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Formation of Explosive Comet in Proto-planetary Nebula

O.G. Gladysheva
Ioffe Physical-Technical Institute RAS, S-Petersburg, Russia (Olga.Gladysheva@mail.ioffe.ru / Fax: +7-812-2971017)

Abstract

The question about the formation of the comet's nucleus is examined, taking into account the peculiarities of the destruction of the Tunguska cosmic body. According to the suggested model, the comet's nucleus consists from ample quantity of organic coverings, one covering inserts into another covering, similar to Russian set of nesting dolls. The space between neighbouring coverings is filled by different size lumps and grains down to micron size. Comets were formed in the inner region of the solar system in the early stages of the evolution of the proto-planetary cloud. Proto-comets began to accumulate their mass on the periphery of proto-planetary nebula (far from the ecliptic), where the temperature decreases to <100 K. Then, under the influence of gravitation, comets many times crossed the plane of the ecliptic, performing relaxation oscillations. Coverings on comet surfaces formed during every crossing by the comet of the ecliptic area, where the temperature was high. During their oscillations, most comets were thrown out of the inner regions of the solar system by planetary perturbations in the Öpik-Oort cloud.

1. Introduction

It is well known that the nucleus of a comet is a friable, porous body which contains water, dust and frozen gases. The comet nuclei as a whole must never have been heated above a temperature of ~ 100 K. There are explosions of comets, when brightness of comet sharply changes. During these explosions, comets can disintegrate into several pieces which move from the parents' body with a speed of 0.23÷1.50 km/s. The comets have coverings, which (i) regulate rates of flow of volatile components, (ii) have isolated properties and (iii) include refractory organics [1].

2. The structure of comets

Proposed model of comet nuclei is based on the results of the investigations of carbonaceous substances from the epicenter of the Tunguska Disaster and peculiarities of the destruction of the Tunguska cosmic body (TCB) over the epicenter. According to estimates, the TCB conveyed $10^{10}÷10^{11}$ kg of water vapour to the Earth's atmosphere [2, 3], and that is why the TCB is considered to be a comet. The following model of the comet's structure is suggested (Fig. 1). The comet has many (several hundred) coverings, which are fit one into another, similar to a Russian set of nesting dolls. The space between the neighbouring coverings is filled up by organic iced grains (~ 1÷3 μm in size), having dust particles as their nuclei. These grains are similar to the typical particles of Halley's comet [4] and could be united in different size lumps, each of which could have its own coverings.

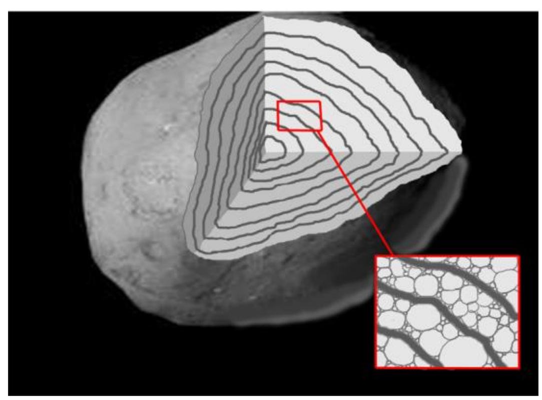

Figure 1: The structure of comets: coverings and lumps.

The number of coverings in a comet was estimated from the series of explosions over the epicenter during the Tunguska Disaster. Eyewitnesses noted that destruction of the TCB was accompanied by 50–60 explosions [5]. Based on the supposition that every explosion was connected with the destruction of one covering and the burning of released substances and also on the conclusion that during its flight the TCB threw off a considerable part of its mass, we roughly estimate that the TCB with an initial radius of ~1 km had ~500 coverings. The places where the coverings fell on the Earth's surface were found and investigated in peat deposits near the epicenter of the Tunguska disaster [1].

3. Formation of the comet

Comets with this suggested structure could be formed in the inner region of the solar system. They start accumulating their mass on the periphery of the proto-planetary nebula, far from the plane of the ecliptic. During decreasing temperature in this distant zone of the initial nebula, the organic components, water vapour and gases started condensing onto dust particles (silicate, metallic etc.). The size of dust particles for the Tunguska body was ~5 10^{-7} m. The water condensed as crystals and formed a structure similar to sea-urchins (SU-structure). Gases (CH_4, NH_3, CO_2, H_2S, etc.) must be condensed either on ice surface or between needles of ice crystals. Chemical reactions, enhanced by UV light and another radiation, could partly change this mixture of volatile organic compounds and form more complicated molecules.

To come into collision, these SU-structures could be united and form snow-flakes and, in future, lumps. Therefore, the proto-comets could begin their formation and accumulate their masses far from the plane of the ecliptic in a zone where the temperature falls below 100 K. As masses of the lumps increase, they start to move onto the ecliptic's plane under the influence of gravitation. Moving to the ecliptic and adding to their mass during motion, the lumps get to a zone of high temperature near the ecliptic, where processes of evaporation start on their surfaces. A boundary distance from the proto-sun (the radius R_{com}) must exist. Lumps could be evaporate completely for $R< R_{com}$. For $R>R_{com}$ the temperature must be "tolerable", which permits to retain without modification the inner structure of proto-comets and form their covering. It is most likely that R_{com} was located near the orbit of Jupiter.

During the heating near the ecliptic, organics on the surface of the lumps underwent further transformation. The rate of chemical reactions increased and processes of polymerisation, poly-condensation, etc. continued. If while moving a lump impacted at a high speed with a large object, it was broken into pieces; otherwise it collected these pieces. The trajectory of a lump along its orbit was similar to slowly damped oscillation. Every crossing of the plane of the ecliptic was accompanied by formation of an immediate covering and, in time, between of these crossings the lump increased its mass by adding little fragments.

4. Discussion

This model we have presented could explain some of the peculiarities of comets. First of all, it explains the moving away of comets from the inner region of solar system and the formation of the Öpik-Oort cloud. It is easy to throw out by planetary perturbations comets having an oscillatory trajectory in comparison with objects which moved around the Sun in the plane of the ecliptic. Secondly, numerous coverings could explain (i) a repeated changing in brightness of the comets; (ii) a circular symmetry of substance thrown down during the explosion; (iii) the possibility of the accumulation of energy for the explosion [1].

Acknowledgements

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References

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