STELLAR VELOCITY DISTRIBUTION IN THE PRESENCE OF SCATTERING MASSIVE CLOUDS

W. Renz
Department of Theoretical Physics
RWTH Aachen, Templergraben 55, 5100 Aachen, FRG

The purpose of this contribution is to show

1. a systematic perturbation-theoretical method of solving multivariate Fokker-Planck equations (FP eq.) as they appear in galactic dynamics.
2. that it is not only important to consider the cooling of the stellar disk by birth of new stars but also to include stellar death processes in the equation. This leads to different stellar velocity distributions.
3. that the input of new stars into circular orbits as it is done in recent numerical work (Sellwood and Carlberg, 1983) leads not only to the cooling effect wanted but also to an additional damping effect on spiral waves.

The FP approach has already been proposed by several authors (Spitzer and Schwarzschild, 1951; Wielen and Fuchs, 1983) as a useful method to calculate the velocity distribution of stars which undergo the influence of random gravitational forces. Nevertheless people used the Langevin approach in connection with a Gaussian velocity distribution, which may be a quite good approximation in certain cases but is generally inconsistent (Lacey, 1984). For simplicity we assume a constant diagonal diffusion matrix $\underline{\underline{D}}$ (Wielen, 1977). As in our Galaxy the diffusion process is known to be very slow in comparison with the rotation period, we can choose $D/\kappa|\underline{\sigma}^2|$ as the small expansion parameter. κ means the epicyclic frequency and $\underline{\sigma}^2$ the main velocity dispersions of the disk stars. The FP eq. is transformed on action angle variables. By introducing the epicyclic approximation one can reobtain the FP eq. (Wielen and Fuchs, 1983) and also the solution given there as the 1st order solution in our perturbation expansion. We give also 2nd order corrections (Renz, 1983).

In order to model stellar birth and death processes we introduce an additional source term into the FP eq. From an empirical initial stellar mass spectrum and the main-sequence lifetime (Zinnecker, 1981) we can calculate that part of stellar mass which is still left as stars after time t (Figure 1). It turns out that about 50% of the initial mass gets lost in the relevant range of dynamical evolution of the Galaxy. For the further analytical calculations we fit the remaining mass by

(*) $M(t) = \{0.2 + 0.5\exp(-\gamma.t)\}.M(10^7\ \mathrm{yr})$ and $\gamma^{-1} = 1.2 \times 10^9$ yr.

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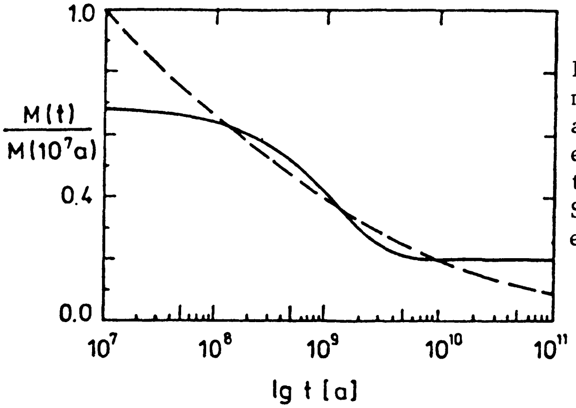

Figure 1. Dashed line:remaining mass M(t) of one generation of stars after time t, derived from an empirical initial mass function and the main-sequence lifetime.
Solid line: the approximation of eq. (*) for the same quantity.

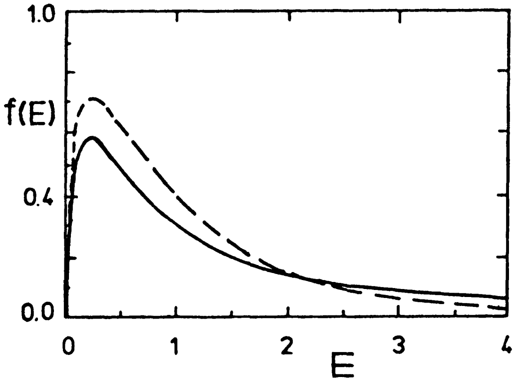

Figure 2. The normalized distribution of epicyclic energies E. The dashed line shows the distribution with only stellar birth processes. The solid line shows the quasi-stationary distribution by taking also stellar death processes into account.

As result we get a quasi-stationary velocity distribution on a time scale of 10^9 yr, which changes slowly only within 10^{10} yr due to the 20% of stars with nearly infinite lifetime (Figure 2). The damping effect can be seen from hydrodynamical equations which derive from the modified FP eq. Details will be presented elsewhere.

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