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NEPTUNE'S TROJANS

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RESUMEN

Se presenta una exploración numérica de la evolución dinámica de cuerpos hipotéticos situados en resonancia 1:1 con Neptuno. Podemos estimar una escala de tiempo de 100 millones de años para la destrucción de libraciones, por lo que no esperaríamos encontrar objetos Troyanos asociados a Neptuno. Se observó capturas temporales de satélites.

ABSTRACT

A numerical exploration of the dynamical evolution of hypothetical bodies located at 1:1 resonance with Neptune is performed. We roughly estimate a time-scale of some 100 Myrs for the destruction of the librations, so we cannot expect to find primordial Neptune's trojans. Temporary satellite captures were also observed.

Key Words: **OUTER SOLAR SYSTEM — RESONANCES — TROJANS**

1. RESONANCES IN THE TRANSNEPTUNIAN REGION

There are observational evidences and dynamical reasons supporting the existence of a significant population of bodies located in mean motion resonance with Neptune (Malhotra 1995). One part of this population has a very stable evolution while the other part migrates, in long time-scales, to the inner solar system due to a collisional and dynamical evolution in the Kuiper-Edgeworth belt (Duncan et al. 1995; Levison & Duncan 1997; Stern 1996). This allows for the delivery of short period comets and *centaurus* from Neptune's resonance zones. We present here some numerical results about the dynamics of Neptune's trojans (resonance 1:1). In the past, Jupiter's trojans were intensely studied numerically and analitically. On the other hand, the hypothetical trojans of the other giant planets were mainly studied by means of numerical integrations because of the difficulty of handling analytically the planetary perturbations.

2. NEPTUNE'S TROJANS

Using the RA15 code (Everhart 1985), we numerically integrated particles for 1 Myrs and 10 Myrs perturbed by the outer solar system. The initial conditions for the outer planets were taken from Cohen et al. (1973) and the mass of the inner planets was added to the Sun. At the begining of the integration the particles were located in the invariable plane of the Solar System. The initial eccentricities were 0.05, 0.10, and 0.15. In all cases, the initial critical angle $\sigma = \lambda - \lambda_N$ was taken 60° or 300°, corresponding with the libration centers for the particles preceding and following Neptune respectibely. The global results are summarized in Figure 1.

3. STABILITY OF THE LIBRATIONS

Mikkola & Innanen (1992) found some trojans following stable librations for 20 Myrs. They conclude that horseshoe trajectories are unstable leading to a close approach with Neptune. Similar results were found by Holman & Wisdom (1993). Using the time-frequency method described in Gallardo & Ferraz-Mello (1997), we followed the time evolution of the libration motion of our surviving librators for 10 Myrs. All particles show

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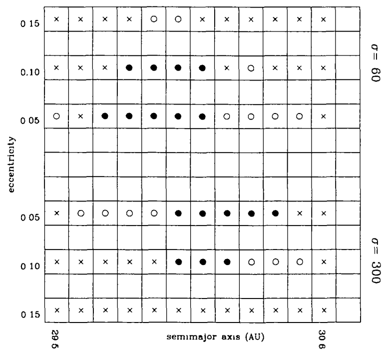

Fig. 1. Evolution as a function of the initial semimajor axis and eccentricity for both groups of trojans (libration centers at $\sigma = 60$ and $\sigma = 300$). Points mean the libration persists after 1 Myrs of the numerical integration, crosses mean the particle is ejected from the resonance and circles mean alternation between both libration centers and *horseshoe* trajectory.

increasing libration amplitude. If this tendency persists the librations will be destroyed. We also followed the time evolution of the libration frequency and obtained a rather chaotic evolution. We can estimate a time-scale of some 100 Myrs for the destruction of the librations, so we should not expect primordial trojans. If some day trojans are discovered, we will have to explain how and when they were captured into the 1:1 resonance.

From our analisys we conclude the libration period does not depend on the eccentricity but on the libration amplitude $\Delta\sigma$. Both groups of libration centers seems to be symmetric in the parametric plane (σ_o, a_o) so there are no differences in their dynamical behaviour. Libration switching between both libration centers (Gallardo & Ferraz-Mello 1998) were obtained without invoking near encounters with Neptune. So, as in the case of the 1:2 resonance (Gallardo & Ferraz-Mello 1997), the transitions are due to the chaos asociated with the separatrix that sourrounds both libration centers. Horseshoe trajectories, instead, can lead to a close approach with Neptune and also to a temporary satellite capture (TSC).

4. TEMPORARY SATELLITE CAPTURE

Finally, we followed some particles with initial horseshoe trajectories and when they were close to Neptune we computed the Neptunecentric energy $\epsilon = -1/a^*$ where a^* is the semimajor axis of the neptunecentric orbit. When $\epsilon < 0$ the particle has an elliptic orbit around Neptune. We obtained some TSC for periods of hundreds of years. It will be usefull to calculate the frequency of TSC in order to estimate the population of transneptunian objects captured temporarily by Neptune and whether we can expect or not to observe it now.

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