THE KAPPA CYGNIDS METEOROID SHOWER AND ITS CONNECTION WITH NEAR-EARTH ASTEROIDS

M. V. Sergienko[1], M. G. Sokolova[1], A. O. Andreev[1], Y. A. Nefedyev[1],
[1]Kazan Federal University, Russia, Kazan, Kremlyovskaya st., 18. E-mail: maria_sergienko@mail.ru

Introduction: The purpose of the research is to study the Kappa Cygnids meteoroid shower's connections with various groups of asteroids crossing the Earth's orbit on the basis of the meteor shower's structure observed and the complex approach of assessing the distance between the orbits of the 2 celestial bodies. The Kappa Cygnids meteor shower (KCG) is observed from 3 to 25 August and relates to showers with low activity. The size of its mean orbit is 3.2 AU, geocentric velocity is 24 km/s. There is no parent body (PB) found for the meteor shower among comets. The meteor shower's connections with asteroids, as probable PB of the shower, are being actively studied; some of them are listed on the IAU MDC website.

Methods: To study the structural features of the Kappa Cygnids meteor shower the long-term statistically supported set of visual observations of meteors by The International Meteor Organization (http://www.imo.net/data/visual) and television observations taken by the Mini-Mega TORTORA (MMT) of Kazan Federal University (Russia) between 2013 and 2016 are used. The source database for the search for the PB consisted of 17800 orbits (http://ssd.jpl.nasa.gov/sbdb_query.cgi). The television orbit catalogues by Japan Meteor Network (http://sonotaco.jp/doc/SNM/index.htm) and Croatian Meteor Network CMN (http://cmn.rgn.hr/downloads/downloads.html#orbitcat) as well as photographic one by IAU MDC (containing 700 orbits of Kappa Cygnids meteors were used. The study of connections between the shower and asteroids from the Apollo, Aten, Amor, and Atira groups was carried out using D-criterion by J.D. Drummond [1] and metrics by K.V. Kholshevnikov [2] as functions of the distance between orbits as well as Tisserand's parameter and 2 parameters (dynamic criteria) of the restricted three-body problem [3]. The critical upper values of D-criterion and the dynamic parameters, under which a hypothesis of the orbits' identity was accepted or declined, were determined by calculating mean orbits of the shower in each catalogue, taking into account their variance and catalogues' observation errors. The probability of the orbits proximity was defined as the full probability of the occurrence of joint events with a given level of significance.

Results: The investigation of Kappa Cygnids structure was performed with the method described in [4]. Using the visual observations of the number and magnitude of the meteors higher than $+3^m$ for the period between 1996 and 2011 it has been found that the increased shower activity is observed from August, 13 and remains at the level of 11 to 14 meteors an hour until August, 19 (the interval of the ecliptic longitude of the Sun is 140°–146°). The highest ratio of large components to small ones is recorded at 142.8° longitude of the Sun. This suggests that a potential parental body for Kappa Cygnids during the formation of the shower might have had an orbit with node longitude of about 142.8°. For the meteors' magnitude range observed between -5^m and $+3^m$ there is a decrease in semi-major axes of 0.8 AU and in eccentricities of 0.04 for the orbits of Kappa Cygnids depending on the meteors' magnitude. When searching for the parental body of Kappa Cygnids among the Apollo group, there are 2 asteroids 2001MG1 and 2002LV marked out with the probability of 0.7. Besides, there are the asteroids from the Amor group 2002GJ8, 2010QA5, and 2012QH49 marked out with the probability of 0.6. In the Aten and Atira groups the probability of identifying asteroids with the orbits of Kappa Cygnids does not exceed 0.2.

Discussion: The asteroids from the Apollo group 2001MG1 and 2002LV are also mentioned by other authors as potentially related to Kappa Cygnids. The asteroids 2004LA12 2008ED69 having the probability of 0.4 are considered as well. As for the asteroids of the Amor group, there are no connections with Kappa Cygnids found. It should be noted that 2002GJ8, 2010QA5, and 2012QH49 from the Amor group have the Tisserand's parameter in relation to Jupiter of 2.6, 2.7, 2.8 respectively, which relates them to the objects of cometary type.

Conclusions: Although the Kappa Cygnids is well studied (unlike other small meteor showers), its parental body is still unidentified. The development of an unbiased method for selection of asteroids with close orbits is of particular importance. The studies of the structure of meteor showers with unknown parental bodies provides additional criteria to clarify the question of their origins [5].

Acknowledgements: The work is performed according to the Russian Government Program of Competitive Growth of Kazan Federal University, was supported by scholarship of the President of the RF CP-3225.2018.3; by the RFBR grant nos. 18-32-00895 mol_a, and by the Foundation for the Advancement of Theoretical Physics and Mathematics "BASIS".

References: [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. (1987) *Astronomical Vestnik* 21/1: 75–83. [4] Sokolova M., et al. (2016) *Advances in Space Research* 58/4: 541-544. [5] Sokolova M.G., et al. (2018) *Advances in Space Research* 62/8: 2355-2363.