# GROUPS OF METEORITE-DROPPING FIREBALLS IN NEAR-EARTH ASTEROIDAL ORBITS

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**Introduction:** In the current abstract we focus in a explores the possibility of the existence of sporadic fireball groups associated with nine known meteorites: Lost City, Innisfree, Villalbeto de la Peña, Almahata Sitta, Jesenice, Grimsby, Križevci, Novato, St-Robert, for which atmospheric and orbital parameters have been obtained from instrumental observations.The IAU MDC-2007 [1] and SonotaCo [2] databases, as well as other published sources, have been used for searching plausible members of these groups, such as meteorite-dropping fireballs, which presumably include some fireballs that survived crashing through Earth's atmosphere and struck the surface as meteorites.

**Methods:** The applied technique of selecting bright meteors and meteorite-dropping fireballs as potential members of aspecific group was based on comparison of their individual orbital elements against a known meteorite's reference orbit recognized as asteroidal according to the Tisserand parameter, $T_J > 3.1$. Three criteria of orbital dissimilarity (D-criteria), namely the Southworth-Hawkins criterion $D_{SH}$ [3] and its refinements by Drummond criterion $D_D$ [4] and Jopek criterion $D_H$ [5], were used to make assumption about an associated group of related bodies. The search has detected nine identified groups that contain meteorite-dropping fireballs associated with nine known meteorites observed at the same coordinates of the radiants over a time span of 1 ÷ 1.5 months.

The orbital clusters among the near-Earth asteroids were found Jopek [6] using a single linkage cluster analysis algorithm and three orbital similarity D-functions. The existence associations of groups of meteorite-dropping meteoroids with near-Earth asteroids (NEAs) is a topical issue with regard to the problem of detecting dynamic and perhaps even genetic relationship between NEAs and groups of meteorite-dropping fireballs with near-Earth asteroidal orbits. Small asteroids from such clusters can be the potencial parent bodies of meteorite-dropping fireballs invading the Earth's atmosphere. In view of this, we have extensively searched in NEO DyS-2 catalogue [7] among ~20,000 orbits of NEAs for those similar to the orbits of nine known meteorites under study. The employed method of selecting NEAs as members of a specific group, as is to meteoroids, was based on the comparison of orbital elements of asteroids against those of the meteorites applying three orbital dissimilarity D-criteria; the following threshold values have been set for the D-criteria: the Southworth-Hawkins criterion $D_{SH} <= 0.1$, the Jopek criterion $D_H <= 0.1$, and the Drummond criterion $D_D <= 0.05$. The selection into specific meteorite groups yielded a great number of NEAs, which was then reduced significantly, having analysed available information about the Minimum Orbit Intersection Distance (MOID) of asteroids with the Earth's orbit and chosen only those with an MOID <= 0.01 au. Such asteroids, according to NASA's definition, are considered potentially hazardous asteroids (PHAs). The NEAs associated with the found groups must be purposefully observed in order to control the date of close approaches to the Earth.

**Conclusions:** Currently, the found groups may include large meteorite-dropping meteoroids, which is a primary motivation for systematic monitoring the sky during relevant periods of enhanced fireball activity. Such monitoring is also essential for detecting NEAs as parent bodies or NEAs only with orbital similarity to meteorite-dropping fireballs in near-Earth orbits. Such groups of meteorite-dropping fireballs and associated NEAs, irrespective of their origin, are potentially hazardous to Earth's biosphere; therefore, nowadays, the search for groups of sporadic meteorite-dropping fireballs is a crucial and urgent task indeed.

**References:** [1] www.astro.sk/~ne/IAUMDC/Ph2003/database.html. [2] http://sonotaco.jp/doc/SNM/index.html. [3] Southworth R.B. and Hawkins G.S. (1963) *Smiths. Contrib. Astrophys.* 7: 261-285. [4] Drummond, J.D. (1981) *Icarus* 45: 545-553. [5], Jopek T.J. (1993b) *Icarus* 106: 603. [6] Jopek T.J. (2020) *MNRAS* 494: 680-693. [7] https://newton.spacedys.com/neodys/index.php?pc = 5