ATMOSPHERIC OSCILLATIONS INITIATED BY THE PENETRATION OF OF A COMET OR AN ASTEROID INTO GASEOUS ENVELOPE OF A PLANET

I.V. Nemtchinov, T.V. Loseva (Institute for Dynamics of Geospheres, Russian Academy of Sciences, 38 Leninskii Prospekt, build.6, Moscow, 117979, Russia)

Lateral spreading of the body due to aerodynamic stresses leads to the disruption of a cosmic body. The simple model [1] leads to the relation $Ro/H = (\rho o^*/\rho o)^{1/2}$, where Ro is the initial radius of the body, ρo - its density, H - the characteristic scale of the atmosphere at the height Z* of the disruption, ρa^* is the density of the atmosphere at this altitude. The mass of the atmosphere **Ma** , entrained into motion behind the blast wave is much larger then the mass of the body Mo, and the velocity much lower then the impact velocity V. When the radius of the shock wave becomes larger then H the atmospheric gas is ejected into the rarefied layers, and the energy is converted into the kinetic energy of the plume with the velocity $Ve = V\ (Mo/Ma)^{1/2} = V(Ro/H)^{1/2}$. For the Shomaker-Levy comet [2] impacting into Jupiter with the initial velocity $V = 60$ km/s, assuming $\rho o = 1$ g/cm^3, spherical shape with radius $Ro = 0.5$ km we obtain the kinetic energy $Ek^o = 0.9 \cdot 10^{28}$ erg, $Mo = 0.5\ 10^{15}$ g, $\rho a^* = 3 \cdot 10^{-4}$ g/cm^3, H = 60 km, Z* = -70 km and Ve = 6 km/s.

The expanding fireball is changing to the conical jet with the angle of divergence of about 40-50^o. The ejected mass is raised against the gravity field to the height Zm ($Zm = Ze + Ve^2/2g$, where Ze is the height of the ejection). For Ve = 6 km/s we obtain Zm-Ze = 600 km. Having reached the maximum height the ejected atmosphere with the addition of small amount of the comet's substance vapor is falling back and its velocity is close to the ejection velocity.

The flow pattern resembles a fountain. The radius Rf of this fountain at the height of the ejection is 2(Zm-Ze) and the area of the cross section $Sm = 4\pi(Zm-Ze)^2$. For Rf = 1200 km and $Sm = 4\ 10^{16}$ cm^2 we obtain the specific mass m=Ma/S= 0.6 g/cm^2. This falling gas compresses the atmosphere and a reflected shock wave is created. The heated gas once more is ejected into the upper rarefied layers. This is the initial substantially nonlinear stage of the acoustic gravitational waves generation. The estimates of the temperature in this shock wave and its location has been obtained by the solution of a 1D-plane nonstationary gas dynamic problem for different masses m, velocities Ve and etc. The results for m = 0.7 g/cm^2, average velocity Ve = 7.9 km/s, Ze = 240 km, the initial length of the jet l = 310 km are typical. The trajectories of different particles are given in Fig.1 (They are labeled by the initial altitudes in km). Amplitude of the oscillations increase with

ATMOSPHERIC OSCILLATIONS: Nemtchinov I.V. et al.

the height of the layer under considerations. They create a large displacement of the ionosphere layers, usually located at the heights of 500-2000 km [2]. Gas dynamic profiles as functions of the time are shown in Fig.2. The dotted curves correspond to the equilibrium characteristics of the atmosphere before the impact. At the height Z > 300 km the density is increasing by many orders of the magnitude and the temperature is very low - less then 50 K due to adiabatic cooling. The condensation of the hydrogen is even possible. But the heating of the shock wave (up to 500-100 K) will lead to its evaporation.

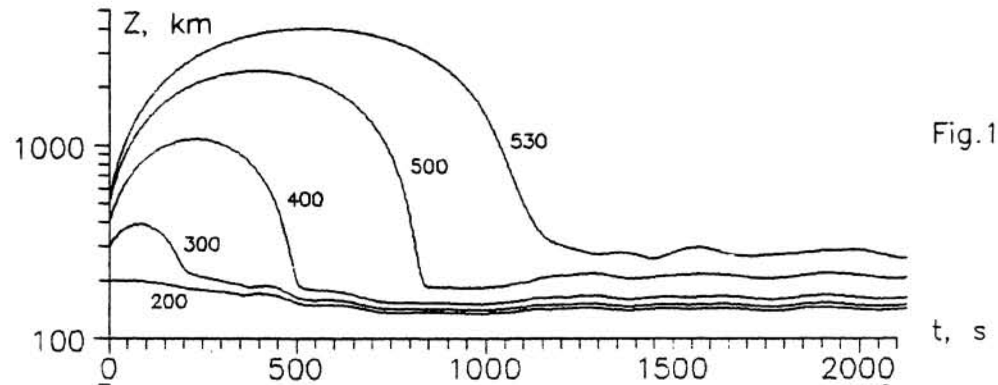

Fig.1

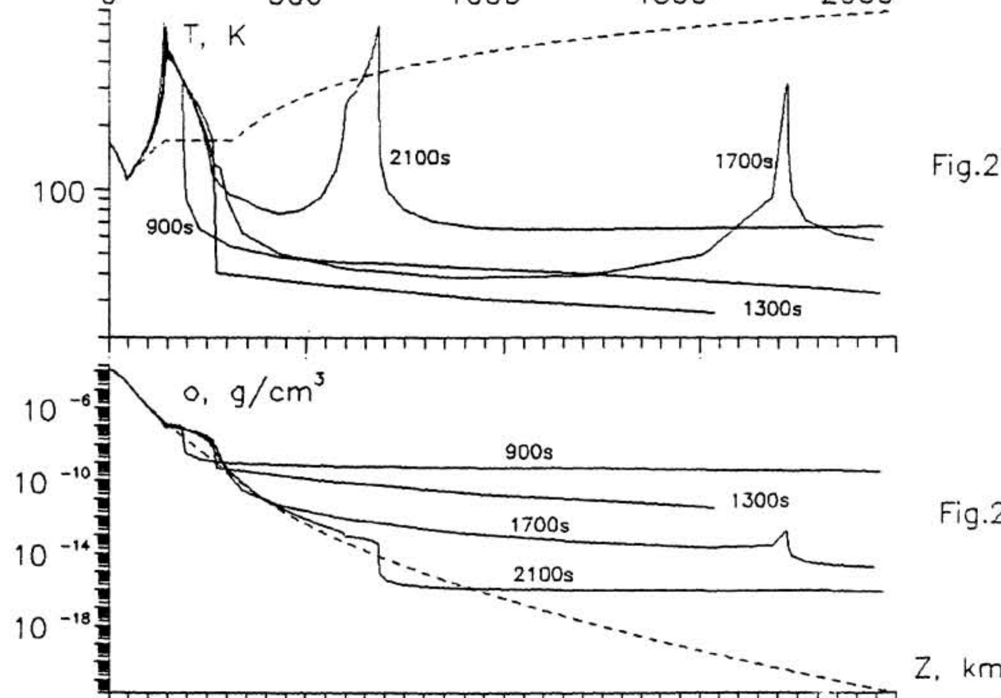

Fig.2(a)

Fig.2(b)

References: 1.Melosh H.J.(1989) Impact cratering: a geological process. Oxford University press, NY, Claredon press, Oxford. 2. Chapmen C.R. (1993) Comet on target for Jupiter, Nature, **363**, 492-493. 3 Gehrels T. (1976) Jupiter. The University of Arizona press, Tucson, Arizona.