PERIODIC ORBITS RELEVANT FOR THE FORMATION OF INNER RINGS IN BARRED GALAXIES

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The study of orbits of a test particle in the gravitational field of a model barred galaxy is a first step toward the understanding of the origin of the morphological characterstics observed in real barred galaxies. In this paper we confine our attention to the inner rings. Inner rings are a very common characteristic of barred galaxies. They are narrow, round or slightly elongated along the bar (with typical axial ratios from 0.7 to near 1.0), and of the same size as the bar. A first step to test the old hypothesis that inner rings consist of stars trapped near stable periodic orbits would be a study of particle trapping around periodic orbits encircling the bar. Such a study is contained in the work of several authors (Danby 1965, de Vaucouleurs and Freeman 1972, Michalodimitrakis 1975, Contopoulos and Papayannopoulos 1980, Athanassoula et al. 1983). In the above works the stability of periodic orbits was studied with respect to perturbations which lie on the plane of motion $z = 0$ (planar stability). To ensure the possibility of formation of rings, a study of stability with respect to perturbations perpendicular to the plane of motion (vertical stability) is necessary. In this paper we investigate the properties of periodic orbits which we believe to be relevant for the inner-ring problem using a sufficiently general model for the galaxy and sets of values for the parameters which cover a wide range of different possible cases. We also study the stability, planar and vertical, with respect to large perturbations in order to estimate the extent of particle trapping. A detailed numerical investigation of three-dimensional periodic orbits will be given in a future paper.

We find that: a) for a wide range of values of the dimensionless parameters stars can be trapped in a significant three-dimensional region around the direct and retrograde periodic orbits in the vicinity of the bar. Such trapping may be responsible for the formation of inner rings. b) the main contribution to the particle trapping is due, in general, to the family x_2 of direct periodic orbits which extends between the two inner Lindblad resonances.

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A comparison of our results with those of other authors shows that the identification of the families which are relevant for the inner-ring problem as well as the relative significance of these families crucially depends on the model used and on the range of values of the parameters involved.

We must note that our work, as well as the works of the above-mentioned authors, offers no proof that a visible inner ring is formed from the orbits we propose. Such a proof is a difficult task which requires additional investigation.

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Terzides discusses his poster with Lynden-Bell (left) and Casertano. CFD

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