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# MERGERS OF ELLIPTICAL GALAXIES AND THE FUNDAMENTAL PLANE

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RESUMEN

Se ha llevado a cabo una serie de experimentos de N-cuerpos para explorar el estado final después de la fusión de dos galaxias elípticas. Más en concreto se estudia aquí si el Plano Fundamental sobrevive a estas interacciones.

ABSTRACT

N-body simulations have been carried out in order to explore the final state of elliptical galaxies after encounters and more expecifically whether the Fundamental Plane (FP hereafter) relation is affected by merging.

*Key Words:* **GALAXIES: INTERACTIONS-GALAXIES:ELLIPTICAL-GALAXIES: FUNDAMENTAL PARAMETERS**

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## 1. INTRODUCTION

Elliptical galaxies are known to follow a relation between some of their observational parameters (namely the effective radius, the luminosity and the central velocity dispersion) known as the Fundamental Plane (Dressler et al 1987, Djorgovsky & Davies 1987). From the Virial Theorem (VT) a relation between these observables can also be obtained, but the VT relation and the observed FP are tilted with respect to each other. The tilt angle is not yet fully understood. The FP can be used, because of its universality and tightness, as a tool to understand the evolution of elliptical galaxies. At present we have two different scenarios for their formation: the monolithic collapse theory and the hierarchical merging scenario. In the last one, present-day ellipticals are formed from small building blocks via successive mergers. This scenario is not only supported by cosmological numerical simulations but there is observational evidence for it as well. In the cluster MS-1054-03, at a $z = 0.83$, van Dokkum et al. (1998) observed a high fraction of spheroidal galaxies involved in mergers and interactions. Treu et al. (2000) and van Dokkum et al. (1999) have shown that the FP is already in place at high redshift. In view of this and the evidence for mergers between E's, one may wonder how the FP is affected by mergers.

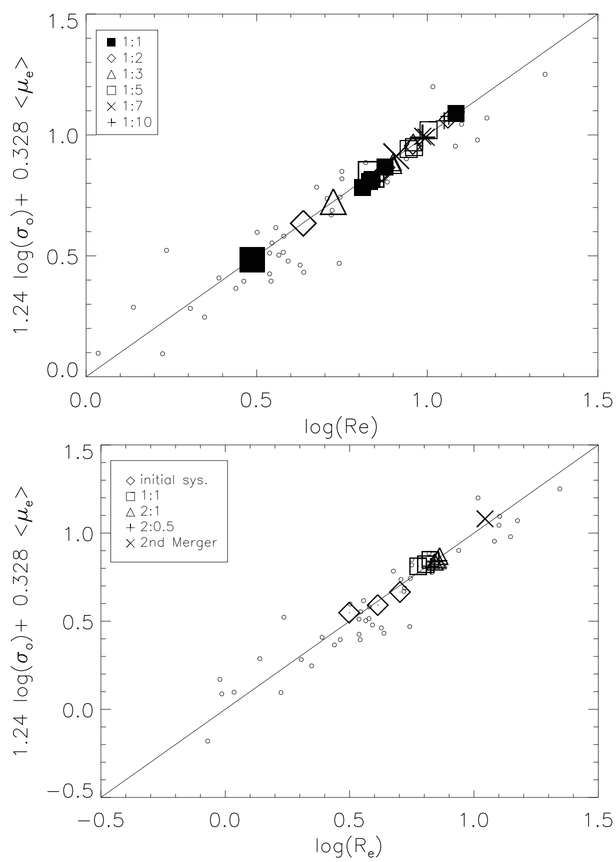


Fig. 1. Merger remnants lie on the same FP as their progenitors. Top panel: models without halo. Large symbols: progenitors; smaller symbols: merger remnants. Open circles: data from Jørgensen et al. (1996).

## 2. RESULTS

To answer this question we have used N-body simulations of elliptical galaxies. We have two sets of simulations. For the first we have Jaffe (1983) models as progenitors (i.e. spherical non-rotating

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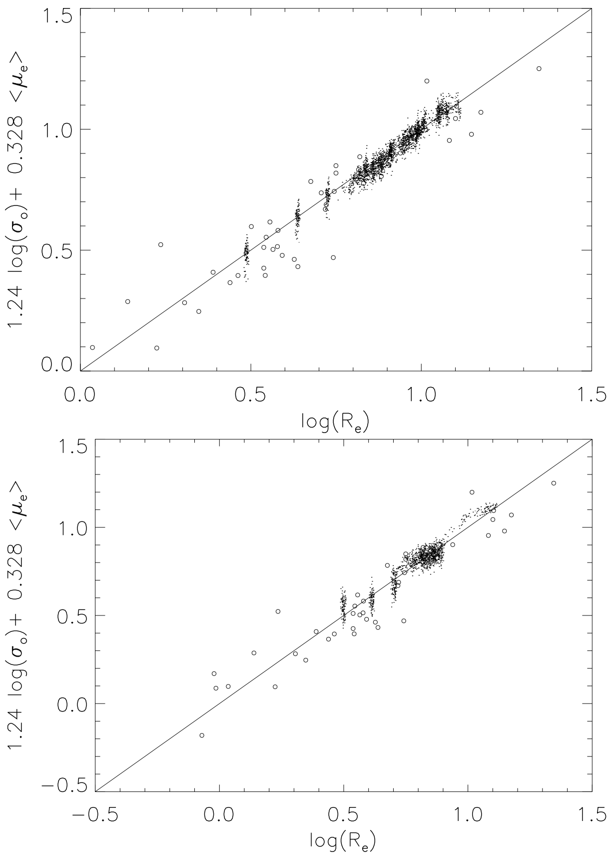


Fig. 2. Projection effects lead to noticeable scatter about the FP. Open circles: data from Jørgensen et al. (1996). Small dots: merger remnants and progenitors seen from 100 random points of view. Top panel: models without halo; bottom panel: models with halo.

isotropic systems). Only a stellar component is included. We varied three initial parameters: mass ratio, impact parameter and the initial orbital energy. The second set does include a second component, a Hernquist (1990) spherical halo. We have placed our initial models on the FP, and allowed the systems to merge. For the merger remnants we compute the effective radius, surface brightness and the central velocity dispersion.

Figure 1, top, shows results for models without halo. When plotted on the edge-on representation of the FP as given by Jørgensen et al. (1996) we see that remnants follow the same FP as their progenitors (large symbols). (1992). This space uses a more meaningful combination of the observables (seen in the upper right corners of the insets). The top plot is again an edge-on view. The bottom one shows a face-on view. Here wee can see that the remanats follow lines of constant velocity dispersion.

Figure 1, bottom, presents the results for the models with a halo component. The mass ratio between stellar and dark component was chosen such that the initial model would lie on the FP. Three different initial models, with masses 1/2, 1 and 2, were built (diamonds). Results are compared with data from Jørgensen et al. (1996). Again the remnants lie close to the initial FP. A further merger simulation was done between two remnants, plotted as a cross. Clearly these models also lie on the same FP as the progenitors.

We checked the influence of projection effects on the FP. In Figure 2, the top panel shows the results of our models without halo compared with the FP obtained by Jørgensen et al (1996). The bottom panel shows models with halo, compared with the same data. This figure shows that the scatter of the FP cannot be explained by projection effects, although one cannot neglect their influence.

## 3. CONCLUSIONS

1. Merger remnants lie on the same FP as their progenitors. Models with halo show marginally larger scatter.

2. This implies that mergers DO NOT destroy the FP.

3. Projection effects lead to noticeable scatter about the FP relation.

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