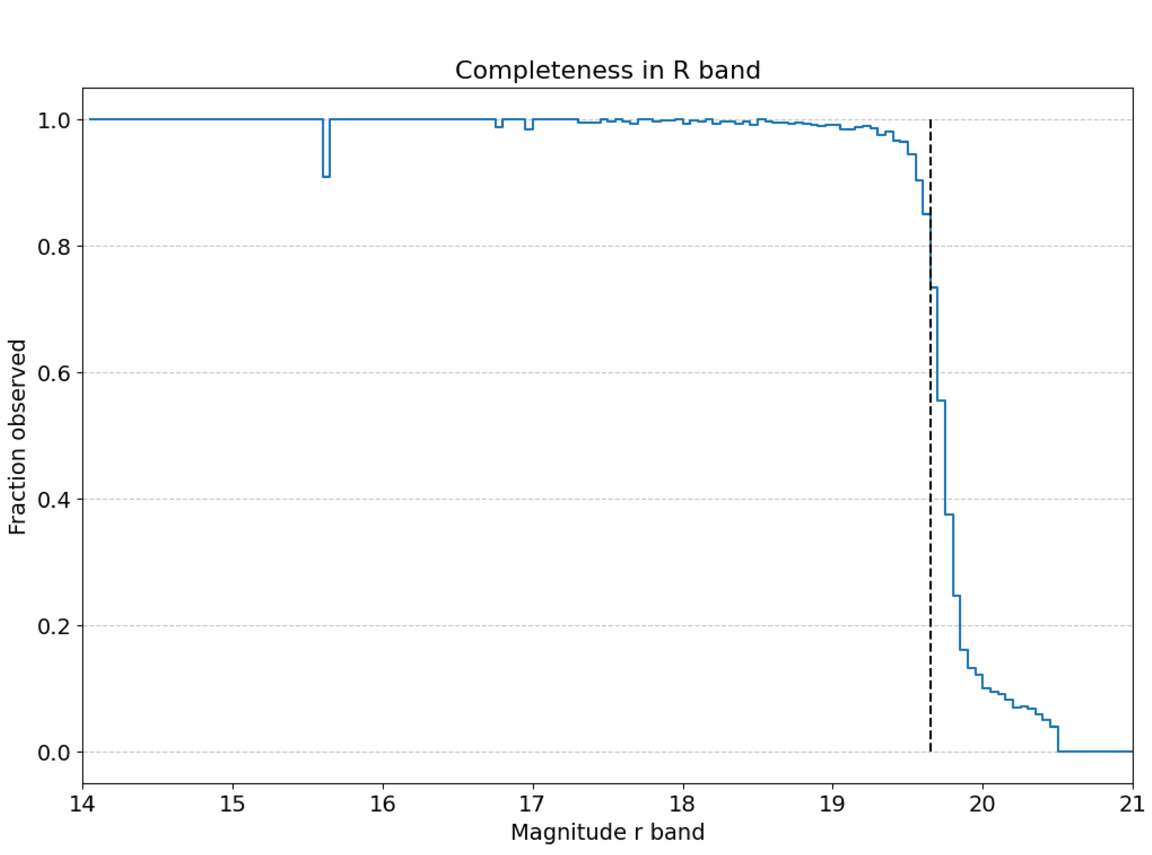
Data Set

The data for this study is drawn from the eFEDS catalog, which identifies galaxy clusters using the SRG/eROSITA telescope, covering an area of approximately 140 square degrees. Of this, 60 square degrees overlap with the G09 region of the GAMA galaxy catalog, and our analysis is restricted to this overlap. The G09 region spans right ascension (RA) from 129.0 to 141.0 degrees and declination (Dec) from -2.0 to +3.0 degrees. The eFEDS catalog from eROSITA telescope provides data in the soft X-ray band, while the GAMA DR4 catalog offers panchromatic data from UV to far-infrared wavelengths. We apply a magnitude cut-off of r = 19.65 mag and a redshift limit of z=0.4. After applying relevant masks and selection criteria, the final dataset consists of 161 galaxy clusters.

