THE ANNUAL ACTIVITY OF METEORITES, SPORADIC METEORITE-DROPPING BOLIDES AND ITS GROUPS. N. A. Konovalova. Institute of Astrophysics of the Academy of Sciences of the Republic of Tajikistan, Bukhoro, str. 22, Dushanbe 734042, Tajikistan. (nakonovalova@mail.ru).

Introduction: The existence of groups of meteoroids that contain meteorite-dropping bodies has been investigated in [1] based on the analysis of the precise orbits of fireballs performed by the Canadian project (MORP). Observational evidence confirms the existence of "rubble pile" asteroids, such as Itokawa and NEA 1950 DA, that could be the result of collisions between asteroids of the main belt. Gravitational perturbations from Jupiter and other planets of the solar system lead to disintegration of the asteroid into many fragments of different range: from decameter to meter or less, which under the influence of evolutionary processes pass into orbits that intersects with the path of Earth [2]. The resulting fragments form a group of asteroid fragments, including the meteorite-dropping ones, that have the identical heliocentric orbits [3]. These fragments later gradually move into the orbits that intersect with the path of Earth due to the resonance effect, especially with Jupiter. A famous origin of meteorites produced by a devastating collision is asteroid Vesta, which has a large crater due to the due to the impact of other body that had ejected large fragments of Vesta – the vestoids. Some of these fragments upon encountering the Earth fell as meteorites and are present in terrestrial collections.

In the recent years, research has been published on the annual activity of fireball groups that can contain meteorite-dropping meteoroids, including both large potentially dangerous asteroid fragments and smaller meteoroids [4,5]. This has become especially relevant due to the Chelyabinsk meteorite, which has changed the earlier assumptions about the lower limit of the size of potentially dangerous asteroids (PDA) that cross the Earth's orbit. Before, the incidents of meteorites falling on Earth were believed to be random in time, and thus should be considered as unrelated events consistent with the Poisson distribution. In that case, the dates of meteorite falls would be distributed evenly throughout the year.

Analysis of the observational data: In order to identify the periods of activity for bright and meteorite-dropping sporadic fireballs and meteorites we analyzed the annual activity profile of such bodies. The several hundreds bright (brighter than the magnitude of -5) sporadic fireballs observed by fireball networks and meteor observing stations from 1942 to 2015 were selected from the international meteor database IAU MDC_2003 [6] and sources published in the past 15 years, including scientific journals and international conference publications. Information on known meteorites was obtained from the Meteoritical Bulletin Database [7], which contains 338 meteorites with the known fall dates. The selected candidates for meteorite-dropping bodies had terminal height $H_e \leq 35$ km, the initial velocity $V_\infty \leq 25$ km/sec, and terminal velocity $V_e \leq 10$ km/sec. On the basis of the orbital element data, the investigated fireballs were separated into cometary and asteroidal by using Tisserand parameter T_J. For cometary orbits Tisserand parameter $T_J \leq 3$, and for asteroidal orbits $T_J > 3$.

The annual distribution of N1 number of bright sporadic meteorite-dropping fireballs and N2 number of meteorites with known fall dates, including the meteorites with atmospheric trajectories and orbits known from instrumental observations versus the solar longitude L was produced. Fig. show annual activity profile of meteorite-dropping sporadic fireballs of asteroidal and cometary origin (top) and annual activity profile of meteorites (bottom) with known fall dates.

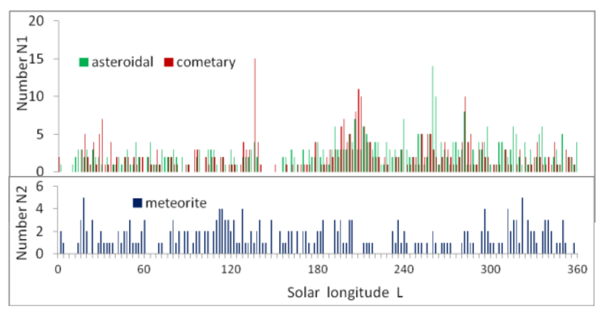

Figure. Annual activity profiles of meteorite-dropping sporadic bolides (top) and meteorites (bottom).

