THE MICROMETEOROIDS IN THE THERMOSPHERE AND MESOSPHERE

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Abstract. The variation of temperature and radius of typical micrometeoroids in the low thermosphere and mesosphere is calculated theoretically, and the formation of the spherule is explained consistently with this model. The fluffy particles floating in the stratosphere is also consistent with our calculation, since the particle of radius 10 μ and initial velocity 20 km s⁻¹ cannot be heated up to the sublimation temperature, even if it is not fluffy.

Our calculation coincides exactly heights and velocities of meteor streams.

The formation of the secondary particles from the evaporated vapour, is also calculated, and it is concluded that they are very few and small, compared with the primary particles.

1. Introduction

There are two kinds of small meteorites, which we can collect directly. The first are fluffy micrometeoroids of the 10 μ size which are captured by airplanes in the stratosphere.

The second, which are found in the bottom of the deep sea, are called spherules, because almost of them are spherical. Their typical size is about 100 μ.

On the other hand, we observe often meteors in the atmosphere. Their magnitudes, velocities, and heights are determined by the simultaneous observation from the several points on the ground.

Though many meteorologists (e.g., Rosen, 1969; Hunten et al., 1980) have studied this micrometeoroids phenomena the difference between them and with our works is that, we try to explain these three phenomena by one model consistently.

2. Method of Calculation

2.1. THE TEMPERATURE MODEL

\[
\begin{align*}
Z > 90 \text{ km} & \quad T = 180 + 4.0(Z - 90) \quad \text{(thermosphere)}, \\
90 > Z > 80 & \quad T = 180 \quad \text{(mesopause)}, \\
80 > Z > 55 & \quad T = 180 - 3.6(Z - 80) \quad \text{(mesosphere)}, \\
55 > Z > 45 & \quad T = 270 \quad \text{(stratopause)}, \\
45 > Z > 30 & \quad T = 270 + 3.33(Z - 45) \quad \text{(stratosphere)},
\end{align*}
\]

30 > Z > 10 \quad T = 220 \quad \text{(tropopause)},

10 > Z \quad T = 220 - 7.0(Z - 10) \quad \text{(troposphere)},

where \( Z \) is height from the ground level, and \( T \) is the corresponding temperature (K).

### 2.2. The Density Model

\[
\rho_a = 3.0 \times 10^{-10} \ e^{-(Z - 100)/H},
\]

with \( H = (k/\mu m_H g)T \) (scale-height).

### 2.3. The Velocity

If the velocity of the meteorite larger than the terminal velocity, it is given by

\[
\frac{dv}{dt} = -\frac{3}{4} \frac{\rho_a v^2}{\rho_m r},
\]

where \( \rho_m \) is the density of the meteorite and \( r \) the radius of the meteorite.

From Equation (2) we have

\[
\ln \frac{v}{v_0} = -\frac{3}{4} \frac{\rho_a H}{\rho_m r},
\]

where \( v_0 \) is the initial velocity outside of the atmosphere.

### 2.4. Temperature of the Meteorite

If the temperature of the meteorite is lower than the sublimation temperature, the kinetic energy of the colliding atmospheric molecules is equal with the radiation loss and the temperature elevation of the meteorite

\[
\frac{1}{2} \pi r^2 \rho_a v^3 = 4 \pi r^2 \sigma (T_m^4 - T^4) + \frac{4}{3} \pi r^3 \rho_m C \frac{dT_m}{dt},
\]

where \( \sigma \) is the Stefan–Boltzmann's constant; \( T_m \), temperature of the meteorite; \( C \), specific heat of the meteorite.

However, as we see later, if \( T_m \) becomes higher than the sublimation temperature \( T_s \) of the meteorite, \( T_m \) becomes constant and the sublimation heat is a main energy loss:

\[
\frac{1}{2} \pi r^2 \rho_a v^3 = 4 \pi r^2 \sigma (T_m^4 - T^4) + L \frac{dm}{dt},
\]

where

\[
\frac{dm}{dt} = 4 \pi r^2 \rho_m \frac{dr}{dt}
\]

and \( L \) is the sublimation energy.