UNSTABLE BOX ORBITS IN CUSPY ELLIPTICAL GALAXIES

H.HASAN

NASA Headquarters, Washington D.C. 29546, U.S.A. and Jet Propulsion Laboratory, 4800 Oak Grove Dr., Pasadena CA 911119,U.SA

D. PFENNIGER

Geneva Observatory, University of Geneva, CH-1290 Sauverny, Switzerland

INTRODUCTION

The alm of this work is to gain physical insight Into the role played by a concentrated central mass in affecting the shape of elliptical galaxies, by examlning its effect on the stability of box orbits which are the backbone of triaxial elliptical galaxles. Ample observational evidence is now available for the existence of a central mass concentration (e.g. Ford et al, 1994), or central cusps (e.g. Lauer et al, 1995) in galaxies. The central mass Is expected to cause orbital stochasticity (Gerhard and Binney, 1985), and chaotic mixing of orbits, which could have ramifications on galactic evolution(Merritt and Valluri, 1996). We investigate here the Interplay between potential cuspiness and eccentricity on the stability of axial orbits ina scale-free potential In a simple, preliminary attempt to characterize this effect.

POTENTIAL

We employ the following scale-free potential:

$$\Phi = \frac{1}{2} \ln (1 + m^2 / \varepsilon) \qquad \text{If } p = 0$$

$$\Phi = \frac{1}{2p} \{(m^2 + \varepsilon)^p - \varepsilon^p\} \qquad \text{if } p = 0$$

where $$m^2 = \frac{x^2}{a^2} + \frac{y^2}{b^2} + \frac{z^2}{c^2}$$

a, b, c being the semi-axes of the potential, and & is a small constant added to avoid numerical problems at the origin. In our computations we consider the spheroidal case with a = b = 1, keeping in mind that in a triaxial case, the conclusions apply in each principal plane independently.

COMPUTATION

We solve the equations of motion numerically for a single Jacobian value, H = 1, and search for the axial periodic orbit along one of the principal axes. The calculation is repeated for a series of values of c/a=0.7, 0.9, 1.1, 1.3, 1.5, corresponding to a potential going from oblate to prolate. For each shape, the value of p is varied from 0.1 to 2, corresponding to density slope, p-2. Elliptical typically have p = 1, while p = 2 corresponds to a homogeneous density profile.

For each axial orbit, the stability index b (Pfenniger 1984) is computed. Orbits with 2< b < -2 are stable, while those with b outside this range are unstable,

RESULTS

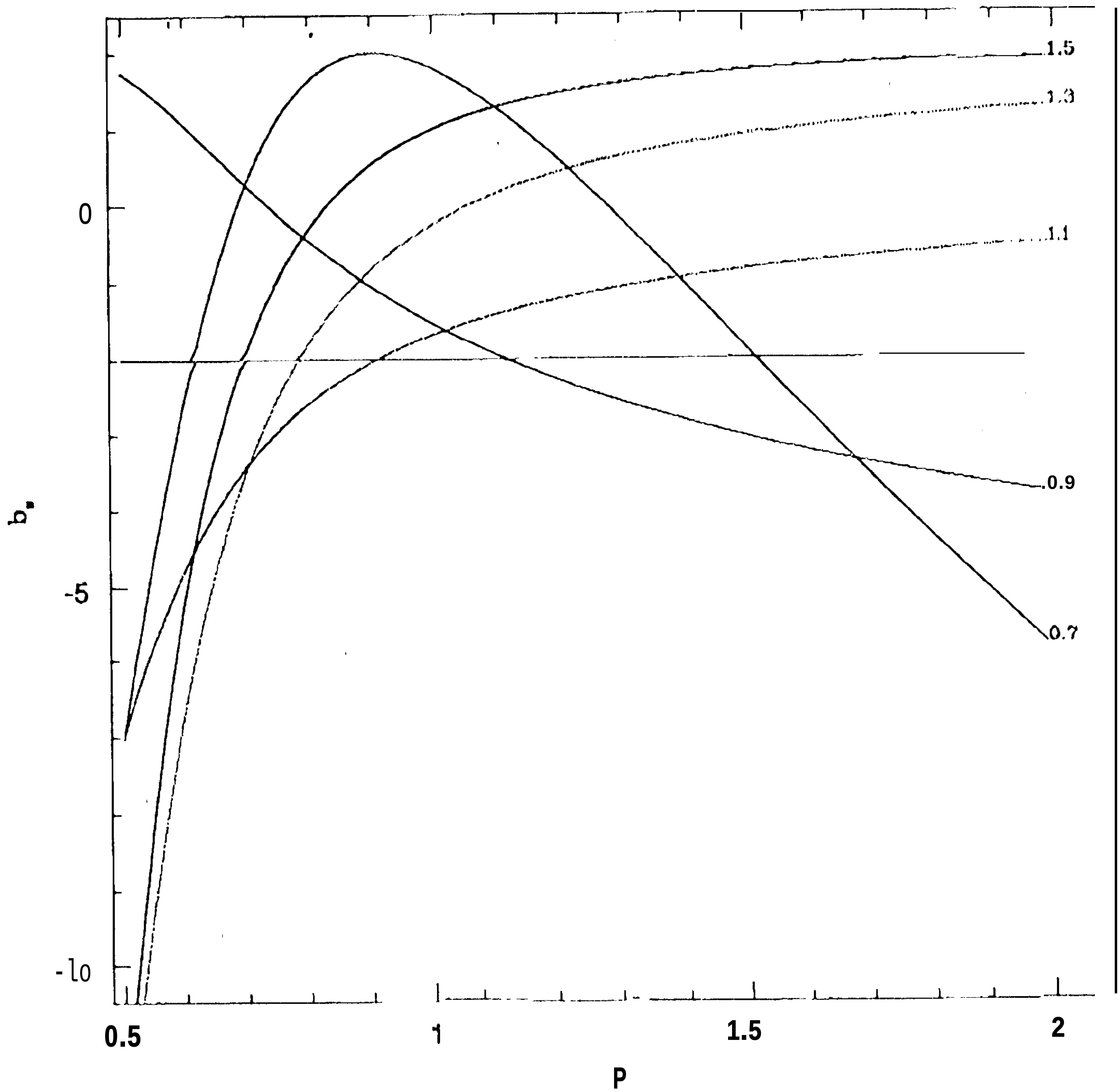
The results are plotted in Figure 1. For a nearly homogeneous, weakly cusped density profile (p-2 ~ 0), the axial orbit is unstable for oblate and stable for prolate potentials, The most stable situation occurs for cusps with a density index p-2~ -1, in which case both oblate and prolate cases are stable for reasonable potential axis ratios. For steeper density profiles,(p-2 < -1 ,4), most of the cases are unstable, though there appears to be transition region where stable shapes could exist (c/a= 0.9).

This simple orbital stability analysis leads us to conclude that ellipticals with homogeneous density profiles will settle to a more prolate "boxy" shape, while the highly cusped elliptical would tend towards an oblate, "disky", shape. Most elliptical lie in between these extremes, and depending on potential cuspiness could be more boxy or disky.

A detailed orbital characterization and comparison with observations is the next step of this project

REFERENCES

Ford, H. et al., 1994
Gerhard, O. and Binney, J., 1985, MNRAS
Lauer, T. et al., 1995
Merritt, Cl. and Valluri, M., 1996, ApJ
Pfenniger, D., 1987, A&A


1.5
1.3
1.1
0.9
0.7
0
-5
-10
b*
0.5
1
1.5
2
P