Precise multi-instrument data on exceptional fireballs recorded over Central Europe in the period 2012-2014

P. Spurny[1] and J. Borovicka[1]

[1]Astronomical Institute of the Academy of Sciences, Czech Republic

Introduction: Instrumental recordings of fireballs provide an excellent means of examining the physical and structural properties of larger meteoroids, as well as their temporal and spatial distribution in the Solar System. Except direct information about this component of interplanetary bodies this study also yields very valuable knowledge about their parent bodies, asteroids and comets. In some special and very rare cases, when such instrumentally observed fireball terminates by a meteorite fall, we have even direct information about the composition, structure and mineralogy not only of this particular meteorite but also of its parent body. The most efficient systems for systematic fireball observations are so-called fireball networks. In this work we present precise and complex data on several exceptional fireballs based on photographic and photoelectric records taken by the Czech Fireball Network, which is the longest continuously operated and the most developed part of the European Fireball Network (EN).

Instruments and data processing: The Czech part of the EN has been entirely modernized in the last decade and its operation was in the large extent automatized [1]. This change significantly increased not only efficiency but also quality and complexity of our observations. However, this observing system, which provides us with photographic and photoelectric data about fireballs brighter than -4 magnitude, still uses photographic films, which brings some limitations for the data processing. Primarily it implies a non-negligible delay between data acquisition and their analysis as we had to transport photographic films physically from remote stations and only then to develop and digitize them. There is also much lower efficiency of observations during the full Moon period than during moonless nights. Taking the advantage of fast progress of digital photography, we have constructed a new generation of the Digital Autonomous Fireball Observatory (DAFO), which provides us with high-resolution digital images available immediately after their recording. This observatory, developed during the last 2 years, sorted out all the above-mentioned disadvantages. These sophisticated digital cameras are currently being deployed on the stations of the Czech Fireball Network. In this work, we present the first data from this new observing system and the comparison with the previous one. Along with this significant modernization we also improved our software for positional and photometric measurement of photographic records, which partly automatizes this time consuming work and make it much more efficient, easier, and even more precise. This observing system based on the DAFO's, provides us not only with the similarly precise dataset of fireballs as the previous large format film system but thanks to the different observing strategy and higher sensitivity limit, significantly increased effective observing time and number of recorded fireballs. Average absolute positional accuracy for the recorded fireballs stayed similar for both systems and it is about 15 m for each point on a fireball luminous trajectory.

Results: To demonstrate this fact, we present complete and precise data on atmospheric trajectories, orbits, lightcurves and dynamics for several fireballs, which are in some sense exceptional and which were recorded by both systems in the last two years. This sample contains, among others the cases which very probably terminate by the fall of a small meteorite, the cases with interesting internal structure and orbital characteristics and also the cases with interesting orbits with respect to their structural properties (i.e. cometary material on a typical asteroidal orbit and vice versa). As the examples of uniqueness of our data we can mention recording of the deep penetrating Geminid fireball (EN141212) which certainly terminated by the fall of a small, only tens of grams meteorite. This unique case with very precise trajectory, dynamic and orbital data (one of the most precise Geminid ever observed) proved that in some special cases even meteoroids with a high initial velocity of 36 km/s can produce a meteorite and that there is real possibility that we could find a piece of Phaethon, the parent of Geminids. Another example is the fireball designated EN130114 which was recorded only by our new digital cameras (it was during the full Moon period). The main exceptionality of this case consists in its lowest ever observed initial velocity which we recorded for natural interplanetary body. Its initial speed of only 11.090 km/s means among others that this meteoroid orbited Sun on a very Earth-like orbit. All presented fireballs well document the high standard of our observations and their usefulness for better knowledge of properties of meteoroids and their parents as well as their distribution in the Solar System.

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References: [1] Spurný P. et al., (2007) in Proc. IAU Symp. 236, 121–130.