Quantifying the Nature of Intracluster Light in a Fornax-like Cluster

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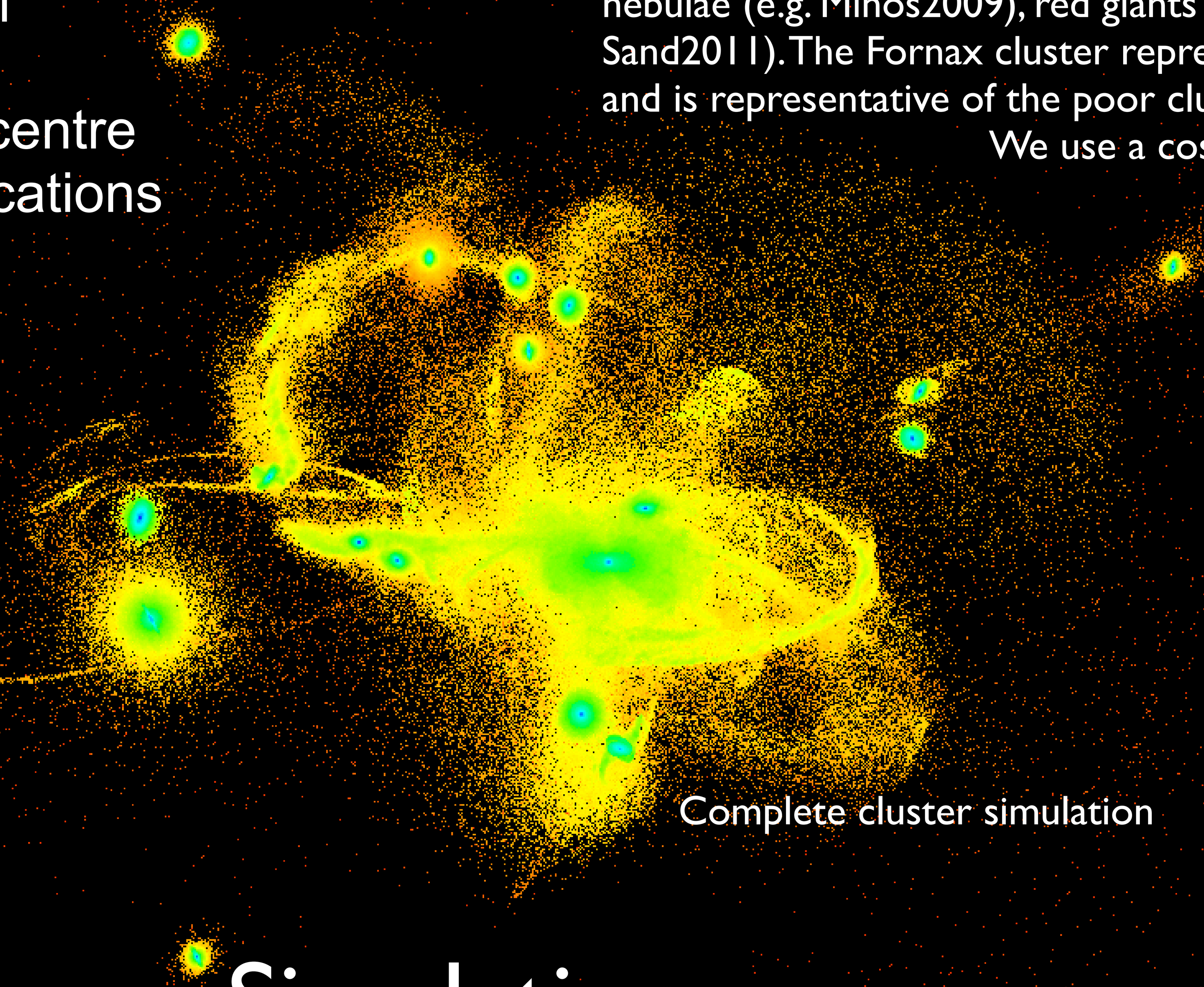
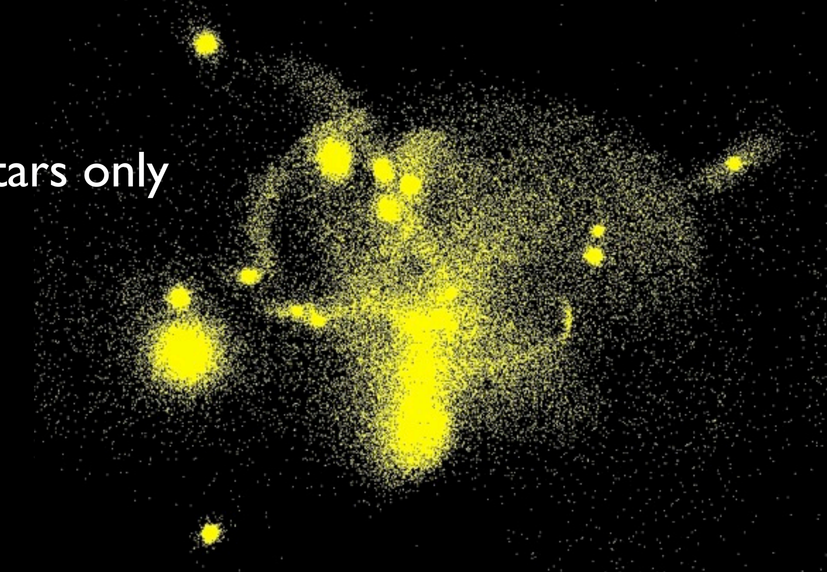
Abstract: Using N-body cosmological simulations, we investigate the contributions of the halo stars and disk stars to the intra-cluster light of a Fornax-like cluster at low redshift. Initial analysis indicates evidence for a difference between the radial concentrations within the cluster of unbound disk and halo stars. The ratio of young to old (disk to halo) contributions to the ICL may thus change as a function of radius from the centre of the cluster. We briefly discuss some wider implications of this result.

