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PHASE-SPACE MIXING OF DARK HALOS IN MERGER EVENT

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Abstract. Cosmological N-body simulations were performed to study the evolution of the mixing effects of dark matter halos after a merger event. Particles of the main halo and of the captured satellite fuse in velocity space in a common Gaussian in a few dynamical timescales. Streams can be seen in phase-space, quite similar to caustics generated in secondary infall models of halo formation and could be "finger-prints" to be searched by the forthcoming GAIA experiment.

1 Introduction

Halos are continuously accreting mass (violently or not). This process affects their dynamical state and contributes this to decrease the phase-space density (Peirani et al. 2006). We have analyzed from our cosmological simulation (see Peirani et al. 2004 for details) some important merging events, in which the number of particles constituting either the main halo or the subhalo is large enough to permit an adequate study of the mixing process in the velocity space. These examples allow an estimate of the timescale of the process and to find possible "finger-prints" left by major events.

2 Phase-space mixing in mergers and main conclusions

The example we present here involves the merging of two large halos with masses of about 4.3×10^{12} $M_\odot$ and 1.2×10^{12} $M_\odot$ respectively, which have undergone an important fusion at $z = 0.92$. Snapshots of the event at three different redshifts are shown in Fig. 1, displaying the evolution in phase-space (top of the panel) as well as the evolution of the radial velocity distribution. In this case, the significant number of particles permitted an analysis not only of the global velocity distribution but also the distribution in shells at different radial distances from the center of mass. At $z = 0.48$ the velocity distribution of the secondary halo (a Gaussian) practically matches with that of the resulting halo, indicating a mixing timescale in the velocity space of about 2.7 Gyr (second line of Fig. 1). The velocity distribution of all particles and secondary halos at different shells ($z = 0$) is shown in the last two lines of Fig. 1. The computation was performed by dividing the resulting halo into ten shells containing ~ 6000 particles while the secondary was split into five shells with ~ 1200 particles. The velocity distribution in all shells, either for all particles or the secondary halo, can be quite well fitted by Gaussians with a decreasing velocity dispersion from the center, as expected. These results contradict those by Wojtak et al. (2005), who have concluded that the velocity distribution is not anymore Gaussian far from the center.

Non-disrupted satellites develop high velocity "tails" in their radial velocity distributions, suggesting that collective mechanisms driven by large fluctuations of the gravitational potential produce important mixing effects in the velocity space. On the other hand, disrupted satellites leave "finger-prints" in phase space (radial velocity x radial distance), generating streams which depend on the initial orbital angular momentum and which remind caustic structures seem in secondary infall models of halo formation.

Stars behave as a "collisionless" fluid similar to dark matter. In this case, one should expect that disrupted satellites will form not only dark matter streams but also baryonic/stellar streams, which could eventually be detected in phase space by the forthcoming GAIA as also suggested by Brown, Velázquez & Aguilar (2005).

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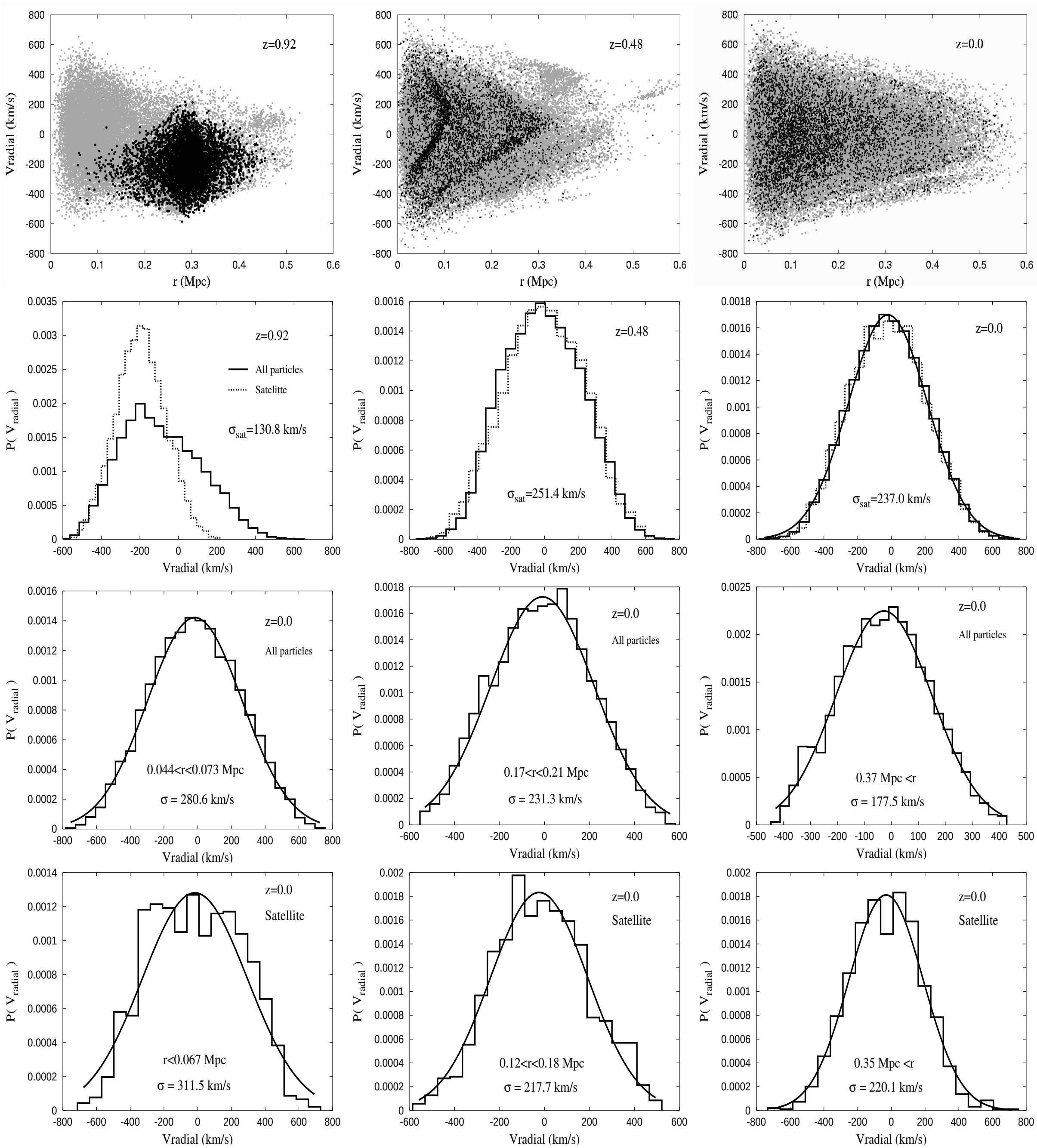

Fig. 1. (Top) The phase-space evolution of a host halo and a satellite (black points) completely disrupted by tidal forces. The three other panels (second line) show the evolution of the radial velocity distribution for both all particles and satellite. The last six panels show the radial velocity distribution at different shells from the center. The solid lines represent the best Gaussian fit.

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