Iochroma asteroid family resonance perturbations

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Abstract

The dynamics of very young compact asteroid cluster associated with asteroid 39991 Iochroma is studied. It is shown that Iochroma family lie between two three body resonances 3A-3J-1M and 2A-5J-3S and perturbed by both of them. It is remarkable, that one part of the family is perturbed mostly 3A-3J-1M resonance when other part by 2A-5J-3S resonance. In this paper we approximated the orbital elements of all members of Iochroma family by harmonic oscillations with different frequencies.

Based on these approximations, we have determined the position of these resonances and boundary between them.

Additionally, we report about one new member of Iochroma family: (2016 UT3).

1 Introduction

The cluster associated with asteroid 39991 Iochroma (1998 HR37) was discovered by Pravec & Vokrouhlicky (2009) [1]. The cluster consists of 5 members with relative velocity smaller than 20 m/s. The four secondaries were discovered in 20052008. We have repeated search for new orbits in vicinity Iochroma cluster by the Lowell observatory catalogue on date 15 June 2021 and have found only one new member: 2016 UT3. The values of proper elements calculated by Knezevic & Milani [2] were given from AsDys site in Table 1. The values of Lyapunov Characteristic Exponents are significantly different between 1.87 and 32.03 Myrs. It notes that orbits of clusters have different stability by some reasons, maybe due to resonances.

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However, there is no detailed study of this group of minor planets up to present. Even the age of 39991 (1998 HR37) association long time had not be estimated. Only recently, Pravec et al in paper [3] give two estimations for the age of family 190^{+200}_{-100} kyrs and 140^{+130}_{-70} kyrs.

Here we report about our studying this cluster, including age estimation, important resonances search for and recent dynamical evolution.

2 Numeric integration and approximation

To study the dynamic evolution of asteroid families in this paper, the equations of the motion of the systems were numerically integrated orbits over 800 kyr using the N-body integrator Mercury and the Everhart integration method.

To the nominal resonance position calculation, we use values of semimajor axis of planets, averaged over time of integration: 1.52368 AU for Mars, 5.20259 AU for Jupiter, 9.5549 AU for Saturn always in this paper.

To study interaction considered pair with resonance and to determine position of resonance center (chaotic zone center) we apply integration of orbits of asteroid with significant values of Yarkovsky effect ($A_2 = 1 \times 10^{-13}$ and different gravitation perturbations.

In the present paper we suppose the following approximation expressions for the orbital elements by method [4]:

$$\begin{aligned} \Omega &= \Omega_0 + st + a_1 \cos s_1 t + b_1 \sin s_1 t + ... \\ \widehat{\omega} &= \widehat{\omega}_0 + gt + a_1 \cos g_1 t + b_1 \sin g_1 t + ... \end{aligned} \quad (1)$$

3 Results

In result we have obtained that Iochroma family is unique: it lies between two three-body mean motion resonances and perturbed both of them. The nearest 3-body resonance to the Iochroma family is: 3-3J-1M ($\delta = +0.00041$ AU from core of family) at 2.445415 AU (2.4454751 AU by Smirnov & Schevchenko [5]). When we use integration with only Jupiter and Mars perturbations and Yarkovsky effect we immediately

Table 1: Proper elements of Iochroma family (26.20.2020)

Asteroid	g,"/yr	s,"/yr	e	a, AU	LCE
39991 Iochroma	41.9146	-46.3827	0.159164	2.44472	3.52
340225 (2006 BR54)	41.9146	-46.3823	0.159154	2.44472	3.24
349730 (2008 YV80)	41.9174	-46.3845	0.159162	2.44476	1.87
428243 (2006 YE19)	41.9192	-46.3851	0.159156	2.44479	11.26
513212 (2005 UU94)	41.9462	-46.384	0.158685	2.44528	8.07

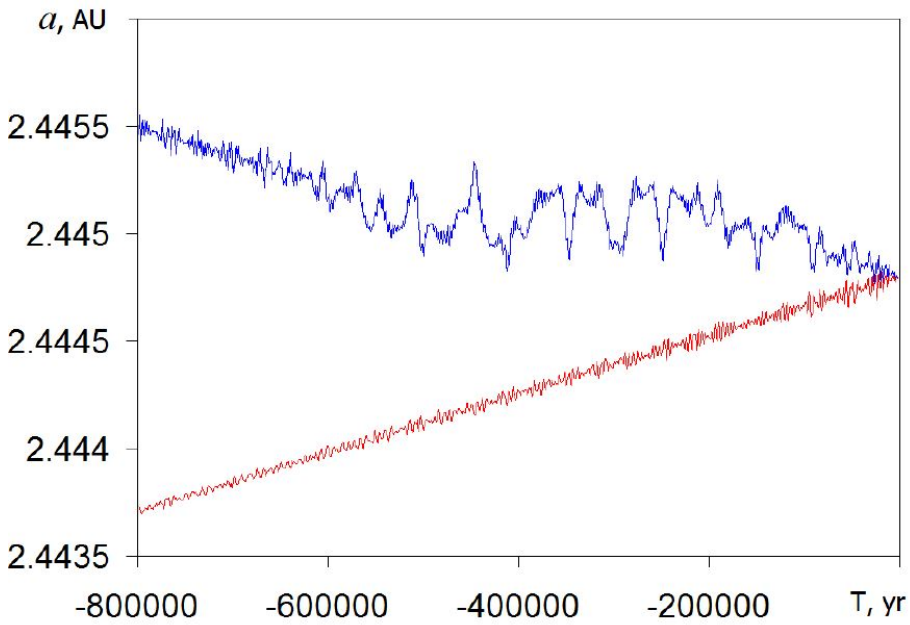

Figure 1: The semimajor axis evolution of 428243 (2006 YE19) with large Yarkovsky effect ($A_2 = 10^{13}$) Mars and Jupiter perturbations.

detect it. The chaotic zone center by numeric integration data is about 2.44502 AU (δ =+0.00039 AU from nominal position) for the 3-3J-1M resonance (Figure 1). The nearest (and most perturbed) to the resonance asteroids are (428243) 2006 YE19 and (513212) 2005 UU94. But when we use only Jupiter and Saturn perturbations and Yarkovsky effect, we detect perturbations with center about 2.44450 AU. Most probably, it is 2-5J-3S resonance with nominal position at 2.445661 AU (2.445333 AU by Smirnov & Schevchenko [5]) (δ=-0.00116 AU from nominal position).

However we note some shift of Jupiter-Saturn-asteroid resonance relative the nominal resonance position. Therefore we have the problem of the exact identification of this resonance and its interaction with 3J 1M -3A resonance and effect on Iochroma family dynamics.

Using our approximation (1) for eccentricity, we detect the resonance related perturbations and calculate the positions of the 3-3J-1M and 2-5J-3S resonances. The results are in the fine agreement with numerically detected position of resonances.

4 Conclusions

The dynamics of very young compact asteroid cluster associated with asteroid 39991 Iochroma is studied. It is shown that Iochroma family lie between two three body resonances 3A-3J-1M and 2A-5J-3S and perturbed by both of them. The interaction between close resonances can leads to their overlapping and as consequence, to arise of chaos.

References

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