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Dynamic picture of the main asteroid belt

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Abstract

Using the Spectral Analysis Method introduced by Michtchenko et al. (2002), we construct a dynamic portrait of the main asteroid belt. For this task, we use information extracted from the distribution of test particles (which were initially placed on a perfectly rectangular grid of initial conditions) after 4.2 Myr of gravitational interactions with the Sun and five planets, from Mars to Neptune. We illustrate in detail the asteroidal behavior on the dynamical, averaged and frequency maps. On the maps, we superpose information on the proper elements and proper frequencies of real objects, extracted from the data base, AstDyS (http://hamilton.dm.unipi.it/astdys), constructed by Milani and Knežević (2003). A comparison of the maps with the distribution of real objects allows us to detect dynamical mechanisms acting in the domain under study. These mechanisms are related to mean-motion and secular resonances. We note that the two- and three-body mean-motion resonances and the secular resonances (strong linear and weaker non-linear) play an important role in the diffusive transportation of the objects and the formation of the clumps which could be misidentified as asteroid families. The long-lasting action of the resonances, overlaid with the Yarkovsky effect, may explain many observed features of the density, size and taxonomic distributions of the asteroids.

1. Introduction

The asteroidal belt has been exhaustively studied from the point of view of its dynamical structure, stability, physical composition and a possible origin. Many problems relative to these issues have been solved, mainly those concerning the dynamics of the massless objects. However, we have noted that some very important features of the asteroid dynamics are still ignored, even in the recently published researches. Thus, we decided to elaborate a global dynamic picture of the main belt, combining already established facts and new results from our investigations.

The main idea of our approach consists in the construction of maps of the asteroidal belt using the information about the distribution of the test particles, which were initially placed over a perfectly rectangular grid of initial conditions, after 4.2 Myr of gravitational interactions with the Sun and five planets, from Mars to Neptune. Indeed, the final distribution of the fictitious particles will reflect the peculiarities of dynamical interactions between asteroids and the planets in the region under study. Particulary, the test particles will preserve (at least, during the time span covered by integrations) some invariable quantities of motion (e.g. proper elements), if they belong to the domains of quasi-regular motion. In contrast, these quantities will exhibit variations in the domains of dynamical instabilities, which can result even in the escape of the objects from the studied region. The test particles can form agglomerations or, on the contrary, some voids in the specific regions of the phase space, due to the action of mean-motion and secular resonances, in such a way indicating the location of these features.

2. The construction of the dynamical portrait

To construct the dynamical portrait of the asteroidal belt, we perform several steps, which include: 1) plotting the density distribution of the asteroid population in the proper elements space and identification of its features; 2) identification of asteroidal families in the region; 3) dynamical mapping of the representative planes in the ($a_{\rm osc}$, $I_{\rm osc}$)–space; 4) plotting the asteroid population in the proper frequencies space and detection of main mean-motion and secular resonances acting in the region under study; 5) construction of the averaged maps and identification of the dynamical mechanisms responsible for the actual shape of the asteroid distribution; 6) examination of possible interactions between actual objects and the web of the resonances, as a source of diffusion of the small bodies; and, finally, 7) study of dynamical implications on the size and spectral distribution of the real objects in the inner main belt.

3. Figures

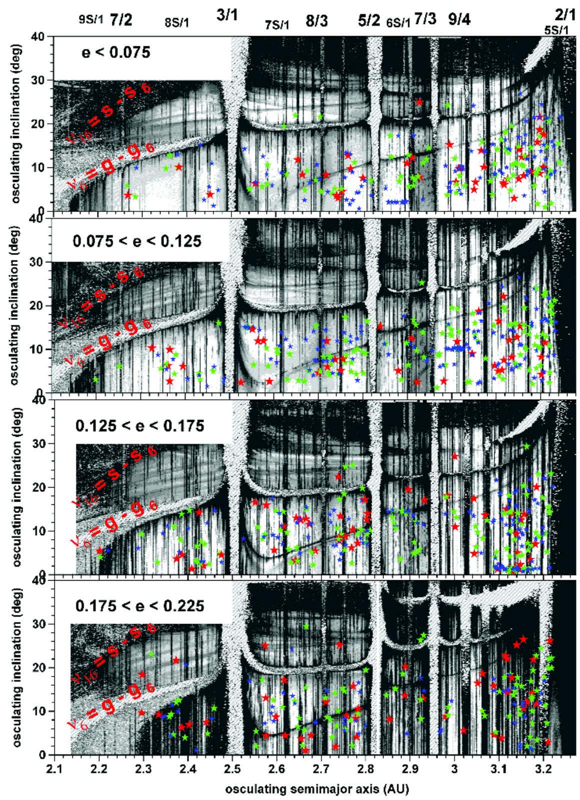

Figure 1: Dynamical maps on the (a, I)–planes of the osculating semi-major axis and inclination. The gray color levels correlate the stochasticity of motion with the spectral number N, in logarithmic scale: lighter regions corresponds to regular motion, while darker tones indicate increasingly chaotic motion. The hatched regions correspond to initial conditions that lead to escape of objects in less than 4.2 Myr. The large objects from the corresponding eccentricity interval are superposed on each graph: red stars are objects with D > 100km, green stars are objects with D in the range from 50km to 100km, and blue stars are objects with 30km< D < 50km.

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References

[1] Michtchenko, T., Lazzaro, D., Ferraz-Mello, S., and F. Roig: Origin of the Basaltic Asteroid 1459 Magnya: A Dynamical and Mineralogical Study of the Outer Main Belt, Icarus 158, 343, 2002.

[2] Knežević, Z. and A. Milani, Proper element catalogs and asteroid families, A&A, 403, 1165, 2003.