EVOLUTION OF THE VERTICAL STRUCTURE OF GALACTIC DISKS

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Numerical simulations of the evolution of the vertical structure of galactic disks have been performed. The physical mechanism for the evolution is the scattering of stars off Giant Molecular Clouds (GMCs) as proposed by Spitzer and Schwarzschild (1951). A model galaxy consists of a fixed, nearly isothermal halo plus an axisymmetric, thin exponential disk consisting of 1000 stars. A population of GMCs is embedded in the disk. The stars interact with each other via a self-consistent axisymmetric field determined from an expansion in spherical harmonics to twelfth order. The stars scatter off the GMCs that are modelled as soft particles. The equations of motion of the stars and the GMCs are integrated directly to high accuracy. Adiabatic cooling is therefore included implicitly. In order to avoid axisymmetric instabilities, the stellar component is initially relatively hot in the plane of the disk. Nineteen simulations were performed with varying parameters to check the consistency of the results.

The results can be summarized as follows. At a given position in the disk the scale height and z-velocity dispersion grow approximately as the square-root of time. The short axis of the velocity ellipsoid points in the vertical direction and the axial ratio is typically 0.55. The vertical density distribution is well fitted by an isothermal sech^2 solution. The z-velocity distribution is well fitted by a Gaussian distribution. These results are consistent with observations of the structure of the solar neighbourhood (Wielen 1977), but differ strongly from the analytical results by Lacey (1983). Further, the scale height can be constant with radius, if the GMC distribution is more concentrated towards the galactic center than the stellar distribution. The effective mass of GMCs can be enhanced by wakes set up in the stellar component. The scattering efficiency depends strongly on the masses of the GMCs, and the resultant scale height will scale with the square of the GMC masses. This makes it difficult to estimate the scale height induced by an observed GMC population.

Details of this work will be reported elsewhere (Villumsen 1983).

H. van Woerden et al. (eds.), The Milky Way Galaxy, 491–492.

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DISCUSSION

R.J. Allen: You have told us what happens to the stars. What happens to the molecular clouds?

Villumsen: By construction nothing happens to them. They run around happily orbiting the Galaxy, unchanged throughout the simulation. The computer program is made that way. I have tried both infinite lifetimes for the molecular clouds, and finite lifetimes with random dissolution and reconstitution; for the same radial distribution it made no perceptible difference.

S.M. Fall: What were the initial conditions, such as Q and shape of velocity ellipsoid, for the simulations?

Villumsen: The initial Q was 1.1, so that the disk was self-supporting and axisymmetrically stable. The ratio of tangential and radial velocity dispersions was taken as 3:4, based on the Oort constants. Another thing to do would be to study the evolution of a cold population with an initial velocity dispersion of a few km/s, rather than a hot population.

R. Güsten: How do you treat the molecular clouds?

Villumsen: As Plummer models. The potential is $U(r) = -GM (r^2+\varepsilon^2)^{-1/2}$, where ε is an assigned size of the clouds. For clouds of 10^6 solar masses, I chose $\varepsilon = 50$ pc. I tried different values of ε, but it made no difference.