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Simulation of the origin of wide meteoroid showers as result of the parent comet disaster by the Earth gravitation (on the Perseids example)

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Abstract

The main meteor showers are believed to be connected to comets as their parent bodies. Some of the showers cannot be referred to any parent bodies. It may be explained by simple idea that really existed parent comets are totally disintegrated and do not exist now. It was shown that primitive evaporation of volatiles from comet nucleus by solar radiation can push away heavy refractory particles with low velocities only [1]. It leads to theoretical radiants to be too narrow for observable ones. Even Earth that yearly crosses stream's orbit cannot widen pencil of orbits enough for meteor shower being observable for weeks. We suppose that parent comet of so wide showers disintegrated step-by-step. Being initially like cluster of snowballs lightly connected by week gravitation [2] and adhesion comet nuclei can split into a row of separate fragments. Such events were observed several times, so this stage of disintegration seems to be common [3, 4]. When such row of partly disintegrated comet fragments comes close to the Earth, the more the planet acts on their orbits the closer fragment encounters Earth. Change of the body's velocity may be calculated as

$$\Delta V = \frac{2 \cdot G \cdot M_{\oplus}}{V \cdot r_0},$$

where $M_{\oplus}$ - mass of the Earth, V - encounter velocity, and r_o - distance of encounter. When the Earth's orbital velocity is 30 km/s and encounter speed is 60 km/s one needs to have at least r_o=2.6·10^6 km to obtain ensemble of orbits that has width at distance of 1 a.u. from Sun about 40 million km (ΔV=7.7 km/s). It is just the length of the Earth's orbit that meteor stream Perseids occupies. Thus the observable parameters of the Perseid shower can be explained by close encounter of primary chain of parent comet fragments or swallow of numerous particles. Its length may be estimated by taking in account long and slow increasing of meteor activity at the beginning and its sharp dumping at the end of the Perseids. This scenarium was used for computer simulation of interaction between the Earth and a sequence of split parent comet fragments. A simplest approach of flat model was used to reconstruct initial line chain of comet fragments from existing orbits of the Perseids family. When the initial orbit of the parent comet had semi-axe about some tens a.u., all Perseids orbits could be created if the Earth passed cross-point of orbits after chain of comet fragments. If minimal distance from the Earth to the head fragment was 2.6 million km, than maximal distance to the rear fragment should be about 5 million km, otherwise increasing of Perseids shower activity would be non-linear. The Earth passes such distance for 8·10^5 s, so orbital velocity of the Perseids about 60 km/s will lead to 4.8 million km as length of initial swallow. As minimal time for meteoroids of Perseids to fulfill whole orbit is 3·10^5 years, it seems that parent comet cannot survive for 5 thousand revolts.

Nevertheless one of its fragments could, if it was last one in a chain of parent comet remnants. In this position the fragment was save of kicking by meteoroid particles ejected from leading fragments and so it could keep save dust shall that protected it from the Solar heating. When the rest of comet fragments slightly decreased their velocity by Earth's gravitation, the last one in a row rested on a close to the initial orbit that is slightly different from the Perseid's orbit. So comet 109P/Swift-Tuttle is proposed to be not the parent but cousin body.

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