On the Redistribution of the Angular Momentum In Minor Mergers

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Abstract **By means of N-body simulations, we study how the angular momentum is redistributed during minor mergers of a giant S0 galaxy and a spherical, initially non rotating satellite (mass ratio 1:10). During the interaction, the internal and the orbital angular momenta are redistributed, depending on the initial orbital parameters as well as on the relative orientation of the galaxy spins with the orbital angular momentum (direct or retrograde orbits). The angular momentum redistribution affects the properties of the S0 disk: the surface density profile become more extended and the v/σ ratio decreases in the outer parts, as a effect of an increase in the velocity dispersion of stars in the outskirts.**

1.The simulations

By means of N-body simulations, we study a set of minor mergers between a giant S0 galaxy (M_{S0}=2.3x$10^{11}M_{sun}$ and an initial disk scale length R_d=4kpc) and a spherical, initially non rotating, dwarf companion (M_{dwarf}=2.3x$10^{10}M_{sun}$). We explored a set of different initial orbital energies and angular momenta, changing the relative orientation of the S0 spin with respect to the orbital angular momentum (i.e. direct and retrograde orbits). All the simulations have been run employing a Tree-code (Semelin & Combes, 2002), a total number of particles N_{S0}=480000 for the S0 galaxy and N_{dwarf}=48000 for the dwarf, redistributed among stars and dark matter, and a gravitational smoothing length ε=200pc.

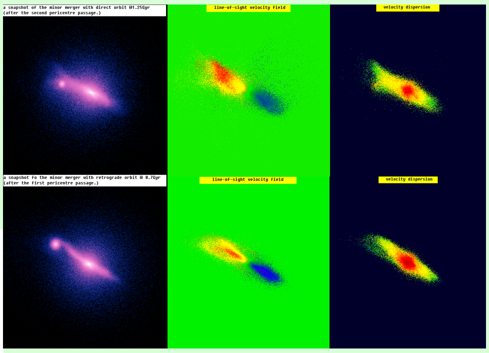


Fig.1 Comparison of a direct (top panels) and a retrograde encounter (bottom panels) between a S0 galaxy and a satellite. For the direct encounter, the density maps and velocity maps are shown just after the second pericenter passage between the two galaxies. For the retrograde case, they are shown after the first pericenter passage.

2. Merging times

The merging times depend on the relative orientation between the spin of the S0 galaxy and the orbital angular momentum (AM), as well as on the orbital parameters (see Fig.2 on the right). With the orbital parameters unchanged, direct interactions have shorter merging times than retrograde ones, due to stronger tidal disturbances.

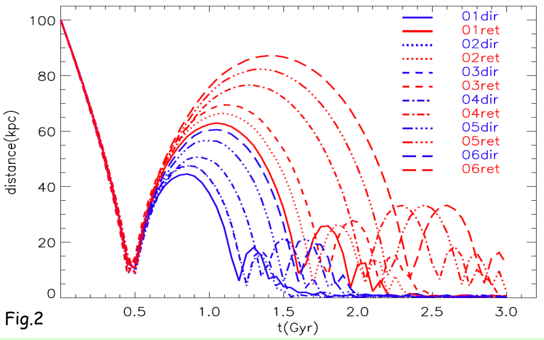


Fig.2

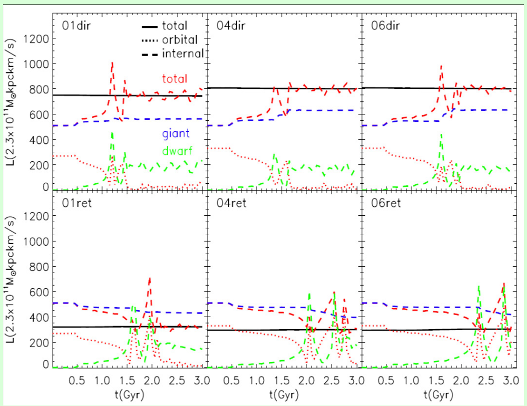


Fig.3 Evolution with time of the total, internal and orbital angular momenta for some of the simulations performed.

