THE INFLUENCE OF VELOCITY DISPERSION ON DYNAMICAL FRICTION IN STELLAR DISCS

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Abstract. We have investigated the force of dynamical friction on a softened point mass orbiting inside a disc galaxy on a planar circular orbit both analytically and by means of numerical simulations. Including a velocity dispersion large enough to stabilise the disc markedly changes the physical picture of the mechanisms producing friction, whereas the numerical value of the friction is almost unaffected. Self-gravity of the disc enhances the friction only by a moderate amount.

1. Introduction and methods

A satellite galaxy orbiting inside a galactic disc will lose angular momentum due to dynamical friction. The dependence of the frictional force on several parameters has been extensively studied, but the effect of the velocity dispersion in a stellar disc has remained largely unexplored.

Using the theory developed by Lynden-Bell and Kalnajs (1972) we have derived analytical expressions for the frictional torque that are correct to second order in the velocity dispersion. We have compared these analytical

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predictions with the results from N-body simulations, carried out using the two-dimensional N-body code written by Sundelius and Thomasson (Thomasson 1991). In our simulations the galaxy consists of a disc and a rigid halo, both initially described by a Kuzmin potential. We have forced the disturber to remain on a circular orbit instead of letting it sink freely, in order to reproduce more closely the analytical assumptions (see Donner & Sundelius 1993). We vary the velocity dispersion by varying either the disc mass or Toomre's Q-parameter, keeping all other parameters fixed.

2. Results and conclusions

For non-self-gravitating simulations with small disc masses our analytical predictions agree well with the measured force. The frictional force in non-self-gravitating models depends only weakly on the velocity dispersion. We have found that the reason for this is that while the friction due to the corotation resonance is strongly reduced by velocity dispersion, this reduction is largely cancelled by a corresponding increase of the contribution from Lindblad resonances. The latter effect is related to radial displacements of the resonances due to asymmetric drift and the variation of the frequencies for non-circular stellar orbits. Both outer and inner Lindblad resonances now give a positive contribution, in contrast to the behaviour familiar from cold discs (e.g. Donner & Sundelius 1993), where the inner Lindblad resonances give rise to a negative friction, and the total effect of Lindblad resonances is to *reduce* the dynamical friction.

Finding acceptable agreement between the analytical and numerical results for small values of the velocity dispersion, we can use simulations with some confidence in order to extend our results to larger values of the velocity dispersion and to self-gravitating discs. We find that even for larger values of the velocity dispersion the friction still depends only weakly on the velocity dispersion. We also find that the inclusion of self-gravity in the simulations increases the force of dynamical friction, but only by a factor of 1.5 at the most, and that this increase is almost independent of Q. Thus the dynamical friction in a galactic disc is essentially a function of only the surface density distribution and the rotation curve. For disc masses larger than ten per cent of the total mass, the friction from the disc is much stronger than that from the halo.

Full details of this work are given in the article by Wahde et al (1994).

References

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