DYNAMIC EVOLUTION OF THE ORBITS OF 2001YB5 AND (356394) 2010QD2 ASTEROIDS

M. V. Sergienko, M. G. Sokolova, A. O. Andreev, Y. A. Nefedyev
Kazan Federal University, Kazan, Russia

KAZAN FEDERAL UNIVERSITY

Introduction

The aim of this paper is to analyze the changes in orbital elements of 2001YB5 and 2010QD2 asteroids over a long-term period and to identify them with the Delta Cancrids (DCA) meteor shower. DCA is a confirmed meteor shower with 2 branches – northern (NCC) and southern (SCC) ones observed between January, 1 and January, 31. For DCA there is no parental body found among comets, and the meteor shower's potential connections with the asteroids crossing the Earth's orbit (Atira, Aten, Apollo, and Amor) are therefore being investigated. Using the D-criterion by J.D. Drummond [1] and the metrics by K.V. Kholshevnikov [2] as functions of the distance between 2 orbits in the orbital phase space as well as Tisserand's parameter and 2 quasidynamic parameters of the restricted three-body problem [3], 9 Apollo asteroids for NCC and 9 Apollo asteroids for SCC were revealed. The modern positions of the asteroids' 2001YB5 and 2010QD2 orbit nodes selected only for the southern branch (SCC) are coinciding within 2° with the position of the shower's maximum activity of 8.6±2 an hour for the meteors with the minimum recorded magnitude of $+3^m$ or higher which is recorded at the ecliptic longitude of the Sun of 298.5°±1.2°. The purpose of the work is therefore to analyze the orbital elements of 2001YB5 and 2010QD2 asteroids over a long-term period. 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 Delta Cancrids.

Methods

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 1550 to 2550 (500 years backward and 500 years forward).

Results

The character of the asteroids' 2001YB5 and 2010QD2 orbital evolution significantly differs. The secular variations of eccentricity, perihelion distance, and angular elements at 2001YB5 are of periodic character. The full period of changes in angular elements is about 3000 years with the orbit node changing from 0° to 224°, the inclination angle varies within 14° over the entire period. The dynamics of 2001YB5 is influenced by Jupiter's orbital resonances resulting in fluctuations of the increase in eccentricity and perihelion distance (up to 0.01 AU) with a period of 3 Jupiter's ones. Unlike 2001YB5, the changes in orbital elements of the asteroid 2010QD2 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 2010QD2 decrease over time, while perihelion distance increases. The asteroids 2001YB5 and 2010QD2 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 2001YB5 it is 2.89, which relates its orbit to a cometary type; for 2010QD2 it is 3.34 with its orbit corresponding to the asteroid type. The calculations of the values of D-criterion [2] and metrics [3] for the elements of the asteroids' 2001YB5 and 2010QD2 osculating orbits and the elements of mean orbit of DCA, NCC, and SCC over the period of 1000 years have shown that only for 2010QD2 is there a monotone decrease in the value of D during the integration of the asteroid's orbit back in time.
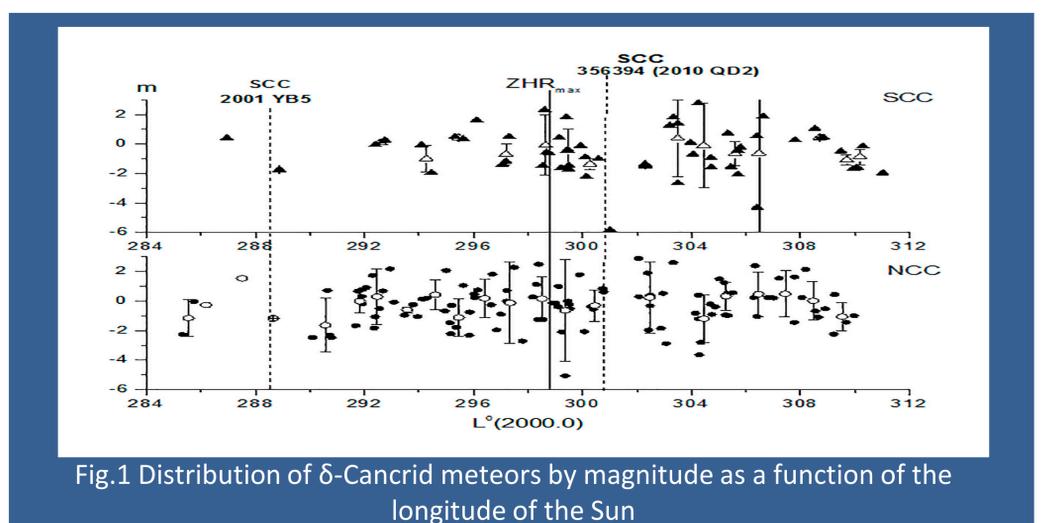

Fig.1 Distribution of δ-Cancrid meteors by magnitude as a function of the longitude of the Sun

Conclusion

The retrograde analysis of the asteroids' 2001YB5 and 2010QD2 orbit elements selected with the probability of 0.6 for the southern branch (SCC) of the Delta Cancrids leads to a conclusion that only the orbital evolution of 2010QD2 demonstrates a possible connection with the meteor shower in the past [6, 7]. The results of the work will find their application when performing research of the genetic links of meteoroids [8], [9], [10].

Acknowledgements

[1] Drummond J. D. (1981) *Icarus* 45: 545-553. [2] Kholshevnikov K.V., et al. (2016) *MNRA* 462/2: 2275–2283. [3] Kramer, E. N. and Shestaka, I. S. (1987) *Sol. Syst. Res.* 21/1: 75–83. [4] The SonotaCo network (SoNotaco) http://sonotaco.jp/doc/SNM/index.html); Croatian Meteor Network (CMN), http://cmn.rgn.hr/downloads/downloads.html#orbitcat). [5] MMO (IMO, http://www.imo.net/data/visual). [6] Sokolova M.G., et al. (2018) *Advances in Space Research* 62/8: 2355-2363. [7] Sokolova M., et al. (2016) *Advances in Space Research* 58/4: 541-544. [8] Nefedyev Y. A. (2018) *Meteoritics & Planetary Science* 53/S1: 6188. [9] Andreev, A. O., (2018) *Meteoritics & Planetary Science* 53/S1: 6157. [10] Nefedyev Y. A. (2018) *Meteoritics & Planetary Science* 53/S1: 6192.