Introduction

The intracluster light (ICL), common to all galaxy clusters, has been observed up to z=0.8. These stars had removed from the cluster galaxies (Guennou2012), due to stripping of stars from galaxies during the initial collapse of the cluster (Merritt1984), accreting galaxies losing stars (Zibetti2005), and stars stripped from galaxies through galaxy harassment (Moore1996). The ICL is observed using planetary nebulae (e.g. Mihos2009), red giants (e.g. Palladino2012), novae (e.g. Neill2005) and supernovae (eg. Sand2011). The Fornax cluster represents the second largest concentration of galaxies within ~20Mpc and is representative of the poor cluster and group environment where most galaxies are located. We use a cosmological simulation of a Fornax-like cluster to investigate the relative contributions of halo stars, disk stars and the cD galaxy to the amount of ICL in a dwarf cluster.



Complete cluster simulation

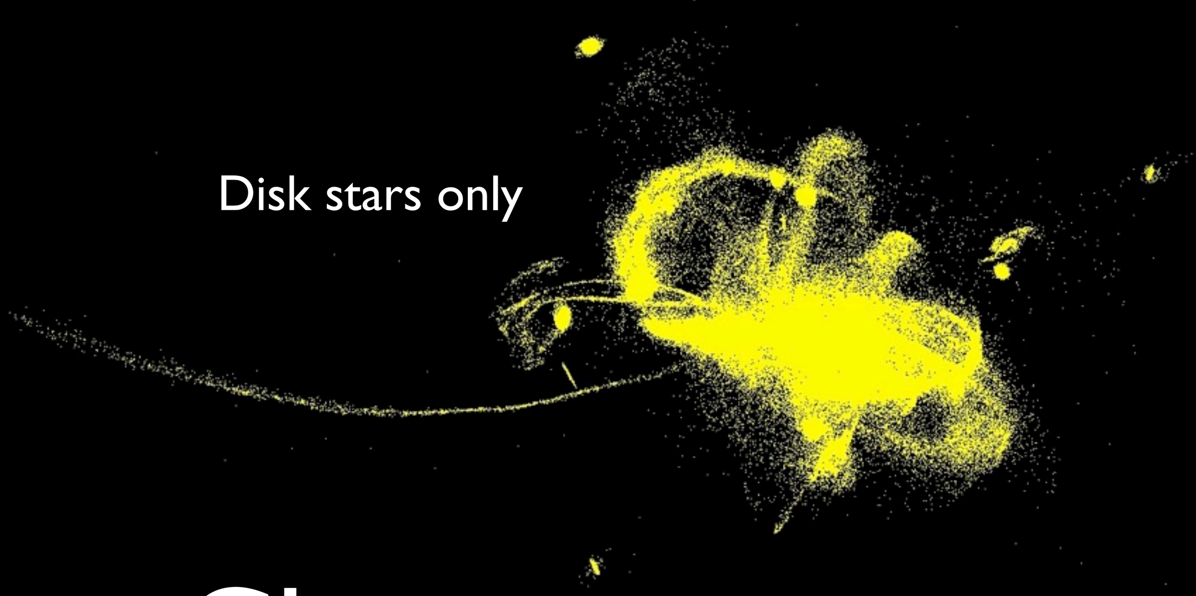


Halo stars only

Measuring the ICL

The values shown are the mean of the 3 orthogonal Cartesian projections of the cluster. The errors are difference between the largest value and the mean.
Two methods were used to class the ICL.
- SB limit method: a Surface Brightness (SB) limit of >26.5 mag per arcsec
- Radius method: cutting a radius of 100kpc around the cD galaxy and 50kpc around the other cluster members

As seen in Figure 1 and 3, using the radius method shows the ICL can have SB values of < 26.5 mag per arcsec. Therefore, using the SB limit method will underestimate the amount of ICL in the cluster.



Disk stars only

Simulation

The N-body simulation contained 18 Galaxies, in a volume of 10^5 h^{-1} Mpc^3. The galaxies were added to the cluster over the redshift range z = 1.6 to z = 0.13. The displayed image above shows the complete cluster at z = 0. The images on the left and right show just the disk and halo stars respectively, also taken at z = 0 and the same orientation as the above image.
The galaxies have a mass range of 10^{11} and 5.2 x 10^{12} h^{-1} solar masses. All ICL stars are assumed to have been stripped from the cluster members and we assume a mass-to-light ratio of 5 (Rudick et al. 2006) for both disk and halo stars. The cluster was set at an assumed distance of 19 Mpc, similar to that of the Fornax cluster. Dark matter halos falling into the cluster are replaced by a full spheroid+disc+DM halo model drawn from a semi-analytic model. Each simulated image contained 1500 x 1500 pixels, with dimensions of 2kpc x 2kpc per pixel.

