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Environmental Effects on Evolution of Cluster Galaxies

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Abstract. Using a combination of a cosmological N-body simulation and a semi-analytic galaxy formation model, we investigate environmental effects on cluster galaxies with the ΛCDM cosmology. We find that stripping of hot gas from galacitc halos as they infall into larger objects sufficiently suppresses star formation in the cluster and successfully reproduces the observed gradients of SFR when we normalize our model to reproduce the observed properties of local galaxies. Consequently, the effect of ram-pressure stripping of cold gas from galactic disks becomes quite small and it is observationally negligible. Therefore, the deficiency of galaxies with intermediate bulge-to-disk luminosity ratios under the hierarchical structure formation cannot be resolved even if we include the ram-pressure stripping in our modeling.

1. Results and Discussion

Some recent studies have focused on observed trends in star formation rate (SFR) and morphology as a function of clustercentric distance (e.g. Balogh et al. 1999). Theoretical studies have shown that the color and SFR gradients are well explained by slow truncation of star formation after their infall (e.g. Balogh et al. 2000; Diaferio et al. 2001). Such truncation is expected by stripping of diffuse hot gas from galactic halos. However, recent studies have suggested that conventional morphological evolution model produces much smaller fraction of S0 galaxies in clusters compared with observations (Okamoto & Nagashima 2001; Diaferio et al. 2001). Since Fujita & Nagashima (1999) have indicated that stripping of cold gas from galactic disks by ram-pressure from an ICM increases bulge-to-disk luminosity ratio of the galaxy and changes the morphology of a Sb galaxy into S0 type, we here investigate effects of ram-pressure stripping and whether it can resolve the deficiency of the S0 population.

For comparison, we use three models. (1) The stripping of hot gas from galactic halos after their infall is considered (standard model). (2) Ram-pressure stripping of cold gas is also included by calculating orbits of cluster galaxies (ram-pressure model). (3) The same as the standard model but for a field environment (field model). Both the hot and cold gas stripping are negligible in this model. The details of our galaxy formation models are described by

Okamoto & Nagashima (2001b). Our results at $z = 0.2$ are compared with low redshift CNOC sample that is taken from Diaferio et al. (2001) assuming the same cosmology. The SFRs are enough suppressed solely by the hot gas stripping and they reproduce the observation well (left panel in Fig. 1). Therefore effect of the cold gas stripping becomes quite small, and then the deficiency of the galaxies with intermediate B/D still significant even if we consider the ram-pressure stripping (right panels). Our results suggest that the hot gas stripping plays most important role for suppress the star formation in clusters and we should consider additional process for morphological evolution other than major mergers and ram-pressure stripping.

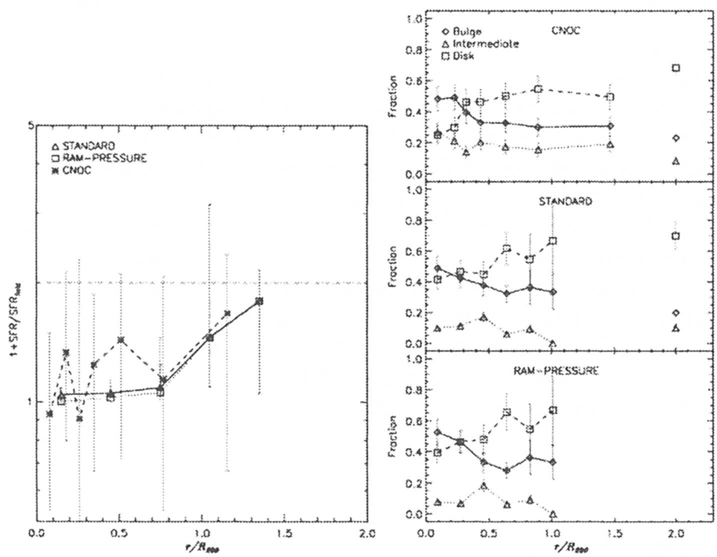

Figure 1. *Left*: The SFRs of galaxies as a function of projected radius at $z = 0.2$. The SFRs have been normalized by the median SFR of field galaxies at the same magnitude and redshift. *Right*: Morphological fractions as a function of projected radius at $z = 0.2$. The symbols at the left indicate the fractions in the field in each panel. An error bar shows the 25th to 75th percentile of the distribution in each bin.

References

Balogh, M. L., Morris, S. L., Yee, H. K. C., Carlberg, R. G., & Ellingson, E. 1999, ApJ, 527, 54

Balogh, M. L., Navarro, J. F., & Morris, S. L. 2000, ApJ, 540, 113

Diaferio, A., Kauffmann, G., Balogh, M. L., White, S. D. M., Schade, D., & Ellingson, E. 2001, MNRAS, 323, 999

Fujita, Y., & Nagashima, M. 1999, ApJ, 516, 619

Okamoto, T., & Nagashima, M. 2001a, ApJ, 547, 109

Okamoto, T., & Nagashima, M. 2001b, preprint (astro-ph/0108434)

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