Near Earth asteroids families

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Ten years ago, tt seemed that meteoroids and the NEAs formed two well separated classes of objects. Today we have another view on this issue because it is no longer true that the objects producing bright meteors (bolides) can be observed only during their flights through the atmosphere. E.g. in January 2014, small asteroid was observed be telescope. It collided with Earth about 20 hours later over Atlantic Ocean. Such events mean that today the same object can be named by meteoroid or asteroid according to the context.
Now one can ask - is it possible that among the NEAs exist the groups of objects (families) alike to the meteoroid streams? This is important question, because if such NEA families exist, it mens that the NEA hazard for Earth is higher then we suppose presently.

We know very well that NEA can be very danger for Earth. Quite recently, in February 2013, unnoticed 20 mete size object entered Earth atmosphere producing powerful air blast which damaged many buildings in one million town Chelyabinsk; as result 1500 people needed medical care.
If this object was a member of the unknown family, this means that all family members move around the Sun on very similar orbits. Hence, each year in February an object of similar size can hit the Earth. Just alike to the meteoroid streams: the Perseids in August, the Geminids in December, which we observ annually.

Fortunately, probability that Earth will collide with a single few tenth meter size NEA is very small, of the order 10^{-5}—10^{-6}. However if the NEA belongs to the family of similar sizes objects, the probability that some of them hit the Earth is five time higher.
Today, reliable estimation of the threat of Earth by the several dozen meter NEAs is not possible. To find this number several programs are dedicated only to NEAs discoveries, e.g.: Catalina Sky Survey … Pan-STARRS 1. However, the observations only, are not sufficient to estimate the NEA threat in full. It is necessary to analyze observations. Our project excellently meets the Earth threat problem, since to estimate it reliably we have to know if the NEAs families exist or not.

In our project we will search for groups among ~14400 near Earth asteroids. We will make use of the methods elaborated for the meteoroid streams searching. They are based on the so called D-criteria enabling to estimate the dynamical similarity among two bodies. The D-function is a measure of the distance between two orbits. If such distance is smaller than an appropriate threshold value D_k one can assume a hypothesis about the common origin of such pair. D-function plus the similarity threshold value D_k and the cluster analysis algorithm enable searching for more numerous groups. Indeed, in our project these three components constitute a definition of the NEA family. We will make a use of several D-functions, some of them already used earlies but also we will test two new functions never applied for asteroids.

The thresholds values D_k we will determine by two statistical method. Using correct threshold, a risk that given group was identified by chance will be smaller than 1/100. For each group we will check if the orbital similarity between them was maintained for ~5000 in the past.
Also we will apply a few cluster analysis algorithms. We will test the properties of all of them. To this purpose as well as to find the orbital similarity thresholds D_k we will have to search for groupings among many sets of artificial orbits. These orbits should be free from groups originated from the same body, and they have to have similar statistical properties as the observed orbits.

To propose this project we were motivated by our earlier studies (Jopek 2011, 2015). Namely searching among ~9000 NEAs orbits we have found ~10 associations consisting of several dozen to several tenth asteroids. The method we have applied was simplified in comparison with the approach proposed in the present project. The orbital plots of the detected groups proved to be remarkably similar to the orbital plots of the meteoroid streams. Such similarity confirmed our belief that the NEA families exist and it strongly motivate us for more exhaustive study.

Jopek T.J., 2011, Mem. Soc. Astr. It. 82, 310-321
Jopek T.J., 2015, Highlights of Astronomy, XXVIIIth IAU GA Beijing 2012, Vol. 16, 474
Southworth R.B., Hawkins G.S., 1963, Smith. Cont. Aph, 7, 261