TOWARDS A SELF-CONSISTENT MODEL OF A GALAXY

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ABSTRACT. Using a theoretical model for the functional distribution of stars in phase space in a spherically symmetric galactic system, it is found upon solving the fundamental equations of stellar dynamics that the rotation curves produced by the model are flat for large distances within the system. The properties of the stellar orbits within such systems are investigated and an N-ring axially and equatorially symmetric model for simulating its dynamics is presented. Poisson's equation is solved by expanding density and potential in Legendre polynomials (c.f. van Albada and van Gorkom, 1977). It is helped to follow the time development of such a system under various forces.

1. BACKGROUND

We are interested in solutions of the self-consistent problem for stellar systems (Richstone and Tremaine, 1984). According to van der Kruit and Allen (1978), it is a fact that not a single galaxy has been found with a Keplerian rotation curve at large radii. This is an important constraint on any theoretical model, together with the fact that the flattening of most ellipticals is not caused by rotation but maintained by an anisotropic velocity distribution (Binney, 1976).

2. MODEL

We define our distribution function to be of the form:

$$f = C\frac{g(J)}{(-E)}$$

where J is the angular momentum, and E is the total energy.

If we choose a "top-hat" distribution for $g(J)$, then the orbits near the centre are more isotropic ($\sigma_r \simeq \sigma_t$), and those in the outer parts more radial ($\sigma_r > \sigma_t$) (c.f. Hénon, 1964; Gott, 1977). The potential can also be separated into two analytic parts and evaluated throughout.

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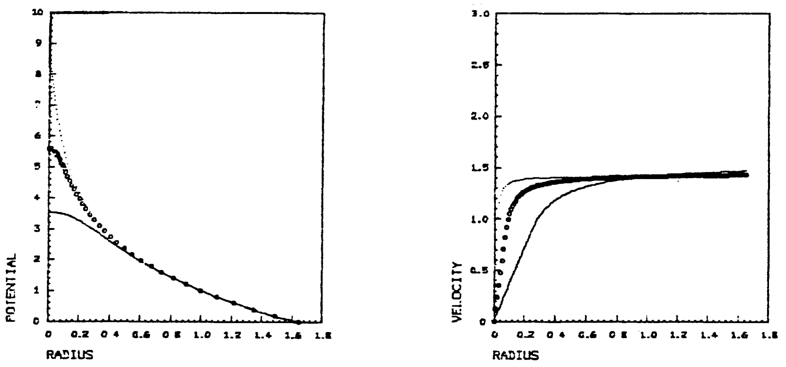

The Figure shows how the potential is gradually softened by the increasing spread in angular momentum, and the corresponding rotation curves.

The orbits of test particles moving in a variety of such systems can be evaluated. These show that the systems with a larger spread in the angular momentum function will be more susceptible to collapse from a passing perturber, as the orbits of their test particles do not precess as rapidly, due to the more softened potential providing less energy for exploring the available phase space.

We produce a model galaxy with N randomly distributed rings. Particles on the same ring and with identical velocities will describe similar orbits around the origin. The potential V and density ρ are expressed as sums of Legendre polynomials.

It is hoped with the aid of our model to show how such a spherical system can be changed into prolate or oblate systems. The source of such distortion could be intrinsic torques or tidal interaction (Peebles, 1969), and can be easily modeled by adding components to the Legendre polynomial coefficients, as the potential outside the system is of the form:

$$V = \sum_n \frac{A_n}{r^{n+1}} P_n(\mu)$$

Our time integration scheme (Hockney and Eastwood, 1981) will allow us to follow the shape of the system and its potential and rotation curve as it develops.

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