DYNAMICS OF THICK SPIRALS

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1. Introduction

Most studies of spiral structure in galaxies use 2D models, since the motion of the stars is supposed to be confined very close to the plane of symmetry. However, galactic disks have a finite thickness and the vertical variation of spiral perturbations should be considered. The effect of 3D orbits in the dynamics of normal spiral galaxies is examined in this paper. We present the basic orbital behavior of the families of periodic orbits, which support a thick spiral pattern.

2. The potential

The potential used for the calculations has the form: $\Phi = \Phi_d + \Phi_h + \Phi_s$, where the axisymmetric part consists of a Miyamoto disk Φ_d (Miyamoto and Nagai 1975) and a halo:

$$\Phi_h(r,z) = \frac{v_h^2}{2} \ln\left(1 + \frac{1}{r_c^2}(r^2 + z^2)\right) \qquad (1)$$

The constants v_h and r_c are the maximum rotational velocity and the core radius of the halo respectively. The spiral perturbation is:

$$\Phi_s(r,\theta,z) = A\, r \exp(-\epsilon_s\, r)\, [\cos(2(\frac{\ln r}{\tan i}) - 2\theta)]\, \mathrm{sech}^2\left(\frac{z}{z_0}\right), \qquad (2)$$

where A is the amplitude of the perturbation, ϵ_s is the inverse radial scale length of the spiral, i is its pitch angle and z_0 its scale height. We have calculated the orbits in a frame rotating around the z-axis. The angular pattern speed was taken so that corotation was located close to the R_{max} distance of van der Kruit and Searle (1982). The parameters used for the axisymmetric part attempted to fit the profiles proposed by van der Kruit and

L. Blitz and P. Teuben (eds.), Unsolved Problems of the Milky Way, 507–508.

Searle (1982) (*Model A*) and by Barnaby and Thronson (1994) (*Model B*) for the surface photometry of NGC 5907. We added a strong open spiral with $i = 30°$.

3. Conclusions

The main conclusions for the 3D models are:

- A thick spiral pattern is supported by 3D families of periodic orbits with elliptical projections on the equatorial plane. These families are bifurcations of the 2D central periodic family at the vertical resonances of the model.
- The structure of 3D periodic orbits makes it difficult to create self-consistent models of spirals reaching corotation.

We found two different types of orbital behavior in the examined cases corresponding to the two different models of the photometry of NGC 5907.

- In *Model A* the successive 3D families which support the pattern are producing a "stair-type" edge-on profile. The most important 3D families of periodic orbits are bifurcated at the vertical 2/1, 3/1 and 4/1 resonances. This way it is possible for peanut shaped structures to appear in the central regions of the response model without invoking any bar in the imposed potential.
- In *Model B* the 3D families are characterized by similar mean z values of their orbits. Thus no "stair-type" effect appears. The most important families of 3D periodic orbits are bifurcated at the vertical 4/1, 5/1 and 6/1 resonances. Their projections on the equatorial plane are identical with the central family even after several kpc beyond the bifurcating point.

The above differences reflect the different locations of the vertical resonances in the models (Patsis and Grosbøl 1995).

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