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OZONE FORMATION DUE TO INTERACTION OF METEORIDS WITH EARTH'S ATMOSPHERE

R. Sh. Bibarsov

Institute of Astrophysics
Dushanbe, USSR

In the previous paper (BIBARSOV, 1985) it was shown that concentration of atomic oxygen in overdense meteor trails may exceed that of the normal atmosphere by a factor of several hundred times. This may lead to the formation of meteoric ozone. Therefore, it is imperative to estimate the concentration of ozone in the trails of meteor bodies with different masses.

In the atmosphere, ozone is formed by Chapman's reaction:

$$O + O_2 + M \rightarrow O_3 + M \tag{1}$$

where M is a particle of air or of meteoric matter.

Simultaneously other reactions occur that lead to the loss of O_3 and O:

$$O_3 + h\nu \rightarrow O_2 + O, \tag{2}$$

$$O_3 + O \rightarrow 2\,O_2\ , \tag{3}$$

$$O + O + M \rightarrow O_2 + M. \tag{4}$$

The reactions (1)-(4) support the chemical balance of atmospheric particles.

The interaction of meteoroids with the Earth's atmosphere leads to a disturbance of the chemical balance of atmospheric particles in some air volume along the trajector. This and subsequent dissociation of oxygen molecules by evaporated atoms of the meteoroid. While balance is recovered again through the reactions (1)-(4), the relative concentration of particles becomes different.

The concentration of newly formed ozone at the initial stage of meteor trail existence can be estimated.

The atomic oxygen concentration n_1 resulting from dissociation of oxygen molecules is $n_1 = 2\gamma n_m$ where γ is the dissociation coefficient of O_2 and n_m is the concentration of the evaporated meteor atoms. Both γ and n_m may be determined from the formulas:

$$\gamma_s = 2.82 \cdot 10^{-2}(V - 9.5) \text{ for stone meteor bodies} \tag{5}$$

$$\gamma_i = 1.82 \cdot 10^{-2}(V - 9.5) \text{ for iron meteor bodies} \tag{6}$$

$$n_m = \frac{4}{g\pi\, r_o^2} \cdot \frac{M_o \cos Z_R}{m \cdot H} \tag{7}$$

where V is the meteor velocity is kms, r_o is the initial radius of a meteor trail, M_o is the mass of meteoroid, z_R is the zenith angle of a radiant, m is the mean mass of meteor atoms in g (for stone meteoroid $m = 4.5 \cdot 10^{-23}$ g, for iron $m = 9.4 \cdot 10^{-23}$ g), and H is the atmospheric scale height ($H \leq 6$ km).

The balance of production and loss of ozone molecules per unit volume n'_3, according to reactions (1) - (3) is constrained by the following equation:

$$\frac{dn'_3}{dt} = k_1 n_1 n_2 n - I n'_3 - k_3 n_1 n_3 \quad , \tag{8}$$

where k_1 and k_3 are the rate constants of the reactions (1) and (3), n_1 is the concentration of oxygen atoms in meteor trails, n_2 is the concentration of oxygen molecules, n is the concentration of all the neutral particles in a trail, I is the photodissociation rate of O_3.

Now, assuming that $dn'_3/dt = 0$, we shall consider the case of photochemical balance where

$$n' = \frac{k_1 n_1 n_2 n}{I + k_3 n_1} \tag{9}$$

The equations (5) - (9), data on atmospheric particles for different heights (PEROV and KRGIAN, 1980), and rate constants of reactions (1) and (3) (PEROV and KHRGIAN, 1980; SHIMAZAKI, 1984) allow one to calculate the maximum concentration of ozone formed in a meteor trail.

Figures 1 and 2 show, on a logarithmic scale, the dependence of predicted meteor ozone concentration ratio to that of atmospheric ozone in the daytime on the log of mass of stone and iron meteors as calculated for altitudes of 70, 80, 90, 100 km. It is assumed here that $\cos z_R = 2/3$ and the values of V and r_o for these heights are taken from Baggaley, (1970).

According to the figures, the predicted meteor ozone concentration in the trails of meteor bodies with masses more than 10^{-2} g may exceed that of atmospheric ozone by a factor of several dozen times.

It seems that meteoric ozone must be taken into account when studying the balance of ionization in the meteor trails formed by particles with masses more than 10^{-2} g. The predicted levels of atomic oxygen and ozone seem sufficient to greatly influence the rate of meteoric plasma deionization.

References

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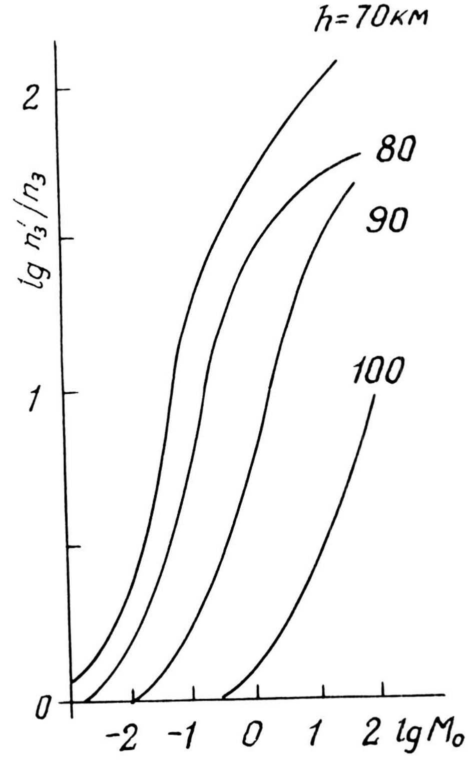

Fig. 1 Predicted daytime dependence of meteor zone concentration in meteor trails of atmospheric ozone for stony meteors at altitudes of 70, 80, 90, and 100 km.

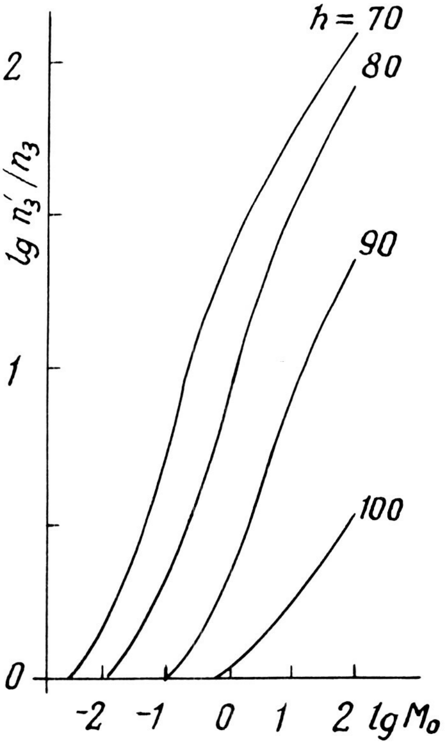

Fig. 2 Same as Fig. 1 except for iron meteors.