DUST OF ORIONID METEOR SHOWER IN THE EARTH ATMOSPHERE BEFORE AND AFTER HALLEY'S COMET

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INTRODUCTION

Among the interesting questions concerning meteor streams associated with Comet Halley is the question of whether or not the activity of a meteor stream was connected with the approach of the comet to the terrestrial orbit in 1985-1986.

Meteoric aerosol getting to the upper atmosphere can be detected by twilight sounding, as has been done in former times by Link et al. in Czechoslovakia and in France [1,2] and in the USSR (in Odessa) by Kasan and Abastumani [3,4].

It has turned out that not only parameters describing some properties of aerosol can be obtained by twilight sounding, but also some characteristics concerning the structure of the stream can be derived.

Among the yearly active streams, the Orionides have always attracted the attention of scientists. The period of activity of the Orionides is October 18-26, and the maximum stream activity is October 21. Figure 1 shows the orbit of Comet Halley and that of the Earth and the dates when the orbits most closely approached one another (0.154 AU for the Orionides and 0.065 AU for the Eta Aquarides).

In detecting aerosol layers in the terrestrial atmosphere, a notion of the logarithmic intensity gradient of scattered twilight light is used, d log I/dH, where I is intensity and H is the real twilight beam height, which is a function of the wavelength observed.

We used a photoelectric photometer with an interference filter at the wavelength of 610 nm.

The observations were carried out in two points of the solar vertical; the zenith angle of the observations points was ±60°. The recording was carried on continuously in each direction during a minute, then the system was switched to the other direction. A calibration standard was recorded before each observation.

The observation dates in the Orionid periods of 1984, 1986, and 1987 are given in table 1.

RESULTS

In figures 2, 3, and 4 the logarithmic intensity gradient as a function of altitude is shown, with clearly pronounced aerosol layers, so that one can follow the layers lowering during several days.

The relations of intensities for two days, October 24 and 25, to that for October 15, i.e., for a day free from the effect of the meteor shower are also calculated for 1986. These relations for 1986 are given in figure 5 and table 2.

It can be seen from figure 5 and table 2 that after the maximum had passed, the intensity of scattered light increased throughout the middle atmosphere, which implies that some matter was distributed in it, consisting of different fractions that precipitated with different rates. Having calculated the ratio of the intensities obtained in 1986 to those of 1984, i.e., before and after the passage of Comet Halley, we found that the intensity of scattered light increased, for various altitudes, from 4 to 14 times (fig. 6).

For 1987, the ratios of intensities before and after the maximum stream (fig. 7) reveal no significant increase in intensity after the maximum of the stream, comparable with that for 1986.

Mean sizes of particles composing the layers are calculated from sedimentation velocities of the layers. Particle sedimentation velocity was determined using the Stokes-Cunningham law with the Cunningham correction,

$$V_t = \frac{2r^2}{g\eta} g(\rho_p - \rho_a)\,(1 + B\bar{l}/r)$$

where η is the air viscosity, ρ_p is the air density for the appropriate altitude, $\bar{l}$ is the mean free path of a molecule, B is a factor for which $\bar{l}r \geq 10$ (where r is the particle radius) equals 1.65. The air density for October was ascertained from CIRA-72.

For the Orionid-1984, the mean particle sedimentation velocity, from October 22–27, at altitudes of 70 to 80 km, was equal to 5.747 cm/sec. The estimated particle radii were ~0.08 μm, and the number density of particles 2.5 g/cm^3. For 1986, the mean particle radius at altitudes of 86 to 70 km, for the mean particle sedimentation velocity of 4.09 sm/sec was equal to 0.065 μm. If we assume the number density of the particles to be 2 g/cm^3, then their mass would be about 10^{-5} to 10^{-6} g.

The information about the structure of the Orionid meteor shower is taken mostly from radar measurement data as well as from visual observations. According to the data of the Spring Hill Meteor Observatory (Canada) [5] for 1958 to 1962, there are several peaks of various magnitudes in meteor hourly rates. In a number of papers (i.e., in those based on the observations carried in Kharkov, as well as in Ondřejov and Bologna [6]) either a shift of the peak of activity, or several peaks of various magnitude have been observed (figs. 8 and 9).

The results of those observations imply that the meteor shower has nonuniform, filamentary structure. This phenomenon can also be verified using twilight observation data, through amplifications of the intensities of scattered light on different heights, and in so doing, some fractions of finest particles can be detected that cannot be registered by the radar method.

In fact, three activity peaks were detected through intensity amplifications at altitudes of 80 and 90 km: on October 22, 25, and 27, 1984 (fig. 10). In 1986 and 1987, there was no possibility to embrace the whole period of activity of the Orionid meteor shower, but still one may note an amplification of scattered light intensity in the evening twilight on October 24, 1986, and another one which took place on October 21, 1987 (fig. 11).

