Fireballs and meteorite falls

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The observations of fireballs, with or without an associated meteorite fall, provide information about the orbital distribution, physical properties, and, when accompanied with spectral observation, composition of fragments of asteroids and comets (so called meteoroids) intersecting the Earth's orbit. They are therefore a complementary tool to the astronomical and in situ studies of asteroids and comets. This invited talk will provide an overview of what is known about meteoroids and their parents from analysis of bolides producing meteorite falls, especially from instrumentally observed meteorite falls. They are the events with the most complete information available based on analysis of both the bolide and the corresponding meteorite. At present reliable atmospheric and orbital information for meteorite falls is known for only about 25-30 cases. This is a tiny fraction of the tens of thousands of meteorites which are known. For this reason, every new fireball producing meteorite with precise atmospheric and orbital data gives us very valuable information not only about each particular event but also about its parent body. From the list of these cases can be seen that meteorites were observed to fall from meteoroids of a wide range of masses, causing fireballs different by orders of magnitude in terms of energy and brightness [1], [2]. At the lower end, there are meteoroids of initial masses of only a few dozens of kg causing fireballs of absolute magnitude of about –10 or even slightly less. On the other hand some meteorite falls were produced by large (>meter-sized) meteoroids associated with super-bolide events which occur globally approximately every two weeks [3] and only very rarely are reliably documented. In these instances when good dynamic and photometric data are available we can obtain insight into the internal structure of the pre-atmospheric meteoroid, for comparison with the physical structure of asteroids as determined from other kind of observations.
Some exceptional cases will be mentioned in more detail in this talk. I will focus mainly on the recent cases which were observed in Central Europe and which were recorded and analyzed by our team from the Astronomical Institute of the Czech Academy of Sciences. Some of them are either not published at all or only partially.

Fig 1 Part of the all-sky image of the Žďár bolide taken by the digital autonomous camera from the Czech station Polom.

Here I will mention two most important cases. First of them is the -15 maximum absolute magnitude bolide connected with a multiple meteorite fall named Žďár nad Sázavou [2]. It was recorded by 10 fully automatic fireball cameras of the Czech part of the European fireball network (EN) over the Czech Republic on 9 December 2014 (Fig 1). Thanks to immediate availability of digital images very precise data on atmospheric trajectory, heliocentric orbit, luminosity, dynamics, fragmentation history and probable impact area were quickly determined. Altogether three meteorites weighing 6, 39 and 42 g were found during dedicated searches and all were recovered exactly in the predicted location for given mass. These meteorites were classified as the L3.9 ordinary chondrite, which means, that it is a very primitive material. Žďár is then the lowest metamorphosed L chondrite among all known instrumentally documented falls and thanks to the high quality and large number of available instrumental records this case belongs to the best ever described meteorite falls.

Second very recent case was also very bright bolide which reached -15.5 absolute magnitude and illuminated extended areas of Austria, Bavaria, and southwestern Bohemia on 6 March 2016. It was again recorded by automatic digital all-sky fireball cameras at six stations of the Czech part of the EN (Fig 2). Although the fireball was outside Czech territory and relatively distant from the cameras (125 – 320 km), the photographic records and the precise light curve from photometers, which are also parts of the cameras, made possible to determine all parameters of the atmospheric passage with very good precision. In addition, a digital photographic spectrum of the fireball was obtained at the Kunžak station in southern Bohemia. Only one recorded meteorite fall has a more detailed spectrum – the Benešov meteorite fall of May 7, 1991 [4]. Until now, 4 meteorites were recovered exactly in the predicted area for a given mass. The unofficial name of the meteorite is Stubenberg (Germany).

Fig 2 Part of the all-sky image of the bolide Stubenberg taken by the digital camera from the Czech station Kocelovice

References

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