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The fossil Oort cloud and the dynamics beyond Neptune

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Abstract

We will present here some dynamical features of the so-called fossil Oort cloud (semi major axis between 100 and 1000 AU and perihelion beyond Neptune). This region has been considered so far as totally inert, because either the planetary perturbations or the galactic tides have an extremely weak effect. However, we will show that Kozai effect can still be efficient at very high distances from the planets, and result in high amplitude oscillations of the perihelion distance on a gigayear time-scale.

1 Introduction

The Oort cloud is a spherical reservoir of comets situated in the outermost confines of the Solar System (up to about 10^5 astronomical units from the Sun). Starting from the pioneer work of Oort, the cloud's dynamics is nowadays fairly well understood, mainly governed by galactic tides, passing stars and occasional close encounters with the planets. However, the internal limit of the Oort cloud is still very ill-defined, and particularly its junction with the inner Solar System (from about 100 to 1000 AU).

Contrary to the "classic" Oort cloud, this region is observable from the Earth: indeed, several bodies have been detected with extremely high perihelion distances (Sedna for instance). Furthermore, long-term simulations by M. Fouchard et al. [1] show that it is continually replenished by objects coming from the outer Oort cloud itself, which guarantees that the region is active. These aspects may be considered as hints for a surprisingly rich long-term dynamic.

2 Overview

Following the work of Kozai [3], Thomas and Morbidelli [4] or Gallardo et. al [2], we will present here some numerical tools for the study of the fossil Oort cloud's dynamics, along with an analytical secular theory (the problem is reduced to a conserved Hamiltonian with two degrees of freedom). The figures below present some preliminary results: in particular, figure 3 illustrates the considerable effect of a high order mean motion resonance with Neptune (ratio 37:2).

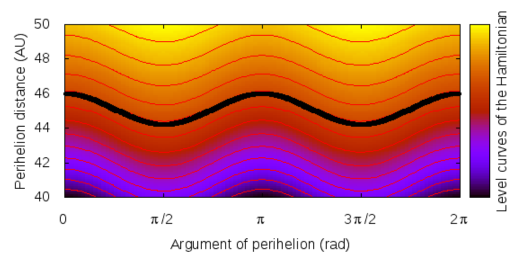

Figure 1: Secular theory *vs.* numerical integration – circulation case.

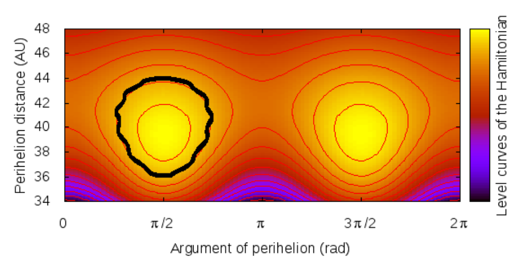

Figure 2: Secular theory *vs.* numerical integration – libration case.

Acknowledgements

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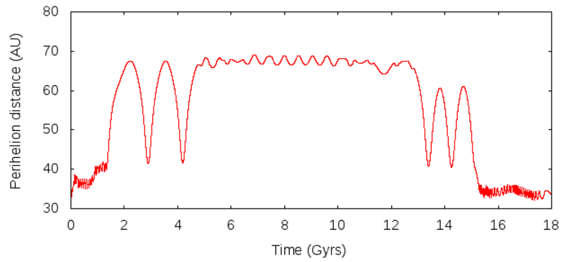

Figure 3: Kozai dynamics near a mean motion resonance with Neptune.

References

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