Orbit determination based on meteor observations using numerical integration of equations of motion

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We review the definitions and approaches to orbital-characteristics analysis applied to photographic or video ground-based observations of meteors. A number of camera networks dedicated to meteors registration were established all over the word, including USA, Canada, Central Europe, Australia, Spain, Finland and Poland. Many of these networks are currently operational. The meteor observations are conducted from different locations hosting the network stations. Each station is equipped with at least one camera for continuous monitoring of the firmament (except possible weather restrictions). For registered multi-station meteors, it is possible to accurately determine the direction and absolute value for the meteor velocity and thus obtain the topocentric radiant. Based on topocentric radiant one further determines the heliocentric meteor orbit. We aim to reduce total uncertainty in our orbit-determination technique, keeping it even less than the accuracy of observations. The additional corrections for the zenith attraction are widely in use and are implemented, for example, here [1].

We propose a technique for meteor-orbit determination with higher accuracy. We transform the topocentric radiant in inertial (J2000) coordinate system using the model recommended by IAU [2]. The main difference if compared to the existing orbit-determination techniques is integration of ordinary differential equations of motion instead of addition correction in visible velocity for zenith attraction. The attraction of the central body (the Sun), the perturbations by Earth, Moon and other planets of the Solar System, the Earth's flattening (important in the initial moment of integration, i.e. at the moment when a meteoroid enters the atmosphere), atmospheric drag may be optionally included in the equations. In addition, reverse integration of the same equations can be performed to analyze orbital evolution preceding to meteoroid's collision with Earth. To demonstrate the developed technique, we provide calculated orbits for several cases, including well-known meteorite-producing fireballs. A comparison of our estimates with previously published ones is also provided.

References: [1] Langbroek, M. A spreadsheet that calculates meteor orbits // WGN, Journal of the International Meteor Organization, vol. 32, no. 4, pp. 109–110, 2004. [2] International Astronomical Union Division A: Fundamental Astronomy "Standards of Fundamental Astronomy Board", Release 10, 31 October, 2013.