# NEW PHENOMENA IN TRIAXIAL STELLAR SYSTEMS

P. Magnenat and L. Martinet
Geneva Observatory, CH-1290 Sauverny

For a number of years the Geneva Observatory stellar dynamics group has undertaken numerical investigations of stellar orbital behaviour in conservative dynamical systems with three degrees of freedom. Compared to results for 3-D axisymmetrical models (2 degrees of freedom), this work displayed the advent of several new phenomena which may appear in rotating or non-rotating stellar systems with three unequal axes (ellipticals, bulges, bars). Some of these phenomena deserve particular attention.

## I. TILTED ORBITS

A. In 1:1:1: resonance regions of a nearly spherical potential, oblique plane periodic orbits (p.o.) can exist,

- which cross each main axis (generally unstable)
- which cross no main axis : the retrograde families are always stable, the direct are generally unstable (Martinet and de Zeeuw, 1982).

B. In a system symmetrical with respect to the fundamental planes, the elliptical p.o. whose orbital plane contains the Z-axis in the non-rotating case are tilted by the rotation around Z. They can be either retrograde or direct, depending on whether the rotation axis is the minor or the major axis (Magnenat, 1982a ; see also Heisler et al, 1982).

## II. INSTABILITY TYPES (Magnenat, 1982b)

Three different instability types of p.o. may exist, to which correspond three kinds of behaviour of the neighbouring orbits in a four-dimensional space of section. These types are determined by the characteristics of the eigenvalues and eigenvectors of the linearized transformation matrix T connecting the consequents in the space of section.



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A. Semi-instability (The orbit is unstable in the orbital plane or perpendicularly to it).

T has two complex and two real eigenvalues : $\lambda_1, \lambda_1^*, \lambda_2, \lambda_2^{-1}$ ; $|\lambda_1| = 1$. The motion of points in the neighbourhood of the p.o. (in the space of section) is dominated by a contracting and a dilating manifold of dimension 1, as in the systems with 2 degrees of freedom.

B. Total instability (Instability in the orbital plane and perpendicularly to it).

Four real eigenvalues corresponding to one contracting and one dilating manifold of dimension 2 in the space of section.

C. Complex instability

Four complex eigenvalues with $|\lambda| \neq 1$ : $\lambda, \lambda^*, \lambda^{-1}, \lambda^{*-1}$. The neighbouring motion in the space of section is dominated by two planes with inward and outward spiralling, respectively.

To conclude, let us recall that a stable p.o. is characterized by 4 complex eigenvalues on the unit circle. The motion of points in the vicinity of the p.o. in the space of section consists then of two independent elliptical rotations around the p.o., leading to toroidal invariant surfaces.

## III. THE NUMBER OF ISOLATING INTEGRALS

- Totally or complex unstable oblique orbits are those generally accompanied by large stochastic regions in phase space. Potentials symmetrical with respect to the three main axes in which these orbits do not exist, are therefore likely to admit 2 isolating integrals of motion besides the Hamiltonian for most orbits.
- In a system without the previously mentioned symmetries, two, one or zero isolating integrals besides the Hamiltonian can exist. This fact, already observed by inspecting invariant surfaces in the space of section (Martinet and Magnenat, 1981), was recently confirmed by means of the Lyapunov characteristic numbers (Magnenat, 1982c).

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