ONSET OF STOCHASTICITY IN BARRED SPIRALS

P.J.Teuben and R.H.Sanders
Kapteyn Astronomical Institute
University of Groningen, the Netherlands

Stellar orbits in the plane of a strong bar potential demonstrate the breakdown of the second integral of motion well inside corotation (Sanders(1980) and more recently Contopoulos(1982),Athanassoula et.al. (1983), Sanders and Teuben (1982)).
The onset of such stochastic motion may limit the bar strength (axial ratio), since stochastic orbits fill equipotential contours rather homogeneously.

The model adopted for the barred spiral is essentially the same as Sanders and Tubbs (1980), although the bar was modeled here by an inhomogeneous prolate ellipsoid with a density falling smoothly to zero at the edge of the bar.
The Surface-of-Section-method (Hénon & Heiles,1964) was used to estimate the percentage regularity in phase space by calculating the largest regular islands, belonging to the stable periodic orbits, in the Y-$\dot{Y}$-diagram (example fig.3). The onset of stochasticity turned out to be rather abrubt (although not as fast and complete as Hénon & Heiles) as a function of various parameters studied so far. For a particular model the percentage regularity as a function of Jacobi Integral (or radius) is shown in fig.1. In fig.2 we see a similar plot of percentage regularity vs. the deviation from axial symmetry, e.g. the axial ratio of the bar and the bar-disk mass ratio.
The pattern speed of the bar turned out to be not of importance for a realistic range of this parameter.

The onset of stochasticity is understood in terms of interaction of unstable periodic orbits. In our case it is the simple (e.g. not self-crossing) 3/1 (epicyclic) resonance interacting with various higher order resonances,such as the 8/3, 14/5 etc. Shortly after the bifurcation of this 3/1-family from the main simple periodic orbit (prograde), overlapping resonances leads to dissolution of invariant curves and to a high degree of stochasticity.

E. Athanassoula (ed.), Internal Kinematics and Dynamics of Galaxies, 211–212.

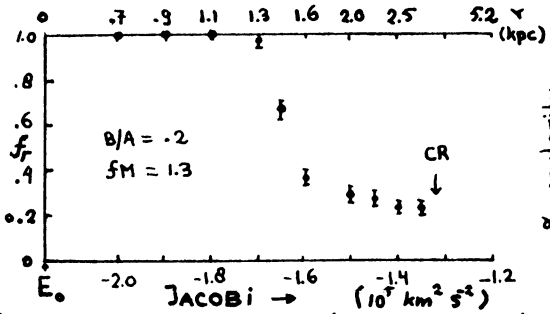

fig.1 Percentage regularity vs. Jacobi energy in a strong bar. CR is corotation, beyond which phase space is infinite.

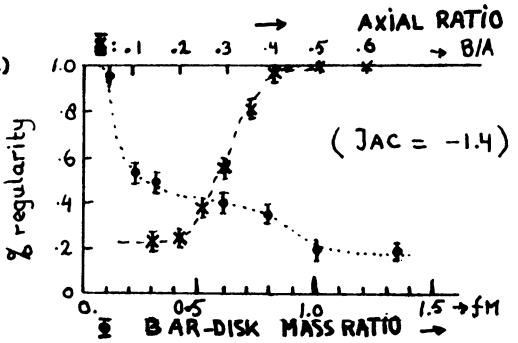

fig.2 Percentage regularity vs. axial ratio and bar-disk mass ratio. A halo of 5 times the bar+disk mass was added.

We can conclude that for this model a limit on the bar strength can be derived, above which selfconsistent bars are probably not possible, although construction of bar and lens models maybe possible by populating both the regular and stochastic orbits.

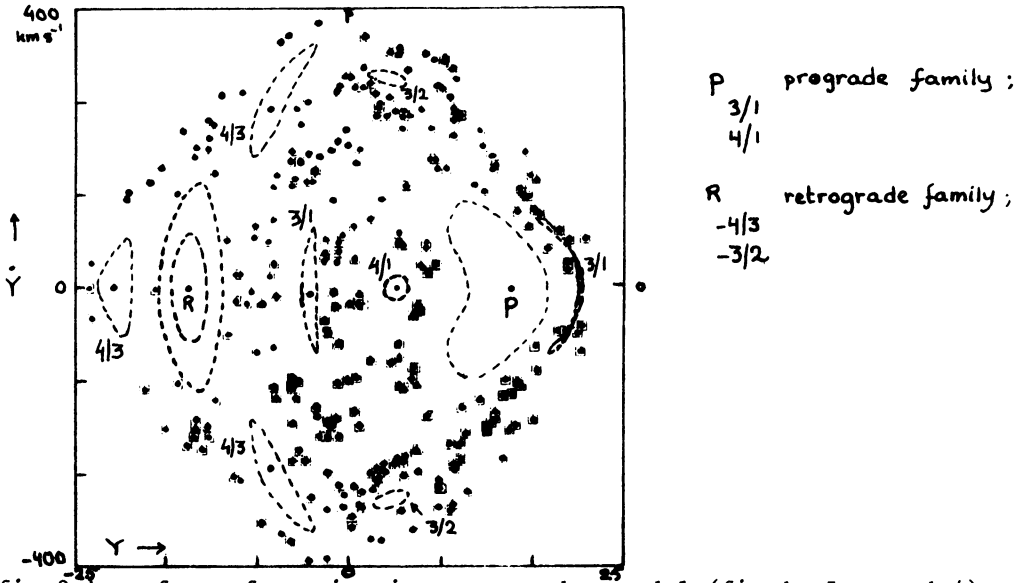

fig.3 A surface of section in a strong bar model (fig.1, Jac = -1.4). The irregular points all stem from one orbit. Major periodic orbits appear as points, with their surrounding invariant curves.

REFERENCES

Athanassoula,E. ,Bienaymé,O. ,Martinet,L. and Pfeninger,D., 1983,this book
Contopoulos,G. ,1982,Astron. and Astrophys., in press.
Hénon,M. and Heiles,C. ,1964, Astr.J. 69,73.
Sanders,R.H. ,1980, Cambridge Workshop on Normal Galaxies.
Sanders,R.H. and Teuben,P.J. ,1982, in preparation.

https://doi.org/10.1017/S0074180900032861 Published online by Cambridge University Press