Results and discussion: The resulting profile of the annual activity of meteorite-dropping sporadic bolides and meteorites with known fall dates shows several periods of increased activity in the course of the year. Thus, it can be argued that invasions of the Earth's atmosphere by decameter-range and smaller sporadic meteoroids are not random.

A detailed study of meteoroids—small bodies of the solar system—provides important information about their parent bodies: comets and asteroids. Observations made by fireball networks of bright meteorite-dropping fireballs penetrating Earth's atmosphere allow obtaining more accurate data on atmospheric trajectories of fireballs and the coordinates of meteorite falls.

Along with large meteoroids, meteorite-dropping groups can contain the meteoroids of small mass that generate meteors with magnitude less than -5. That allows to determine their physical properties using various ablation models. The observational data on the atmospheric trajectories, velocities and luminosity of meteors obtained by instrumental methods are used for this purpose. This abstract analyzes the physical properties of three sporadic meteorite-dropping fireballs 062D3, 058D8 and 230708 which were observed in Tajikistan on different years during of july-august and october-november periods of increased activity of the meteorites and bolides [8].

The terminal mass m_e of the studied fireballs was calculated and suggests that meteoroids was survived in the Earth atmosphere and can be meteorites [9,10]. One of the important physical properties of the meteoroid is structural strength, which counteracts the destructive aerodynamic pressure P_{dyn} of the incoming atmospheric flow during the flight. Disintegration of the meteoroid, accompanied by a bright flash, occurs when the pressure overload becomes greater than the structural strength of the meteoroid. The critical aerodynamic pressure at which meteoroid disintegrates is calculated and was estimated bulk density ρ_m of the studied meteoroids, using the dependence of the bulk density on the critical pressure, as shown in figure 1 in [11].

Near-Earth Objects [12] were investigated in search for the parent bodies of the three studied meteorite-dropping fireballs. Based on the orbit proximity as determined by D_{SH}-criterion of Southworth and Hawkins [13], bodies with D_{SH} <0.2 could be the source of meteorite-dropping fireballs. In order to find a likely members of possible groups that can contain meteorite-dropping bodies the set of 737 sporadic bolides were investigated. Fireballs with D_{SH} <0.2 could be the members of group of meteorite-dropping fireballs with the orbits being similar at the present time. Also following criteria have been adopted to define what might be considered a group of related meteoroids: the mean date of appearance; mean values for v_∞ and the radiant position. The results are presented in Table, which contains the following information: object number, semi-major axis a (AU); eccentricity e; orbital inclination i (°); perihelion distance q (AU); argument of perihelion ω (°); and longitude of the ascending node Ω (°).

References:

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No	q a.u.	e	i (°)	ω (°)	Ω (°)	D_{SH}
Group I	0.990	0.590	1.0	185.0	241.0	mean
062D3	0.984	0.583	0.2	15.3	36.7	0.14
190F1	0.988	0.591	0.3	180.9	239.3	0.06
406PN	0.990	0.600	2.0	179.0	242.0	0.06
160E1	0.959	0.675	2.3	204.5	207.5	0.18
289F1	0.987	0.604	1.5	178.4	242.8	0.05
169I1	0.980	0.576	1.1	191.5	243.4	0.09
291103	0.986	0.543	1.0.	3.4	67.2	0.08
SL189	1.022	0.566	1.4	63.0	347.9	0.16
VB	1.044	0.618	1.3	107.9	305.3	0.15
Group II						
058D8	0.791	0.258	17.9	270.7	133.6	–
154F1	0.945	0.289	12.5	224.4	154.6	0.12
CV8	0.841	0.352	15.3	279.3	132.0	0.10
DF4	0.767	0.371	18.5	260.2	146.7	0.12
Group III						
230708	1.015	0.523	9.6	173.5	121.0	–
181E1	0.995	0.501	8.6	199.8	79.2	0.18
263F1	1.011	0.461	15.6	169.9	123.5	0.12
008O4	1.012	0.462	10.0	189.7	101.1	0.09
054I1	1.013	0.498	6.4	187.5	90.4	0.17
SL19	1.036	0.515	7.4	182.4	116.2	0.05
QA2	1.028	0.516	8.4	159.4	132.8	0.06
VE82	0.963	0.544	9.94	186.4	110.5	0.06

Table. Data for the three groups of fireballs and NEOs with the similarity of orbits.