3. Angular momentum exchange

In the merging process, orbital AM is transferred into internal one, due to dynamical friction and tidal torques. For direct orbits, the dwarf galaxy loses orbital AM during the interaction, which is absorbed by the giant S0 galaxy, leading to an overall increase of its initial internal AM. For retrograde encounters, in turn, the orbital AM of the dwarf galaxy being anti-parallel to the internal spin of the S0, this leads to an overall decrease of the S0 initial spin (see Fig.3).

4. Evolution of the internal angular momentum of the giant S0 galaxy

The merging process modifies the internal AM of the giant S0 galaxy (see Fig.4). This is particularly evident for direct orbits, where an important fraction of the AM is transferred to the outer regions of the S0 galaxy.

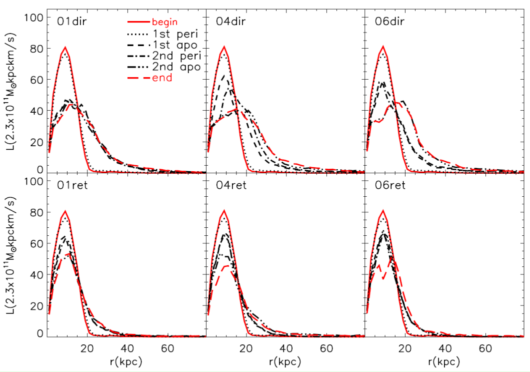


Fig.4 Distribution of the internal angular momentum of the giant S0 galaxy as a function of the distance from the galaxy center. Different lines correspond to different epochs during the merging process.

5.Surface density profiles

We present the surface density profiles of both the giant (red) and the dwarf galaxy (blue) at different epochs during the interaction and for different orbits (see Fig.5). During the interaction, stars are stripped from the dwarf galaxy, going to populate tidal tails. In the first phases of the interaction, this process affects only the outer parts of the dwarf, while its inner density profiles is mostly unchanged. As the interaction proceeds, the inner parts of the dwarf galaxy are strongly affected too.

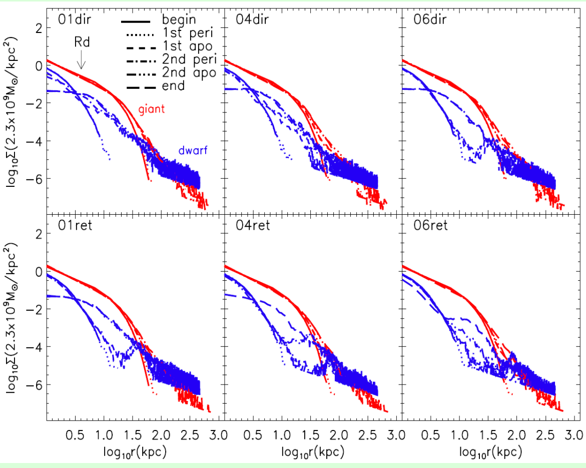
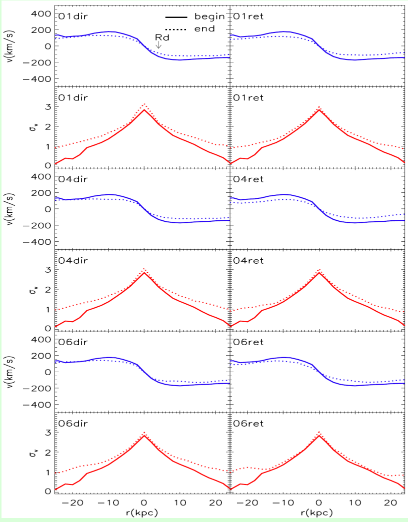


Fig.5 Surface density profiles.



6. Line-of-sigh velocities and velocity dispersions

The minor interaction leads also to a modification of the kinematical properties of the parent S0 galaxy. In particular, while the line-of-sight velocities are not strongly affected by the merging process, the velocity dispersion increases mostly in the galaxy outer parts, leading to a decrease of the v/σ ratio in the outer disk (see Fig.6).

Fig.6 Line-of-sight velocities (blue) and velocity dispersion profiles (red) of S0 stars at the beginning (solid lines) and at the end (dotted lines) of the interaction, for different simulated orbits.

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