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Dissertation Summary

Star Formation in Central Cluster Galaxies

NICOLÁS CARDIEL

Present address: Departamento de Astrofísica, Facultad de Ciencias Físicas, Universidad Complutense de Madrid, E28040-Madrid, Spain; ncl@astrax.fis.ucm.es

Thesis work conducted at Departamento de Astrofísica, Universidad Complutense de Madrid, Spain

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A large fraction ($\sim$70%–90%) of the X-ray–detected galaxy clusters show centrally concentrated X-ray emission from hot gas. This emission, which constitutes an important energy loss, forces the gas to increase its density, accelerating the emission rate. At the center of the clusters, the characteristic cooling time is shorter than the age of the cluster, and the gas, pushed inward by the hotter intracluster medium, may settle toward the central cluster galaxy (CCG), giving rise to a *cooling flow* (see review in A. C. Fabian, 1994, ARA&A, 32, 277). The typical total mass deposition rates are $\dot{M} \sim 10$–$1000\ M_\odot\ \mathrm{yr}^{-1}$. Although it is still unclear whether cluster cooling flows can be described by steady state models with mass dropout throughout the inner $\sim$100–200 kpc of the cluster or by catastrophic episodes of mass deposition (see discussion in J. Binney & G. Tabor, 1995, MNRAS, 276, 663), it is likely that at least a fraction of the cooled gas could accumulate as molecular clouds at the center of CCGs, forming new stars.

In this thesis we have investigated in detail the presence and extension of the star formation in CCGs, through the study of radial line-strength gradients, namely, the λ4000 Å break (D_{4000}; see definition in G. Bruzual, 1983, ApJ, 273, 105) and the Mg_2 index (definition in S. M. Faber et al., ApJS, 1985, 57, 711). Our sample includes 20 CCGs, 15 in clusters with cooling flows (with $\dot{M}$ in the range 20–1000 $M_\odot\ \mathrm{yr}^{-1}$) and five in clusters without. After the careful removal of the emission lines found within the D_{4000} and Mg_2 bandpasses for some cooling flow galaxies of the sample, we find that the existence of correlations of D_{4000} and Mg_2 indices with the X-ray–derived mass deposition rates depends unambiguously on the presence of such emission lines. In particular, the nuclear indices are anticorrelated with $\dot{M}$ only when emission lines are found in the central regions of the galaxies. The central D_{4000} and Mg_2 indices in cooling flow galaxies *without* emission lines are completely consistent with the indices measured in CCGs in clusters without cooling flows. In the same sense, CCGs in cooling flow clusters exhibit a clear sequence in the D_{4000}-Mg_2 plane, with a neat segregation depending on the emission-line type and morphology. This sequence can be reproduced by a recent ($\lesssim$0.1 Gyr old) burst of star formation (adopting Scato initial mass function and solar metallicity; evolutionary synthesis models of G. Bruzual and S. Charlot, 2000, in preparation).

In CCGs with emission lines, the gradients in the spectral indices are flat, or even positive, inside the emission-line region, revealing the spatial extent of the star formation. Using a deprojection algorithm, and extrapolating the fitted line-strength gradients from the outer regions (emission-line free, and assumed to be representative of the underlying old stellar population) toward the inner parts (with emission lines), we have also derived the spatial profile for the density of mass transformed into stars. Interestingly, the derived profiles are quite parallel to the expected density profile of the mass deposition in inhomogeneous cooling flows. Such a close connection would be difficult to understand without most of the gas accreted in the emission-line region being transformed into stars.

In the light of the new measurements, we also discuss the evolutionary sequence suggested by B. R. McNamara (in ASP Conf. Ser. 115, Galactic Cluster Cooling Flows, ed. Noam Soker [San Francisco: ASP, 1997], p. 109), in which radio-triggered star formation burst may take place several times during the lifetime of the cooling flows. This scenario allows us to conclude that cooling flows, emission lines, blue light anomalies, radio emission, the detection of excess soft X-ray absorption in some CCGs in cooling flow clusters, and star formation, are different aspects of the same phenomenon.