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Binary Galaxy Spin Correlations in Small Galaxy Groups

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Abstract.
Statistics of spin orientations in binary galaxies may be used as a tool to study the formation process of galaxies. Helou (1984) found that the spins of spiral galaxies in binary systems are anticorrelated, and he suggested that it may have to do with the inclination dependence of the galaxy merger process. We study this dependence in small groups of galaxies. An N-body code is developed which uses an inclination dependent dynamical friction law to affect mergers of galaxies. It is found that some correlation results in this way in groups, which have initially random spin orientations.

1. Merger evolution in small groups

This work continues our previous studies of merger evolution in small groups of galaxies (Valtonen et al. 1993, Zheng et al 1993, Byrd et al 1994, Valtonen and Wiren 1994, Wiren et al. 1996). Here we use the Chandrasekhar approximation of dynamical friction in N-body simulations. When galaxies are far away from each other they are treated as point masses. When the radii of the galaxies overlap, a frictional force is introduced. In this case the friction is a function of the spin of the primary (more massive) galaxy relative to the orbital angular momentum of the two body motion of the two galaxy centers. The spin dependence of the dynamical friction is set so that it agrees with numerical simulations of Quinn and Goodman (1986). The initial characteristics of the groups are as follows (see our previous studies mentioned above): the maximum group size is set to 300 kpc, the initial number of galaxies in the groups is varied between three and seven and the virial coefficient $C_V = 0.5$. The masses are originally selected from a distribution shown in Fig. 1. There the range of masses is from 2.25×10^{10} to 2.25×10^{11} $M_{\odot}$, and the distribution falls towards the higher mass end. We put the restriction that the minimum initial distance between any two galaxies in a group is three times the sum of their radii.

The introduction of the dynamical friction often leads to mergers of two galaxies. Then their masses are added to make a new galaxy mass, the radius corresponding to this mass is given to the new galaxy, and the new spin is formed

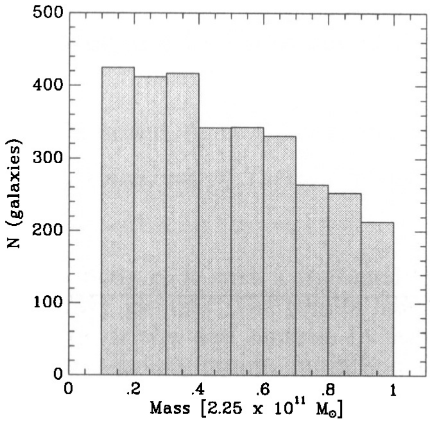

Figure 1. Initial mass distribution for 500 six-galaxy groups.

as a vector sum of the spins and orbital angular momentum of the original components.

Unlike Helou (1984) we do not find an excess of anticorrelated binary spins at the end of our simulations when only two galaxies are left in a bound state after mergings. What we do find is that parallel spins occur more often than is expected in a random distribution. This happens when we start with more than three galaxies (Fig. 2). If we start with three galaxies, the merging results agree with random spin orientations, i.e. there are as many parallel as antiparallel binaries in the end. The result does not depend on the value of the virial coefficient, the total evolution time, nor on the initial mass distribution of the galaxies.

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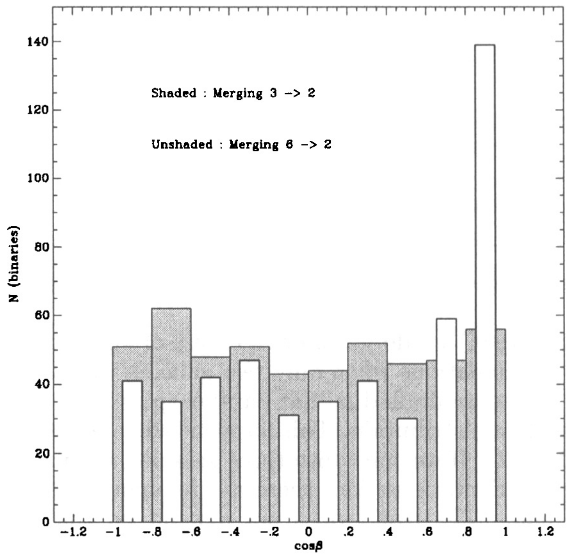

Figure 2. The distribution of the angle β between the spins of the two remaining galaxies. The shaded distribution corresponds to binaries remaining after mergers of three-galaxy groups, and the unshaded bars to the distribution after the mergers of six-galaxy groups. The spin angles are initially uncorrelated. In the case of three-galaxy groups, the final spin angles remain uncorrelated (i.e. the $\cos\beta$ distribution is uniform) while in the case of six-galaxy groups an excess of parallel spins ($\cos\beta > 0.8$) is found.

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