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ANALYSIS OF ORBITAL ELEMENTS OF NEAR EARTH OBJECTS OVER A LONG-TERM PERIOD

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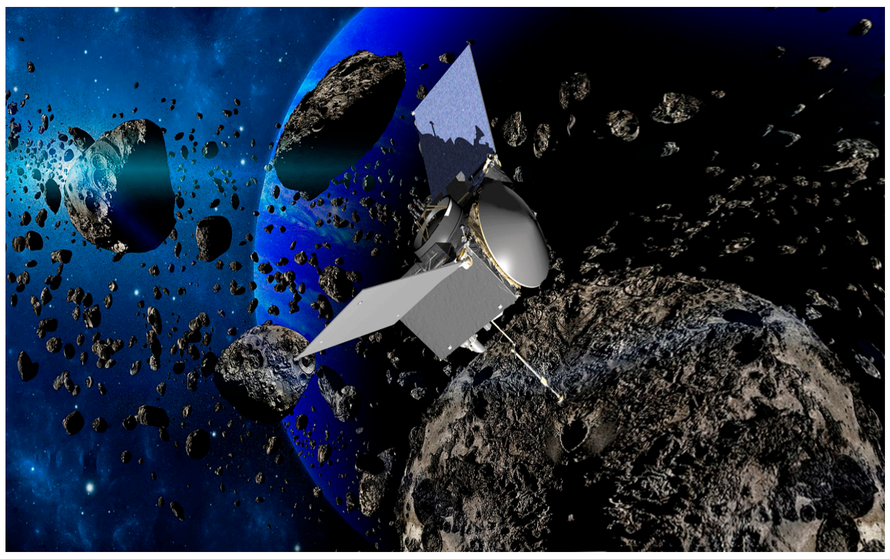

Introduction

The aim of this paper is to analyze the changes in orbital elements of near earth objects (NEO) over a long-term period and to identify them with the meteor shower Delta Cancrids (MSDC). We designated objects genetically related to MSDC as MSDCO. MSDC is a confirmed meteor shower with 2 branches. For MSDC there is no parental body found among comets, and the meteor shower's potential connections with the near earth objects (Amor, Atira, Apollo and Aten) are therefore being investigated. Using the Kholshevnikov metrics [1] and the Drummond D-criterion [2] as functions in the orbital phase space and the distance between orbits as well as Tisserand's parameter and quasidynamic parameters of the restricted three-body problem [3], nine Apollo NEO for NCC and nine Apollo NEO for SCC were revealed. The modern positions of the MSDC orbit nodes selected only for the southern branch (SCC) are coinciding within 2° with the position of the MSDC's maximum activity of 9.0±3 an hour for the MSDC with the minimum recorded magnitude of $+2{,}8^m$ or higher which is recorded at the ecliptic longitude of the Sun of $295.7^0 \pm 1.5^0$. In this paper, the orbits of meteoroids belonging to NCC and SCC branches (178 orbits) produced on the basis of television [4] and visual [5] observations were used to determine the activity profile for the MSDC.

Methods

The MSDCO have significantly elongated orbits with eccentricities close to 0.8, perihelia are within the Earth's orbit, aphelia are about 4 AU, the asteroids' sizes are up to 1 km. The values of Tisserand's parameter significantly differ: for some MSDCO it is 2.9, which relates its orbit to a cometary type; For others MSDCO it is 3.34 with its orbit corresponding to the asteroid type. To determine orbit elements at the given moment of time, HORIZONS integrator that takes into account perturbations from all the planets was used. The integration of orbits was carried out over a period of 1000 years starting from 1549 to 2551 (499 years backward and 499 years forward).

Results: The character of some MSDCO orbital evolution significantly differs. The secular variations of eccentricity, perihelion distance, and angular elements at some MSDCO are of periodic character. The full period of changes in angular elements is about 3000 years with the orbit node changing from 0^0 to 225^0, the inclination angle varies within 14^0 over the entire period. The dynamics of some MSDCO is influenced by Jupiter's orbital resonances resulting in fluctuations of the increase in eccentricity and perihelion distance (up to 0.009 AU) with a period of 3 Jupiter's ones. The changes in orbital elements of the some MSDCO demonstrate an unvarying character with short-period changes in eccentricity and perihelion distance but multidirectional and smaller oscillations amplitude. At a long-term period, the values of node longitude, inclination, and orbit eccentricity for some MSDCO decrease over time, while perihelion distance increases.

The calculations of the values of D-criterion [6] and metrics [7] for the elements of the MSDCO osculating orbits and the elements of mean orbit of SCC, NCC and DCA and over the period of 1000 years have shown that only for some MSDCO is there a monotone decrease in the value of D during the integration of the asteroid's orbit back in time.

Table 1 The meteor stream k Cygnids is genetically associated with asteroids have following orbital elements (see Table). These are: a - major semiaxis; q - perihelion distance; i – obliquity; Ω - longitude of the ascending node, ω - perihelion argument, T - rotation period, H - absolute stellar magnitude, D - equivalent diameter of the object, TT - taxonomic type. All parameters are given in J2000.0 equinox.

Asteroids	a, a.e	e	q, a.e	i°	Ω°	ω°	T, год	H	D, km	TT
For the meteor shower k Cygnids										
153311 (2001 MG1)	2,50	0,65	0.89	28,42	142,36	218,49	3,95	17,20	1,1 – 2,4[1]	-
385343 (2002 LV)	2,31	0,61	0,91	29,54	132,21	224,21	3,52	16,60	1,73	L,T; QX; S
For the meteor shower Delta Cancrids										
(2014 RS17)	1,94	0,77	0,44	1,63	322,13	274,37	2,7	23,20	0,069 – 0,154[1]	-
(2006 BF56)	2,34	0,79	0,47	0,96	125,25	102,61	3,58	29,60	0,003 – 0,008[1]	-

Conclusion

The retrograde analysis of the MSDCO orbit elements selected for a likely assessment of 0.6 for the southern branch (SCC) of the MSDC leads to a conclusion that only the orbital evolution of MSDCO demonstrates a possible connection with the meteor shower in the past [8, 9]. The results of the work will find their application when performing research of the genetic links of meteoroids [10], [11], [12].

Acknowledgements

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