Brightest Cluster Galaxy Formation in the Cluster C0037-2522: Flattening of the Dark Matter Cusp

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Abstract. The X-ray cluster C0337-2522 at redshift $z = 0.59$ hosts in its core a group of five elliptical galaxies. Using N-body simulations we show that a multiple merging event among the five galaxies is expected to take place in the next few Gyrs, forming a central brightest cluster galaxy. We also find indications that dynamical friction heating associated with this event is likely to modify the central slope of the cluster dark matter density profile.

1 Introduction

We have identified a group of five ellipticals (Es) located in the core of the X-ray cluster C0337-2522 at redshift $z = 0.59$ (ROSAT Deep Cluster Survey [12]). This system represents a strong candidate for the initial stages of brightest cluster galaxy (BCG) formation through galactic cannibalism [9]. Here, we explore how many of the five galaxies under consideration are expected to merge before $z = 0$ and we study the properties of the merger remnant. We address these questions by using N-body simulations, exploring several initial conditions compatible with the imaging and kinematic information from our ESO-VLT data. The details of observations and numerical simulations are given in [8].

Recent observational studies [13,14] of a few galaxy clusters find central dark matter (DM) density distributions ($\rho_{\rm DM} \propto r^{-\beta}$) flatter ($\beta \sim 0.5$) than predicted by cold dark matter simulations [6,7] ($\beta \sim 1 - 1.5$). A possible interpretation of this discrepancy is that dynamical friction heating [1] is effective in flattening the DM cusp. We investigate this hypothesis using our simulations, where the initial DM profile is cuspy ($\beta = 1$), galaxies are deformable, and initial conditions correspond to an observed cluster.

2 Results

In all the simulations 3 to 5 galaxies merge before $z = 0$. The merger remnant is similar in its main structural and dynamical properties to a real BCG (but with no evidence of the diffuse luminous halo typical of cD galaxies). In particular, it satisfies the Faber-Jackson [3] relation and the K-band Fundamental

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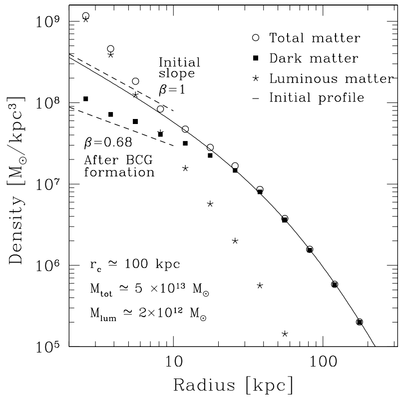

Fig. 1. Final DM, stellar, and total density profiles for a representative simulation. In this case, the best–fitting inner slope of the final DM profile is $\beta = 0.68$. The solid curve is the initial ($\beta = 1$) cluster DM profile.

Plane [10], under the hypothesis that the five Es are placed on these scaling relations, and that the mass–to–light ratio remains unchanged in the merging process. However other features of Es, such as the $M_{\rm BH}$-σ_0 relation [5,4], and the metallicity gradient [11], are hardly reproduced by this multiple dissipationless merging scenario. As regards the properties of the cluster DM halo, we find final profiles flatter than the initial $\rho_{\rm DM} \propto r^{-1}$ profile (see Fig. 1). We fit the cluster DM density profiles with the formula $\rho_{\rm DM} = \rho_{\rm DM,0}(r/r_{\rm c})^{-\beta}[1 + (r/r_{\rm c})]^{-4+\beta}$, with β, $r_{\rm c}$, and $\rho_{\rm DM,0}$ free parameters. For the final DM profiles in our simulations $\langle\ \beta\ \rangle\ \simeq\ 0.66\ \pm\ 0.15$ to be compared with $\beta = 1$ of the initial profile. Our results (in accordance with recent simulations using rigid galaxy models [2]) point towards a major role of dynamical friction associated with BCG formation in determining the cluster DM profile on small scales.

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