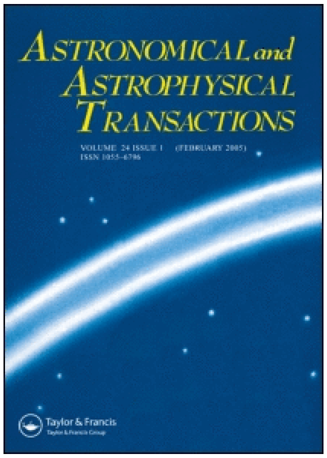

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How accurate is common wisdom on dynamical friction?

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HOW ACCURATE IS COMMON WISDOM ON DYNAMICAL FRICTION?†

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The evolution of a system of 1250 particles was followed for 68 crossing times. Two possibilities were considered: a) all the particles have the same mass; b) half of the particles are four times more massive than the others. It was found that the equipartition effect is very clear.

KEY WORDS N-body simulations; dynamical friction

Dynamical friction plays an important role in several problems of dynamical astronomy (motion of a globular cluster within a galaxy, of a galaxy within a cluster of galaxies, and so on), but several missunderstandings are found in the literature as shown recently by Muzzio (1993). Here we will deal with the question pointed out by Bekenstein and Maoz (1992) that the usual Chandrasekhar (1943) derivation of the dynamical friction effects does not lead to equipartition of energy, as it should.

We described 1250 particles according to a King model of unit mass and radius, and total energy −0.5 (i.e., the crossing time is unity). We followed its evolution for 68 crossing times, using Aarseth's (1985) NBODY2 code. The softening parameter was taken as 0.003125 and we considered two possibilities:

a) All the particles have the same mass;

b) Half of the particles are four times more massive than the other.

To allow for any possible transient effects, we adopted as reference the condition at 4 crossing times, rather than the initial condition. The dispersion of the relative difference in the individual energies of the particles between 4 and 68 crossing times was 0.637 for case a), and 0.646 for case b), i.e., essentially the same; besides, since the relaxation time goes with the inverse of the square of that dispersion, we have covered an interval of 40% of the relaxation time.

Figure 1 presents an x–y projection of the particle distribution at 4 and 68 crossing times for case b). The equipartition effect is very clear: after the evolution the

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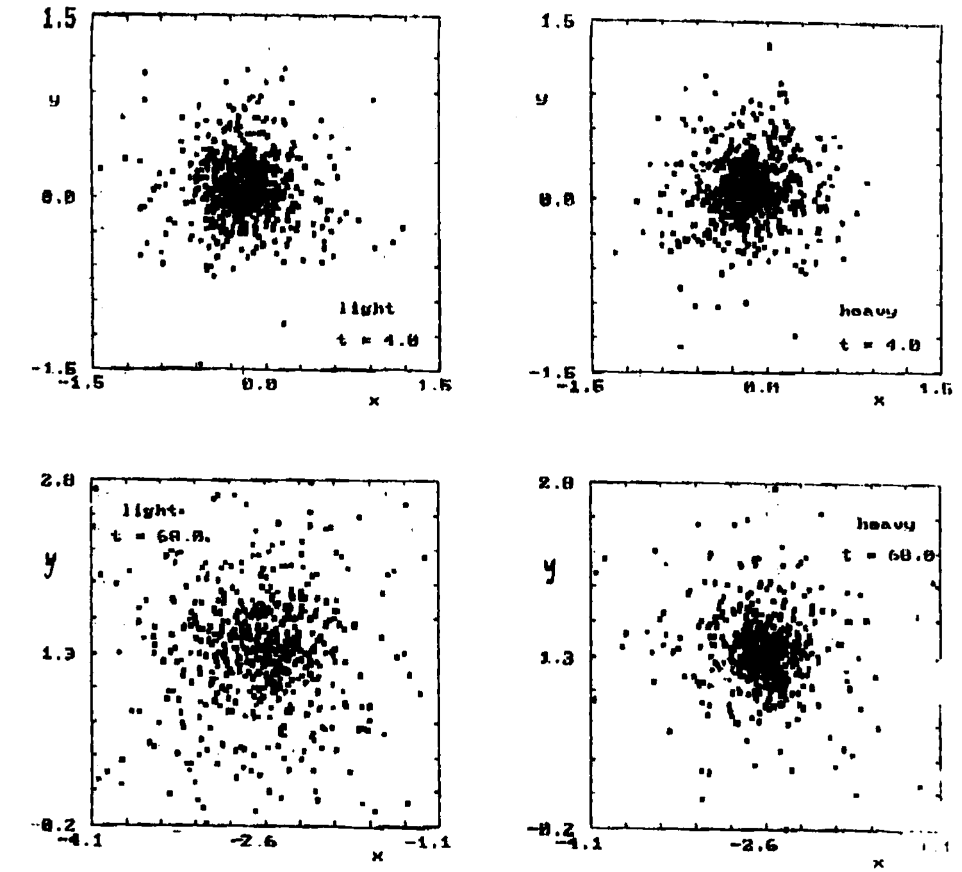

