LUMINOSITY OF THE BOLIDES CREATED BY SL-9 COMET FRAGMENTS IN THE JOVIAN ATMOSPHERE

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Shoemaker-Levy 9 Comet fragments intruding into the Jovian atmosphere form a wake, i.e., a hot, luminous, dissociated and ionized column. This wake expands and becomes a rarefied channel. In the dense atmosphere cracks grow in number and size and the fragment deforms as a liquid. Under aerodynamic load the meteoroid is additionally fragmented due to growth of instabilities. A cloud of small fragments decelerates, disintegrates and is vaporized. Debris and atmospheric gas escape through the rarefied wake formed at the "bolide" stage of the impact and stretched along the trajectory. A fireball, or a plume, rises to high altitudes due to nonuniformity of atmospheric density. Later, the ejected gas falls back onto the atmosphere causing atmospheric oscillations and heating.

Here we present results of theoretical investigations of the bolide phase of the impact and compare the results with Galileo observations (Chapman et al., 1995).

2D and 3D numerical radiation-hydrodynamic simulations of the bolide stage of SL-9 fragments intruding into the Jovian atmosphere have been conducted. Radiation fluxes in each wave band of the Galileo mission instruments (SSI, PPR, NIMS and UVS) in the direction of Galileo have been calculated. The simulations were based on the detailed tables of spectral opacities calculated assuming thermodynamic equilibrium and the initial composition of $0.89H_2 + 0.11He + 0.00195CH_4$. Small amount of methane and its products strongly changes spectral absorption coefficients in the IR and visible in comparison to pure hydrogen-helium mixture.

Simulations begin at the moment when the bolide head is at an altitude of 300 km. The intensity of light rapidly increases till the moment when the bolide head disappears below clouds, but the wake still shines above the cloud tops. This changes the slope of the intensity versus time and creates a plateau on the light curve.

A small difference in the observed maximum intensity for K, W and N fragments registered by SSI and for L, G, H and Q1 fragments registered by PPR instruments (no more than 2.5 times) implies that sizes of all the above mentioned fragments vary no more than within a factor of about 1.5 . A comparison of the theoretical peak intensity with the observed one for all these fragments gives an estimate of the fragment radius in the range of 0.5 to 0.7 km. NIMS data at $\lambda = 4.38\ \mu m$ for G fragment give the same value of radius. The radiating volume is located mainly at altitudes of about 30 to 100 km and slowly changes its size and shape. The brightness temperature is much smaller than the temperature of gas in the bolide head and in the hot core of the wake (see Fig.1). This effect of screening due to absorption in cold outer layers of the wake explains a rather low brightness temperature of PPR and NIMS. A short duration of the signal in the ultraviolet is also explained by the simulations.

A theoretical profile of the light curve before and some time after the peak intensity is similar to the observed one (for K fragment until 15-20 sec). The discrepancy at later time is probably due to the heating and evaporation of the clouds by the shock wave and mechanically induced ablation, which have not been taken into account in the physical model as yet.

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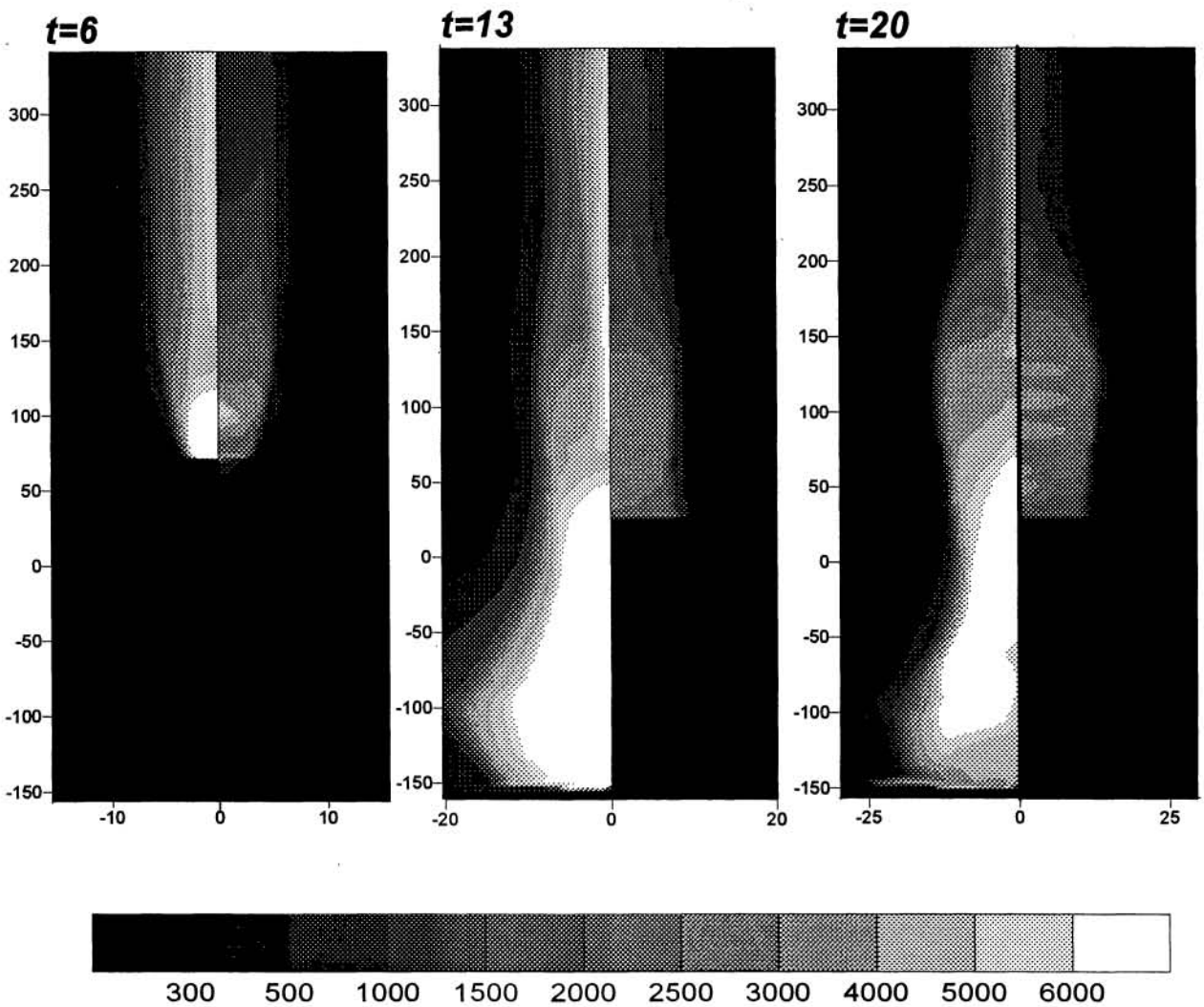

Fig. 1

Distributions of gas temperature (left from axis) and brightness temperature at 890 nm (right from axis) in the bolide. Time t = 7.2 sec corresponds to the fragment passing through 1 bar level. A vertical scale indicates a distances along the trajectory.

References:

Chapman, C.R., Merline W.J., Klaasen K., Johnson T.V., Heffernan C., Belton M.J.C. and the Galileo Imaging team. Preliminary results of Galileo imaging of SL-9 impact sites. *GRL V.22, No.12,* pp. 1561-1564, 1995.