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IR FLASHES INDUCED BY METEOROID IMPACTS ONTO THE PLUTO'S SURFACE.

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In recent years, the Pluto-Charon system has become recognized as a key element for understanding the origin of the outer solar system. The proposed future Pluto-Kuiper Belt Mission will provide our understanding of the origin, architecture of the deep outer solar system, the nature of binary worlds, the interior and surface evolution of small bodies, the physics of cryogenic atmospheres [1]. These topics are of broad interest to planetary science and geophysics.

Pluto has a tenuous atmosphere with base pressure in the range of 3 microbars to 150 microbars. For such low pressures even small meteoroids can penetrate through Pluto's atmosphere to the surface without substantial deceleration (at least meteoroids with the sizes of about 1 cm and larger). Thus the meteoroid's energy will be released not during the flight through the atmosphere, but after the impact onto the surface of the planet. The kinetic energy of the impactor is transformed into the thermal, elastic and kinetic energy (both of the projectile and target).

The extrapolation of the impact frequency dependence [2] on the decimeter range allows to consider that collision rate on the Pluto corresponds to one impact a day, i.e. impacts of such bodies are enough frequent. Therefore appreciable part of information may be obtained from IR flashes due to impacts of 10-cm size bodies at the Mission spacecraft flyby of Pluto-Charon system.

The impact speed onto the Pluto is about $v_{imp} = \sqrt{e^2 + i^2} \cdot v_p$, where e and i ($\approx$ 0.3) are the mean eccentricities and inclinations of the EKB particles near the Pluto and ν_p is the Pluto's orbital speed. Its value at its recent Pluto position close to perihelion is about 6 km·s^{-1}. We also must take into account additional gravitational acceleration of ≈ 1.2 km·s^{-1} for impactors on Pluto. This gives an impact velocities near $v_{imp} \approx 3.7$ km·s^{-1} [3].

The impact debris stream is released from the crater into the atmosphere. This stream of vapor and fragments expands and its average density becomes comparable to the density of the atmosphere. It decelerates and heats the atmosphere. A fireball is being formed. Turbulent mixing of the atmosphere and vapor increases the thickness of the shock-compressed layer and decreases temperature in it. For the escape velocity of 1 km/sec and characteristic impact velocity of several km/sec the temperature of the fireball is of the order of about 2600 K. Radiation will be emitted mainly in the IR range of wavelengths. This flash may be used for determination of energy of the impactor and size - frequency distribution of small bodies in the vicinity of Pluto. The shape of the radiation impulse and its spectra may give information on the characteristic of the impactors, and of the Pluto's atmosphere and surface layer.

We bring below some results of numerical simulation for the 10-cm body impact on the Pluto surface obtained by using gasdynamical code. We consider vertical impact of porous ice body with density 0.1 g?s^{-3}, R = 10 cm, V = 3.7 km·s^{-1}, length L = 2 R. In our calculations the wide range equation of state for water and tables of optical properties for atmospheric gases are used [4].

At the initial impact stage the shock wave moves in the impactor transforming it in dense plasma column with density 0.485 g·cm^{-3} and specific internal energy e = V^2/2 = 6.85 kJ·g^{-1}. Following rarefaction stage begins after the shock reaches impactor boundaries. Fig 1 represents distribution of gasdynamic parameters for the time moment t = 58.5 μs.

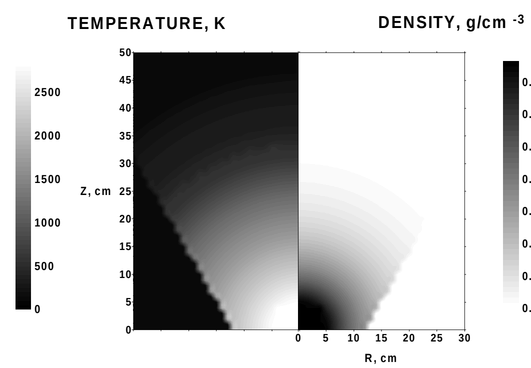

Fig. 1. Distribution of temperature and density at the ice body impact onto the Pluto surface at the time moment 58.5 μs.

Fig. 2 represents emergent IR radiation intensity coming through the atmospheric gas. The mixing ratio of CH_4 in the Pluto's atmosphere was accepted to be 1% [5], atmospheric gas temperature 100 K, its pressure 100 microbar. Radiation transfer equations are solved along 10^4 rays in the atmosphere. Radiation at this stage is dominated by strongly broaden water vapor bands and is close to the blackbody emission. At further rarefaction the impactor temperature is decreased and radiation emerges from inner parts of the impactor volume.

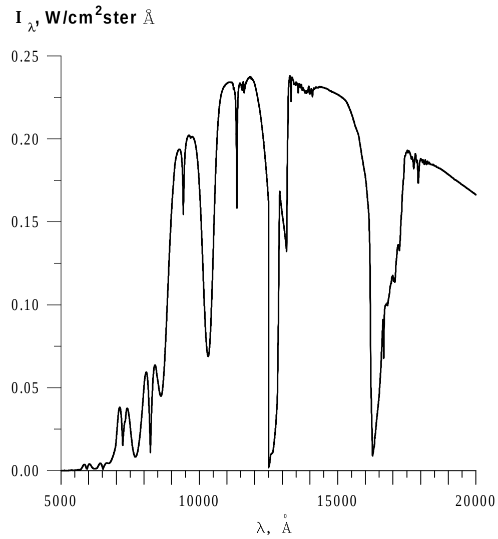

Fig. 2. Spectrum of radiation emitted at the ice body impact onto the Pluto surface t = 58.5 μs.

As it is seen from the graph of Fig. 2 strong IR radiation is emitted by hot water vapor volume. Emission power of hot compressed volume is equal to 5 kW/ster, total photon number emitted in steradian is $5 \cdot 10^{22}$ s^{-1}. Total power emitted in hemisphere is equal approximately to 30 kW. At an albedo of 0.55 [1] this value is compared with reflected solar radiation from the Pluto surface area near 1 km^2. But these flashes must be distinctly seen on the shady side of the Pluto.

Admixture of methane in the Pluto's atmosphere leads to absorption in IR methane bands. Methane emission in broadened line wings from of the hot region can be efficiently detected at large distances from the impact point. Other molecular gases in the vapor such as CO, CO_2, NH_3 and H_2O are also rather effective emitters in windows between the methane bands. Luminous efficiencies and duration of the radiation impulse are much larger than in the case of the airless Moon.

Thus, estimates of the luminous efficiency and frequency of impacts show that detection of the radiation impulses is technically possible for a rather long time of the Pluto-Kuiper Belt Spacecraft flyby before and after the closest approach.

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