ICL Distribution

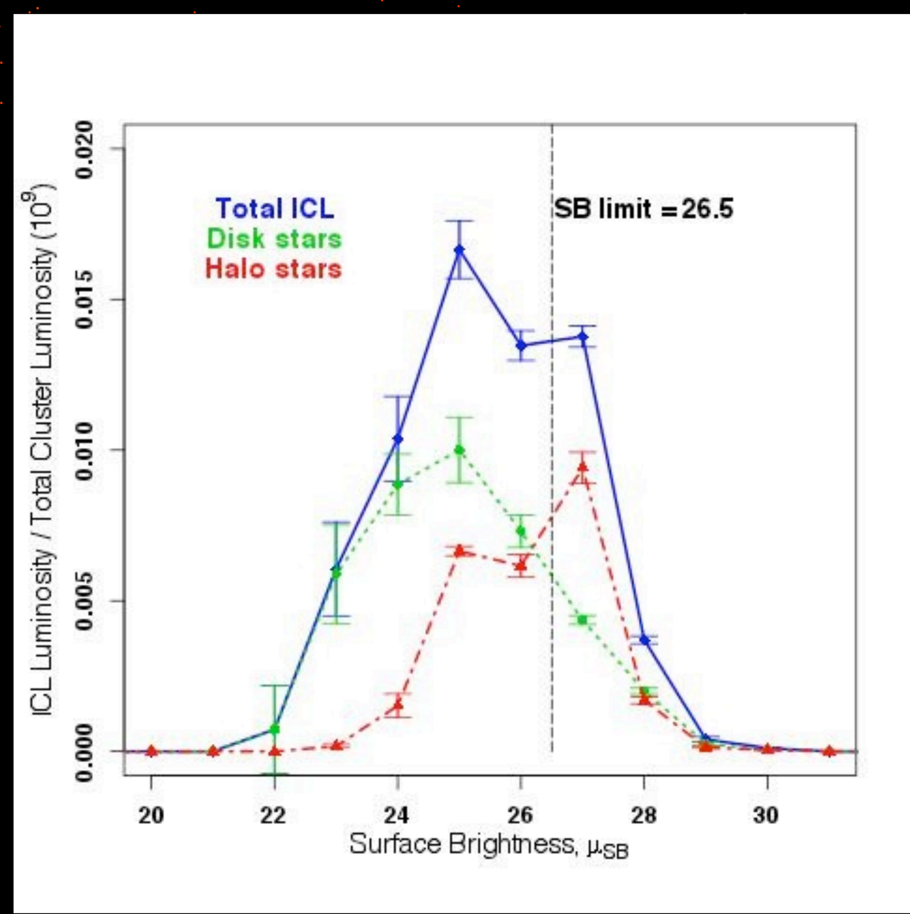


Figure 3 shows the distribution of the surface brightness of the ICL as a function of the fraction of the luminosity of the cluster.
The black vertical line shows the surface brightness limit used to select the ICL in the SB limit method. This limit will underestimate the ICL.
There is also a change in the amount contributed by disk and halo galaxies as a function of the surface brightness.
As the surface brightness becomes fainter, the halo stars become more important than the disk stars. Brighter than a SB limit of 26.5, the disk stars contribute the majority of the ICL.

