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On chaotic motion of asteroids near 3:1 resonance

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Abstract

We have obtained very chaotic behavior of some asteroids close to 3:1J resonance. Studied orbits obtain very large eccentricity in less than 50 kyr. We note the significant role of encounters with large planets as a reason of observed chaoticity. However, non-resonance perturbations of large asteroids and minor planets, such as 1 Ceres and 4 Vesta are important, too.

1. Introduction

As it is well known, the dynamical evolution of all test particles in 3:1 resonance is characterized by very rapid increasing of their eccentricity. This phenomenon is predicted by the works of Wisdom [3,6]. Moreover, 50% particles becomes Earth-crosser in 1Myr due secular resonance overlapping inside 3:1J resonance [4].
Evidently, it is interesting to reconstruct dynamical history of real asteroids near 3:1J resonance in the past. First of all, we perform backward integrations of orbits of some 3:1J resonant asteroids (Table 1). The equations of the motion were numerically integrated 800 kyrs into the past, using the N-body integrator Mercury and the Everhart integration method [1] and also the Lie-integrator [2].
We repeat our integrations using three types of perturbations: 1) only Jupiter; 2) only Planets**;** 2)Planets+Ceres; 2)Planets+Ceres+Vesta in large interval (10 Myrs).

Table 1 Osculating orbital elements at epoch 1998-Jul-06 (JD2451000.5)

asteroid	*i*	*e*	*a*
121268(1999 RD108)	11.35	0.19782	2.50014
410088 (2007 EJ)	8.333	0.62945	2.49802
887 Alinda	9.303	0.56272	2.48549

2. Results

In spite of small eccentricity of 121268(1999 RD108) at present epoch e=0.2, we have found very large eccentricity e>0.9 after 300-500 kyrs of backward integrations. This effect still present for clones 121268(1999 RD108) and 410088(2007 EJ), indicate continuous chaotic region, but strongly depends on large asteroids (at least Ceres and Vesta) perturbations. Similar behaviour we note for 887 Alinda.
The orbits of studied asteroids are very unstable. Small variations of initial semimajor axis give very different orbits. Some of them are impossible: backward integration ends collision with Jupiter or Sun.
We test encounters with planet and large asteroids (Ceres and Vesta) as possible reason of observed chaotic behaviour of studied asteroids and found them very important.
For example, the first important close encounter in the past for one of clones of 121268(1999 RD108) is at 158.4 kyrs ago with the Earth, then the first one with Mars is at 190.3 kyrs ago and finally with Venus at 4033.8 kyrs ago. (See Fig. 2).

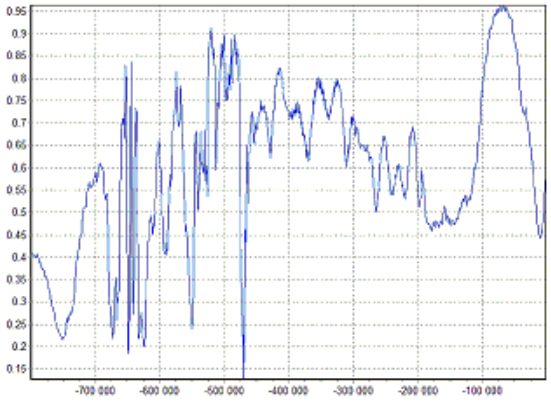

Figure 1: Eccentricity evolution for 410088 (2007 EJ) nominal orbit Panets+Ceres+Vesta perturbations

Preliminary results, shows that effect of encounters with Ceres and Vesta are negligible, in fact also the MOID confirms this, e.g. Vesta and 2007 EJ has a MOID of 0.17 au and 1999 RD108 and Vesta of 0.32 au. However Ceres might influence asteroids, for example the MOID with 1999 RD108 is only 0.09 au.

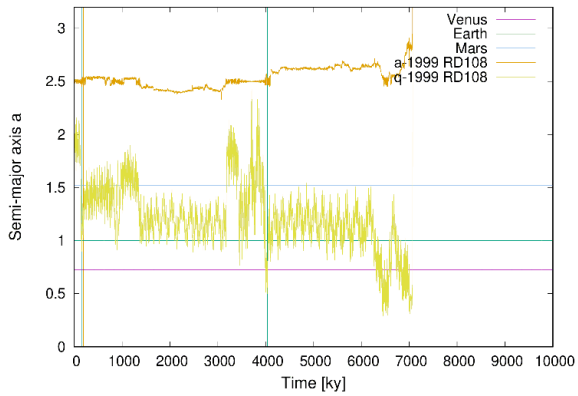

Figure 2: Orbit of 1999 RD108, semi-major axis and perihelion vs time. Vertical lines represent the first close encounters with each planet in the past

3. Summary and Conclusions

In result of backward numerical integrations we obtain very chaotic behaviour of asteroids close to 3:1J resonance. One reason is close encounters with Jupiter, Mars and Earth, but large asteroids in the very proximity of the relative asteroids can also perturbe slightly the orbits. On the other hand Radovic (2017) [5] showed that backward integration method is restricted by interval 18 Myrs for asteroid families. In case 3:1J resonance this interval is much less.

References

[1] Chambers, J. E.: A hybrid symplectic integrator that permits close encounters between massive bodies, MNRAS 304, 793-799, 1999

[2] Hanslmeier, A., Dvorak, R.: Numerical integration of dynamical systems with Lie series, A&A, 132, 203, 1984

[3] Migliorini, F. et al.: Vesta fragments from v6 and 3:1 resonances: Implications for V-type near-Earth asteroids and howardite, eucrite and diogenite meteorites, M&PS, 32, 903-916, 1997

[2] Moons, M., Morbidelli, A.: Secular resonance in mean motion commensurabilities: the 4/1, 3/1, 5/2, and 7/3 cases, Icarus., 114, 33- 50. 1995.

[3] Radovic V.: Limitations of backward integration method for asteroid family age estimation, MNRAS 471, 1321–1329, 2017

[1] Wisdom J. Chaotic Behavior and the Origin of the 3/1 Kirkwood Gap. Icarus 56, 51-74 (1983)