ORDERED AND SEMI-ERGODIC MOTIONS IN BARRED GALAXIES

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A preliminary step towards the construction of self-consistent models for barred galaxies consists in understanding the stellar orbital behaviour in a given axisymmetrical + bar-like potential and, in particular, the influence of various parameters characterizing the bar on the different kinds of possible motions. To do this we undertook a systematic study of the main periodic and quasi-periodic orbits in a two-component mass model: An axisymmetrical part characterized by a rotation curve $V(r) = V_o(r/r_o)^{1-\delta}$ and a prolate bar-like perturbation whose density distribution is $\rho = \rho_o(1-(x^2+z^2)/b^2-y^2/a^2)^2 (a>b)$. This rather realistic choice for the bar is in agreement with the available photometric data and has several advantages, i.e. all $\cos(m\theta)$ terms are included and the physical parameters such as the length of the bar a or its eccentricity e are explicitly included in the formulae. The ratio of bar to disk mass measured up to the outer Lindblad Resonance (ε) and the angular velocity (Ω_s) are also free parameters.

Fig. 1 shows the general aspect of the characteristic diagram representing the main families of symmetrical simple periodic orbits: every such orbit is represented by a point (H,x) (H is the Hamiltonian and x the distance to the centre where the orbit intersects the y=0 axis). Orbits A (elongated ellipses) and B' (rather round) are aligned perpendicularly to the bar. Orbits B (elongated) and A' (rather round) are aligned along the bar. We also find family L, starting from the Lagrangian point L_4 and continuing for larger H, and family R of retrograde orbits. A family of (1/1) resonant orbits (off-centered ellipses) exists outside the corotation radius r_{co}. The stability of these orbits as well as the influence of the different parameters mentioned above on the relative position of the various characteristics will be examined elsewhere in more detail[1].

The method of surface of section was used in order to get an insight into the quantity of trapped matter around the main stable periodic orbits inside and outside corotation. For different models and for given

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values of H we estimated the percentage A of the accessible region in the plane of section $(x,\dot{x})$ which is occupied by good invariant curves. Fig. 2 shows A (in percentage) as a function of H, inside corotation, for an axial ratio a/b = 4(1) and 7(2) of the bar. (The values of the other parameters are $\varepsilon = 0.1$, $a = r_{co}$, $\Omega_s = 0.5$, $\delta = 0.8$, $V_o = r_o = 1$). The sharp decreases of A correspond to the advent of semi-ergodic orbits and become bigger with increasing axial ratio. Only direct orbits are considered here (the large majority of retrograde orbits is regular and trapped around family R). This and other similar curves show that both ε and the eccentricity of the bar are essential in determining the relative amount of ordered motions. The only orbits which strengthen the bar inside corotation are orbits trapped around family B. Practically only the Hamiltonian is a constraint for semi-ergodic orbits. In any case the region they occupy is considerably less elongated than the bar. We shall consider some consequences of these results for constructing self-gravitating models of barred galaxies in another paper[1] as well as the effect of increasing ε and Ω_s. Computations of surfaces of section outside corotation (for $\varepsilon = .1$ and $\Omega_s = .5$) give the following results: 1) Short bars ($a = r_{co}$) do not trigger semi-ergodicity, 2) long bars ($a = 2r_{co}$) induce dissolution of invariant curves between corotation and the outer Lindblad resonance but large regions of phase space are still occupied by ordered motions, in particular, there exists a non negligible trapping of matter around the resonant stable periodic orbit 1/1 outside OLR, 3) the presence of an extended stochastic region between corotation and OLR implies a rather long and eccentric bar of mass greater than roughly one tenth of that of the disk inside the outer Lindblad resonance.

[1] E. Athanassoula, O. Bienaymé, L. Martinet, D. Pfenniger, submitted to Astronomy and Astrophysics.

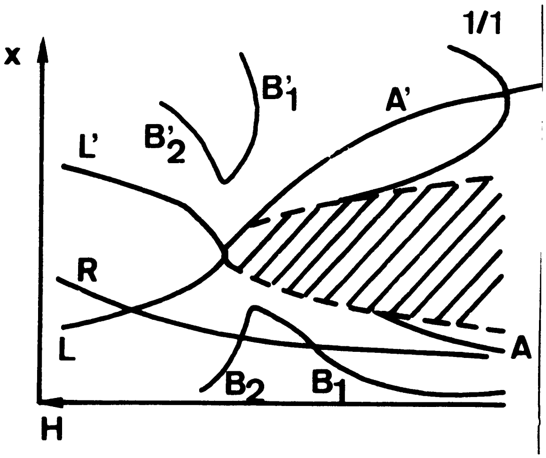

Fig. 1

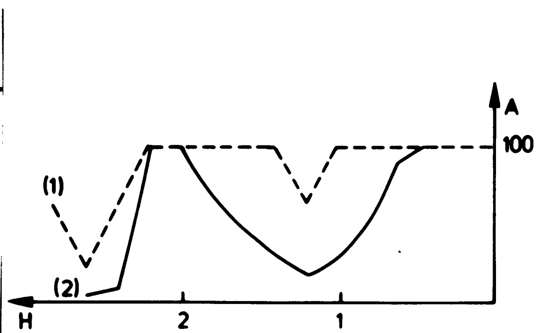

Fig. 2