THE INFLUENCE OF DENSITY FLUCTUATIONS ON THE LARGE SCALE DYNAMICS

A. JUST, B.M. DEISS, W.H. KEGEL
Institut für Theoretische Physik, J.W. Goethe- Universität
Robert-Mayer-Strasse 10, D-6000 Frankfurt a.M.
Federal Republic of Germany

In terms of averaged physical quantities, small scale fluctuations yield an additional momentum and energy transfer between the stellar and gaseous component. The nonlinearities lead to dynamical friction $\langle\rho_{s1}\vec{g}_{g1}\rangle$ and energy loss $\langle\vec{q}_{s1}\vec{g}_{g1}\rangle$ of the stellar system [1],[2]. Here $\vec{g}$ is the gravitational force and $\vec{q}$ the momentum density, subscripts s and g refer to the stellar and gaseous component, respectively. Since the density fluctuations in the stellar and gaseous component are correlated due to gravitational forces, these transfer functions are in general nonzero. We treat the stellar system collisionless and the ambient gas hydrodynamically including dissipative processes. We computed the effect of fluctuations induced by the pointlike structure of the stars in quasilinear approximation taking stable modes into account only. Thus the resulting transfer rates seem to be lower bounds, since the effect of growing modes, nonlinearities in the wave structure, and fluctuations induced by different mechanisms are not included. For the timescales τ_b and τ_E of momentum and energy loss, respectively, we find the relation

$$\frac{\tau_E}{\tau_b} = \left(1 + \frac{I_2}{I_1}\right)\left(1 + \frac{\rho_s}{\rho_g}\right)$$

where I_1 corresponds to the 'Coulomb logarithm' in the usual scattering theory and I_2 is an additional asymmetry measure of the power spectrum [1]. We discussed two very different astrophysical enviroments, where this effect of density fluctuations is of considerable magnitude. First, the systematic motion of a young stellar system, i.e. with low velocity dispersion, in a molecular cloud is slowed down in a timescale τ_b as short as $10^6 yr$ [see also Deiss et al., this Vol]. The timescale τ_E of energy dissipation is of the same order of magnitude. This estimate shows that friction and dissipation terms may not be neglected in the phase of early evolution of stellar systems as done in [4] e.g.. — Secondly, the fluctuation theory can be applied to clusters of galaxies as well [3]. In this context the heating of the intracluster medium and a possible mass segregation of the galaxies are the dominating effects. The main uncertainty arises from the badly known mass-to-light ratio of the galaxies.

[1] Deiss,B.M.,Just,A.,Kegel,W.H.:1990 Astron.Astrophys, in press
[2] Just,A.,Kegel,W.H.,Deiss,B.M.:1986 Astron.Astrophys. **164**,337
[3] Just,A.,Deiss,B.M.,Kegel,W.H.,Böhringer,H.,Morfill,G.E.:1990 ApJ **354**,400
[4] Lada,C.J.,Margukis,M.,Dearborn,D.:1984 ApJ **285**,141

F. Combes and F. Casoli (eds.), Dynamics of Galaxies and Their Molecular Cloud Distributions, 399.