Figure 1

heavy particles are more concentrated, while the light particles are more dispersed. Figure 2 presents, at 4 and 68 crossing times, the energy vs. angular momentum distribution of the particles, separately for the light and the heavy particles in case b) and for all particles together in case a). Figure 3 does the same only for the particles that have suffered the largest energy change (in absolute value). Both Figures 2 and 3 show that the general trend is for light particles to go from low to high energy values, while the reverse is true for the heavy ones. Light particles tend to gain angular momentum, while heavy particles tend to reduce it.

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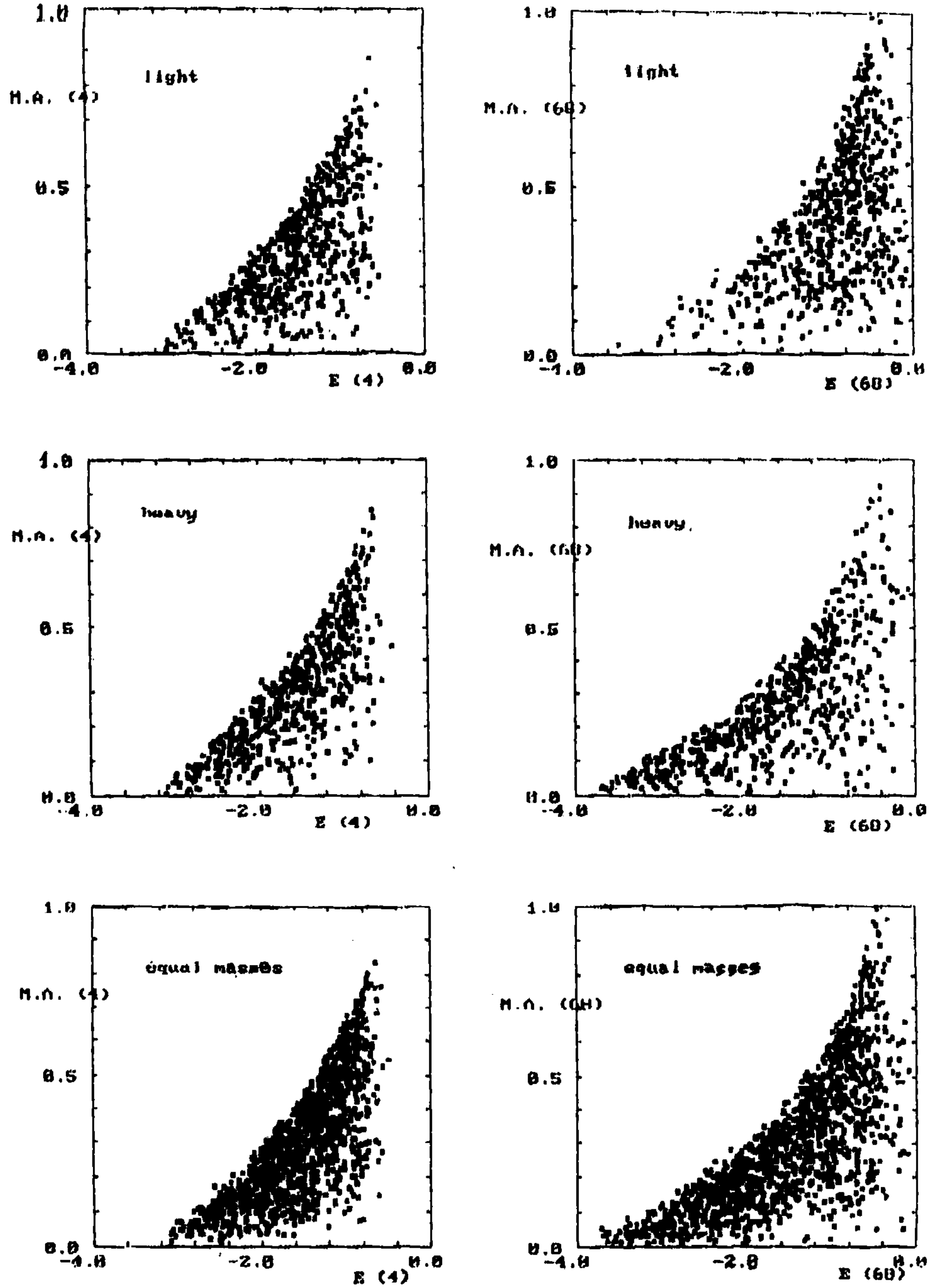
light
M.A. (4)
E (4)
light
M.A. (60)
E (60)
heavy
M.A. (4)
E (4)
heavy
M.A. (60)
E (60)
equal masses
M.A. (4)
E (4)
equal masses
M.A. (60)
E (60)