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TABLE 1.– OBSERVATION DATES

October	15	16	17	18	19	20	21	22	23	24	25	26	27
1984	---	---	---	---	---	---	---	E	E	E	E	E	M
1986	M	---	---	---	---	---	---	---	---	E	E	---	E
1987	---	E	---	---	---	E	E	M	---	---	---	---	---

Note: E is evening twilight, M is morning twilight.

TABLE 2.– RELATION OF INTENSITIES

H, km	$I_{24.X}/I_{15.X}$	$I_{25.X}/I_{15.X}$	$I_{27.X}/I_{15.X}$
40	5.5	10.7	3.8
50	3.9	6.8	3.6
60	4.0	4.8	3.5
70	3.8	4.1	3.0
80	3.2	2.9	---
90	3.0	1.7	---
100	4.0	1.9	---

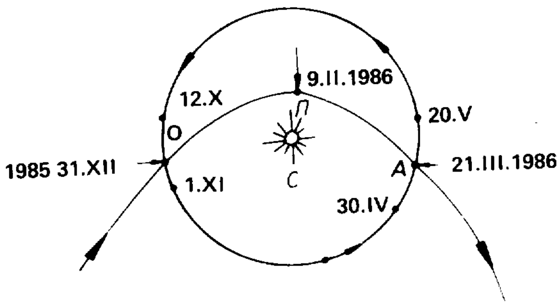

Figure 1

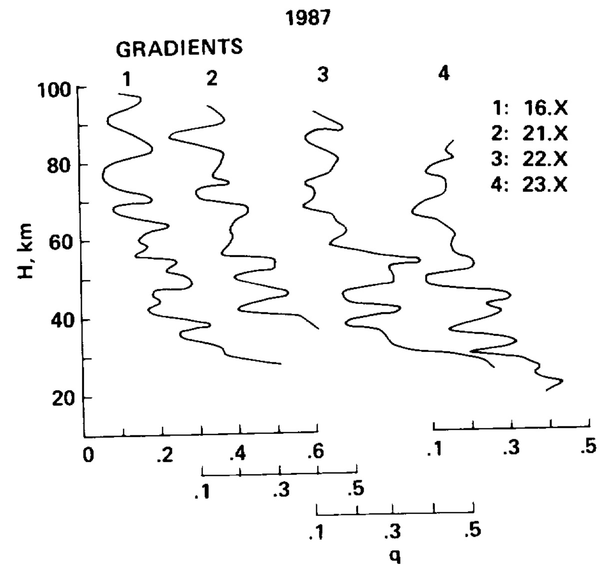

Figure 4

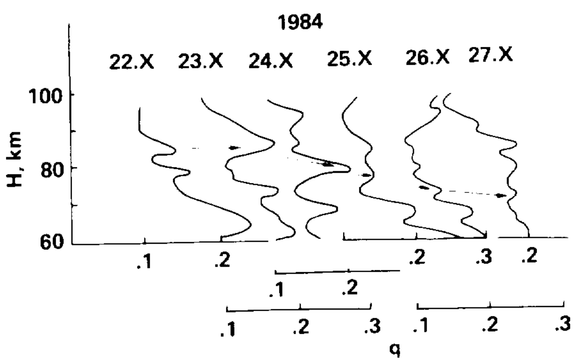

Figure 2

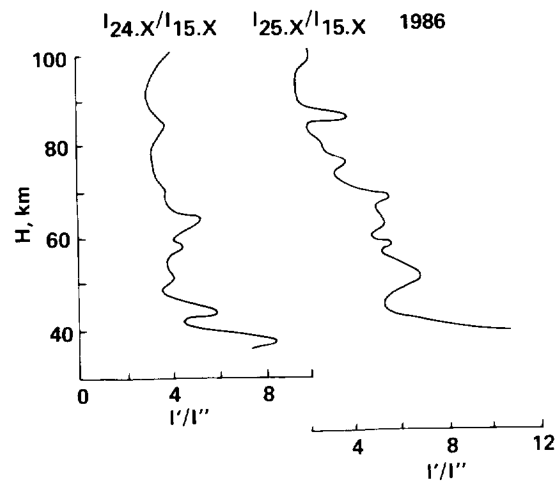

Figure 5

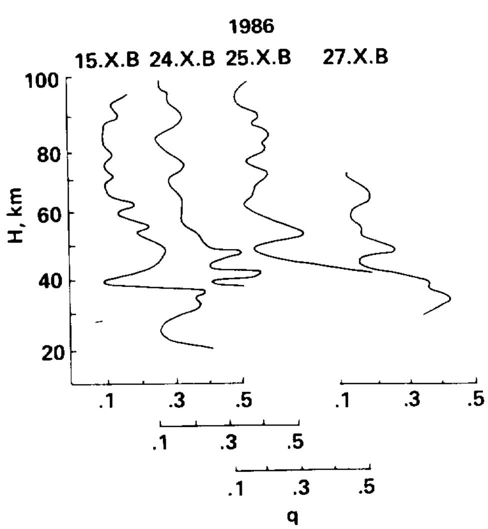

Figure 3

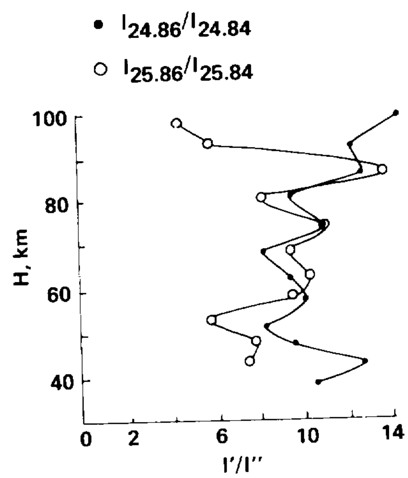

Figure 6

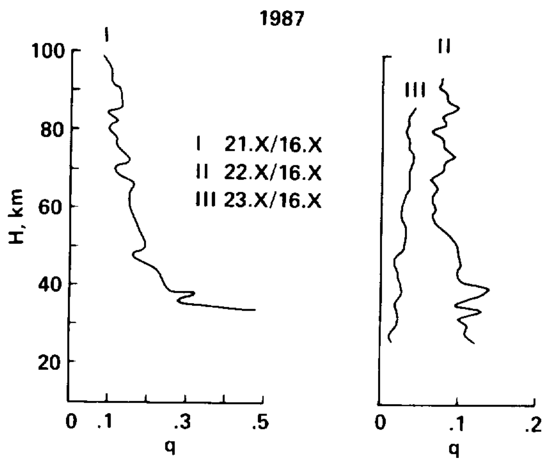

Figure 7

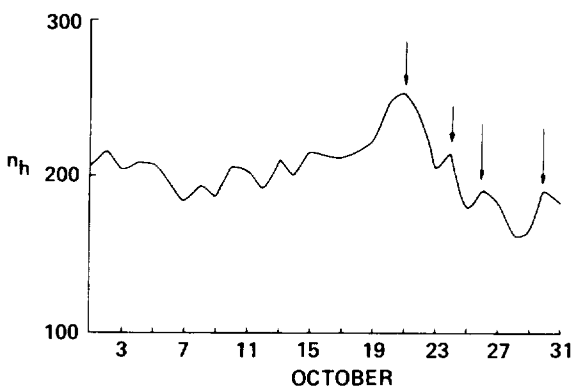

Figure 8

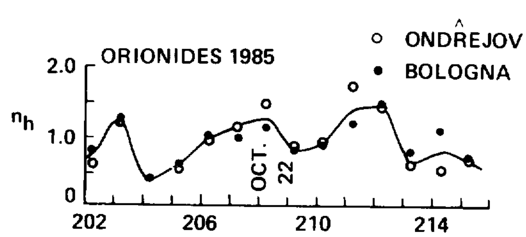

Figure 9

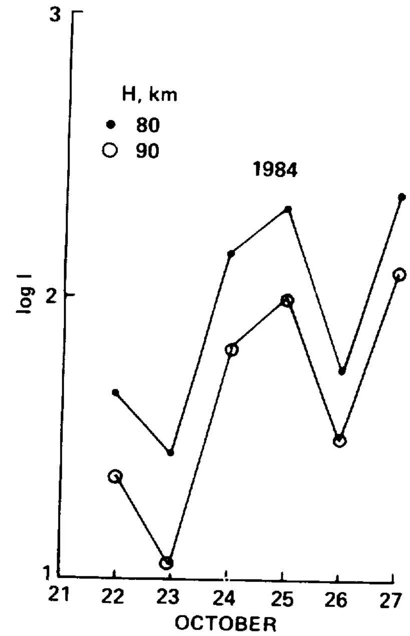

Figure 10

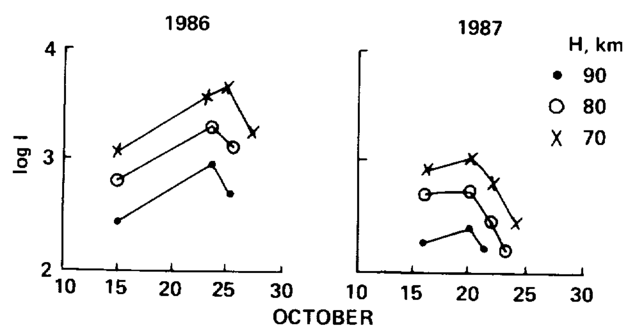

Figure 11