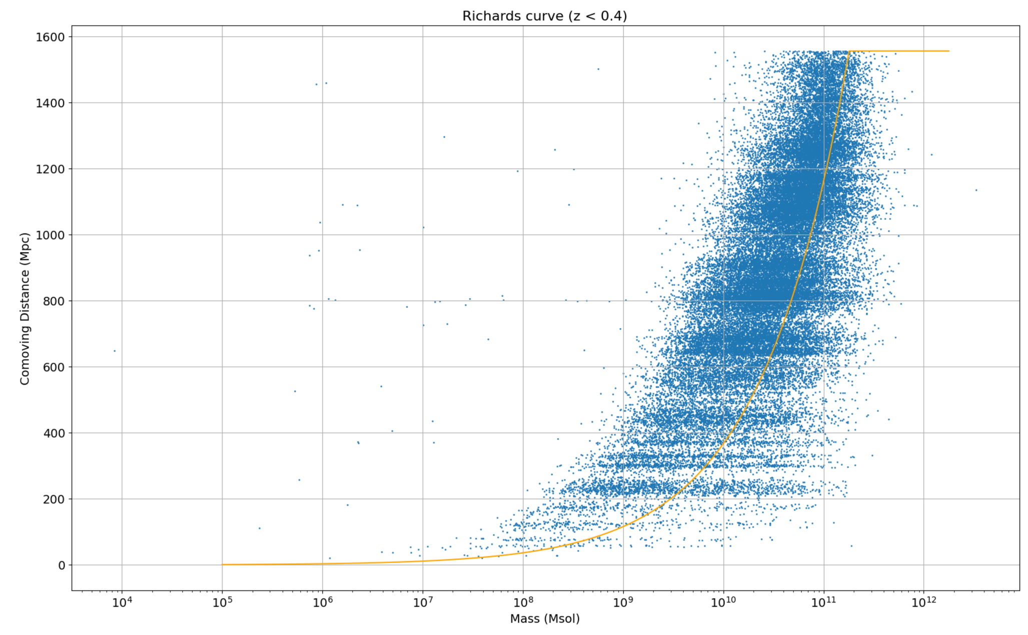
Methods

To create an unbiased Galaxy Stellar Mass Function (GSMF), we correct for two key factors: redshift incompleteness and observation volume.

Redshift incompleteness is calculated by comparing the total observed objects to those with known redshifts. For each flux bin, we determine the ratio of objects with redshift data to the total number of objects, giving us completeness as a function of flux.



Observation volume depends on galaxy mass. Due to Malmquist Bias, smaller galaxies are visible only nearby, while larger ones are detectable at greater distances. To account for this, we apply a Richards Curve to model the maximum observable distance for each mass range. For field galaxies, we calculate the volume as a slice of a sphere, based on the G09 survey area and the observable distance. For cluster galaxies, the volume is the sum of spherical volumes of clusters within the observable range.



The GSMF is generated by binning galaxies by stellar mass, correcting for both their effective search volume and completeness factor.

Cluster membership is determined by comparing the GAMA and eFEDS catalogs. Galaxies within three times the cluster's velocity dispersion in redshift, and within one Rλ of the cluster center, are classified as cluster members. Others are considered field galaxies. This approach reduces contamination from non-member galaxies and improves accuracy, as it does not rely on external data like RedMapper.

Star formation classification (Preliminary)

is based on a color-color diagram, using rest-frame U-R and R-J magnitudes, as per Williams et al. (2009). This method categorizes galaxies as either star-forming or quenched, providing critical information on galaxy evolution.