Figure 2

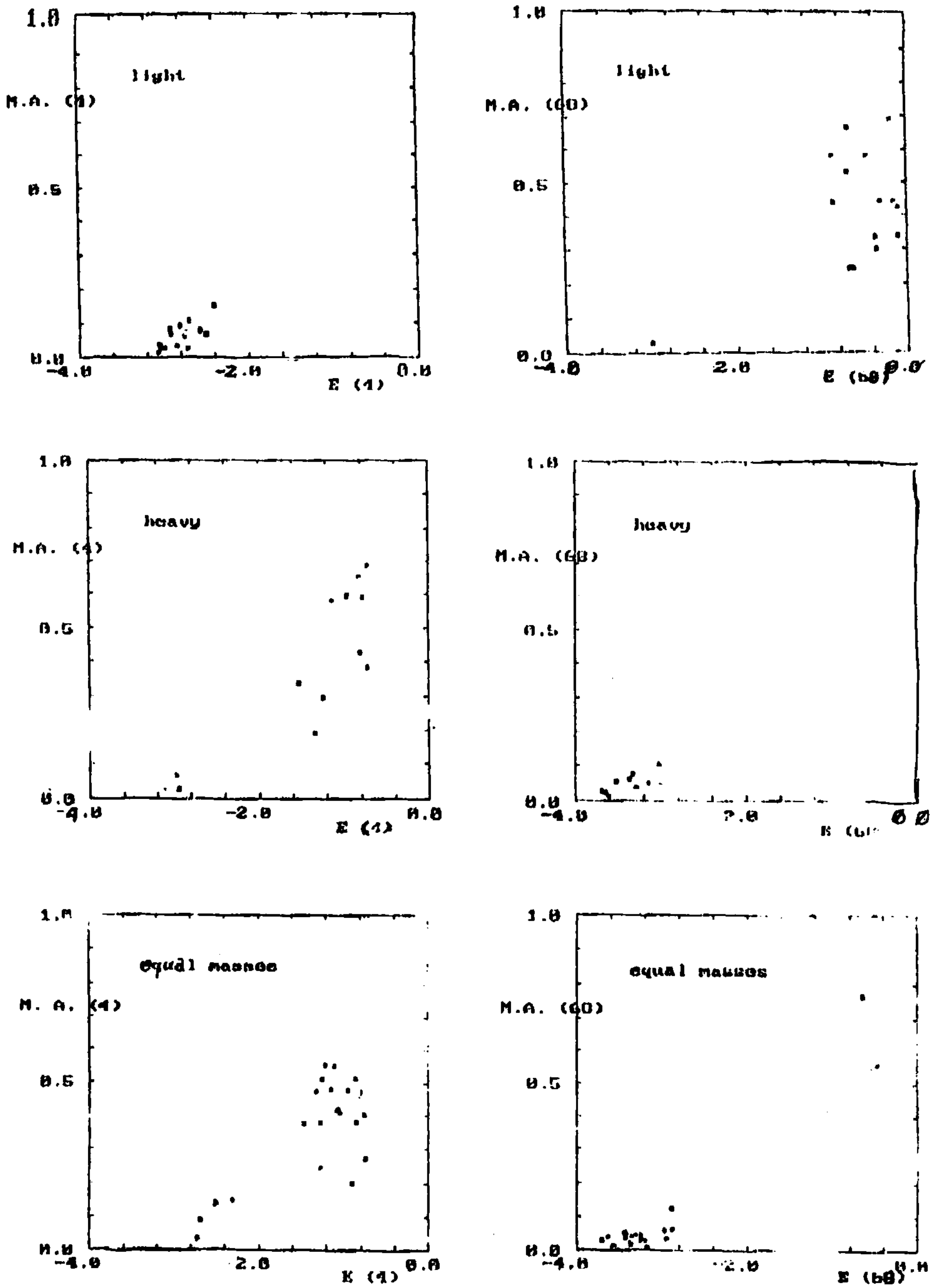
light
M.A. (4)
E (4)
light
M.A. (60)
heavy
M.A. (4)
E (4)
heavy
M.A. (60)
equal masses
M. A. (4)
equal masses
M.A. (60)
E (60)

Figure 3