Meteoric Ablation in Venus atmosphere: Mass, Speed and Temperature variation. S. Nambiar[*] and J. P. Pabari. Physical Research Laboratory, Ahmedabad, India-380009. *Email: srirag@prl.res.in

Introduction: Our solar system is filled with dust particles stemming from a variety of sources. The inner solar system has dust primarily coming from Asteroidal belt and comets. These particles dynamically evolve under different forces like gravity, Poynting-Robertson drag, radiation pressure and Lorentz force. Furthermore, they are replenished by collisions among themselves and with air-less planetary bodies.

During dust particle's evolution in the solar system, they may interact with planetary bodies. In case of planets with atmosphere, these particles get ablated because of their high speed. This process deposits metallic ions and atoms which affects the atmospheric chemistry. Ionospheric layer associated with meteoric ablation has been reported for several planets [1,2,3,4]. A meteor layer at Venus has also been reported by [5] around 110 km, which is relatively less explored as compared to ablation related layers in other planets.

Here, we study the ablation process in Venusian atmosphere, specifically the variation in mass, speed and temperature of particle along the descent path. Different incoming particle speed is considered and its effects are discussed.

Ablation Process: The particles entering at high speed loss their mass and speed by interaction with atmospheric atoms. The increase in temperature because of friction further aids in the mass loss. These effects are described by equation of motion, mass-loss and energy balance [6].

$$cos\theta \frac{dv}{dz} = \frac{\Gamma A \rho v}{\delta^{2/3} m^{1/3}}$$

$$cos\theta \frac{dm}{dz} = -\frac{4AK_1 m^{\frac{2}{3}}}{\delta^{\frac{2}{3}} v T^{\frac{1}{2}}} e^{-\frac{K_2}{T}} - \frac{\Delta_s A \rho m^{2/3} v^2}{2G\delta^{2/3}}$$

$$cos\theta \frac{dT}{dz} = \frac{4A\rho v^2}{8C\delta^{\frac{2}{3}} m^{\frac{1}{3}}}(\Delta - \Delta_s) - \frac{4A\sigma T^4}{C\delta^{\frac{2}{3}} v m^{\frac{1}{3}}} - \frac{4AK_1 G}{C\delta^{2/3} m^{\frac{1}{3}} T^{1/2}} e^{-\frac{K_2}{T}}$$

T, m and v are temperature, mass and speed of the particle respectively. ρ is atmospheric density, δ is particle density, σ is Steffan Boltzmann constant, Γ is drag coefficient, Δ is the heat transfer coefficient, Δ_s is the sputtering coefficient and G is evaporation energy of 1 gram of particle. Other constants are taken from [6] and [7].

Simulation: The ablation model requires particle mass, speed, flux and particle density as input. Based on these parameters and atmospheric conditions, the particle deposits ions and atoms in the Venus atmosphere. Here we have used flux model given by [8]. The particle speed is taken to be 15.2 km/s for Jupiter family comets, 11.4 km/s for Asteroidal particles and 29.5 km/s for Halley type cometary particles [9]. The atmospheric temperature and density data is taken from [10] and [11]. Based on these inputs, the ablation model is run and the mass, speed and temperature profiles are derived; whose plots are displayed in Figure 1 for a typical mass of 10^{-4} g. Similar results are obtained for other particle masses.
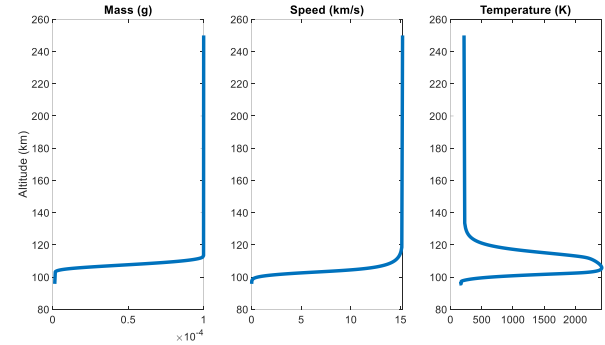

Figure 1: The mass, speed and temperature profile on ablation of a particle with mass 10^{-4} g entering at 15.2 km/s speed in Venus atmosphere.

Discussion: As particle descents in the Venusian atmosphere it loses its mass and speed along with increase in temperature. The major mass loss and speed reduction is observed around the altitude of 95 km. The maximum temperature of particle is observed for the largest particle of 10^{-2} g which reaches ~2500K. The effect of incoming particle speed is also observed. These data can be used to derive the production rate of metallic ions and atoms in Venus atmosphere which is crucial to study the effects to atmospheric chemistry.

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