Cluster Components

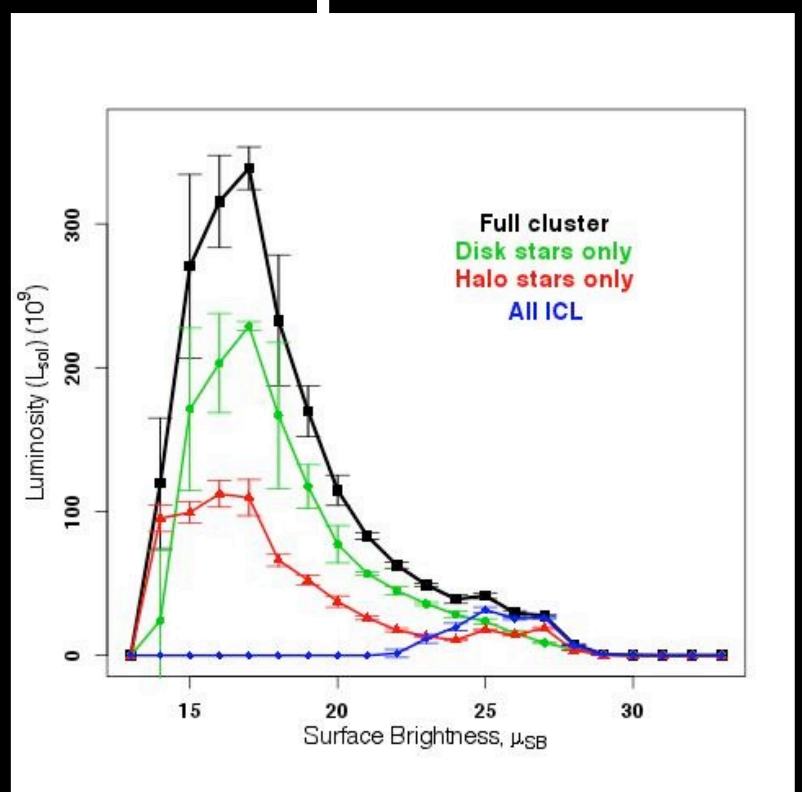


Figure 1 shows all of the cluster light as a function of the surface brightness of each of the cluster components. The cluster is split into 4 components: the complete cluster, disk stars, halo stars, and any stars which is classed as the ICL. Here the ICL is selected using the radius method to remove the galaxies. The majority of the light at surface brightness fainter than ~25 is made from the ICL.

ICL with Radius

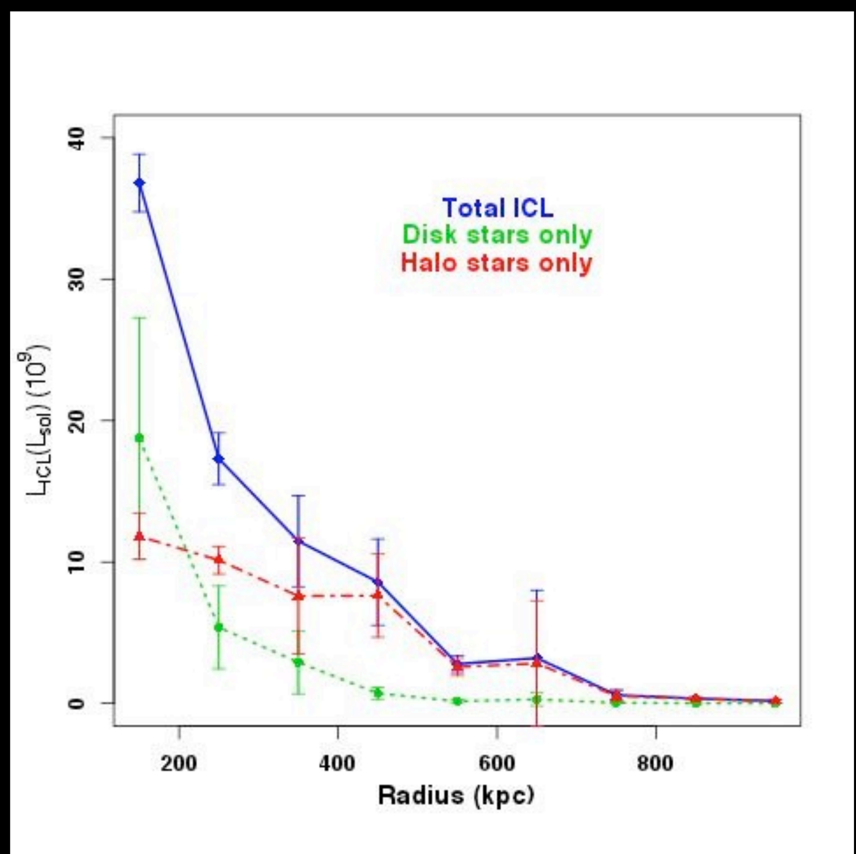


Figure 2 shows the luminosity of the ICL as a function of the radius from the centre of the cluster. The ICL is classified using the radius method. As the distance from the cluster centre increases, the halo stars become greater component of the ICL.

Conclusions

The ICL is likely to be underestimated when using a surface brightness cut. At SB values brighter than 26.5 mag per arcsec, the disk stars are a greater component of the ICL so will not be included in the ICL estimate.
At SB values fainter than 26.5 mag per arcsec, the halo stars contribute the majority of the ICL. Therefore at this SB limit, using an ICL estimator such as planetary nebulae, which locals younger stars, may also create an underestimate.