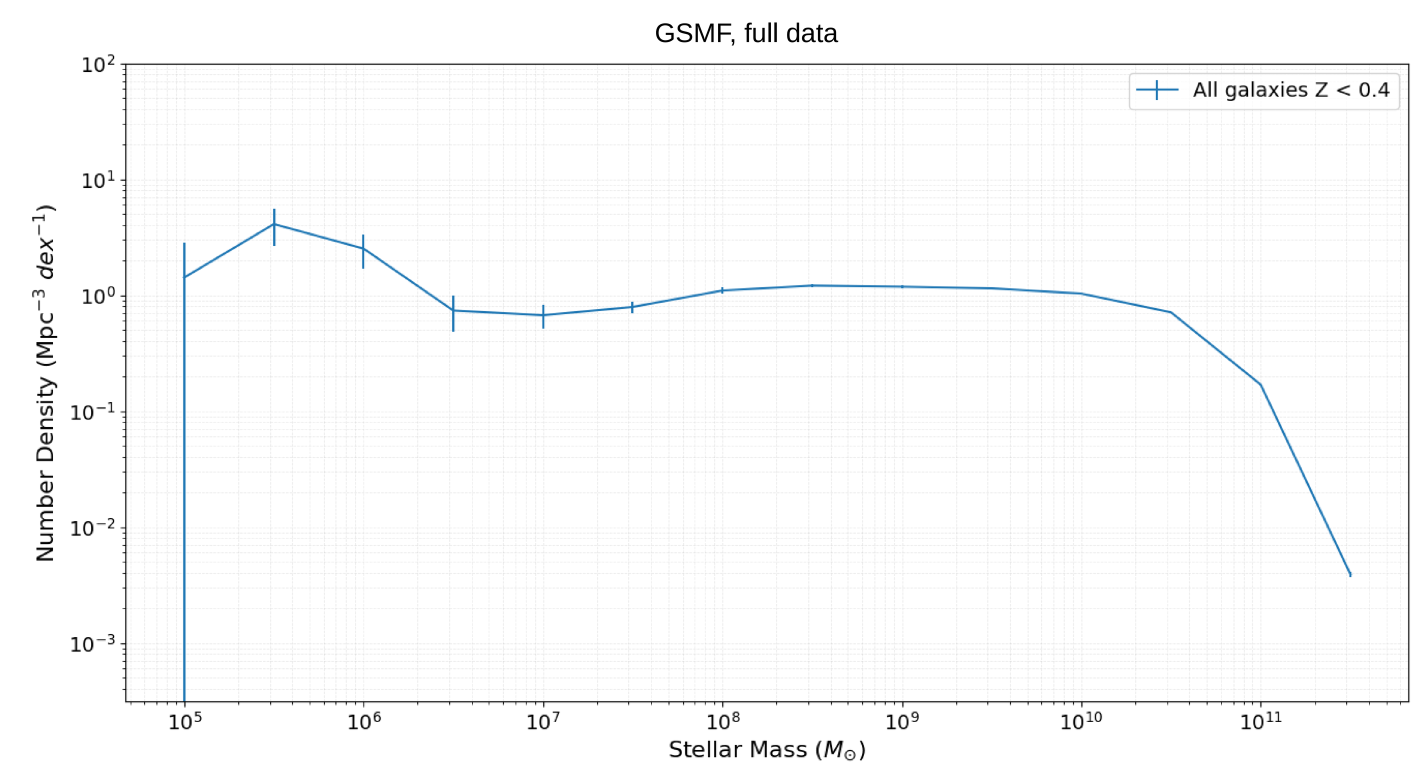
References

1. MPE, under supervision of Johan Comparat

Results

1. GSMF Analysis for the Full Dataset:

Our GSMF analysis reveals that a single Schechter function is insufficient to describe the mass distribution. The knee, marking the transition from a power-law to an exponential cutoff, indicates that galaxy growth below this point is driven by star formation, while above it, more massive galaxies grow through mergers and accretion. Notably, the knee occurs slightly earlier in our data than in studies like Driver et al. (2022), likely due to selection effects rather than differences in the datasets, which are otherwise comparable.



2. Preliminary GSMF Analysis by Population and Environment:

When classifying galaxies as star-forming or quenched and comparing cluster and field environments, quenched galaxies in both settings follow a similar GSMF, modeled by a single Schechter function. However, clusters host more quenched galaxies, likely due to environmental factors like ram-pressure stripping and tidal interactions that suppress star formation. The GSMF for star-forming galaxies in clusters is more localized, with a peak around 10^9 M⊙, indicating a narrower range of stellar masses and a slightly higher number of low-mass galaxies compared to high-mass ones.