INCIDENT METEOROID FLUX DENSITY

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Complex photographic and radar meteor observations have been carried out at the Institute of Astrophysics since 1957. Using the available observational data we have tried to estimate the density of incident flux of meteoroids over a wide mass range of 10^{-3} to 10^{2}g.

To avoid the influence of apparatus selectivity a special technique was applied. Its main characteristics are:

1. An integrated meteoroid mass distribution on a logarithmic scale defined as

$$\log N(m) = \log B - (S-1) \log m \qquad (1)$$

where N(m) is the number of meteoroids of mass greater than m which interesect a fixed area within a fixed time and B and S are parameters to be determined.

If we assume B and S to be constant then (1) can be fitted as a straight line equation. B will be constant only in the case of stable effective interception area. If this condition is met for meteoroids whose masses exceed m_o, and a linear trend in the integral distribution (1) is obtained, it means that all the meteoroids of $m \geq m_o$ are recorded and the effective area for these meteoroids is indeed constant at least on average or for the given radiant.

2. It is supposed that for sporadic meteors, the parameters are constant or vary little over the range of meteor velocities.

3. Since we wish to determine the average density, the average parameters of both apparatus and meteors are used.

The meteoroid incident flux density was determined by:

$$N_o(m) = \frac{N(m)}{\sigma t k} \qquad (2)$$

where N(m) is the number of meteoroids of mass greater than m, recorded for the time t; σ is the average effective area, K is the correction coefficient depending on the type of apparatus and method of observation used.

Only meteors corresponding to the linear part of the cumulative distribution (1) were selected.

To estimate the incident flux density using radar observations, we selected data on sporadic meteors producing overdense trails of duration $\underline{T}$ > 0.1s that corresponded to masses greater than $m = 1.4 \cdot 10^{-3}$g. Some 226,000 meteors of that type were recorded during 6,800 hours.

Taking into account the meteoroid density distribution and correcting for the attachment of electrons to neutral particles in meteor trails (when $T \geq 10$ s), S is found to be 2.1 for meteoroids with masses from 10^{-3} to 10^{2}g.

The average effective area σ for the mean radiant is estimated by:

$$\sigma = \frac{(S - 1) \cdot 1.8 \sqrt{R\lambda \; \ell}}{(S - 1.25) \cos Z} \tag{3}$$

Here R is the average range of meteor registrations, λ is the radar wave length (λ = 8m), Z is the zenith distance of the mean reflecting point, ℓ is the length of the horizontal line drawn between the ends of the aerial orientation diagram, through the mean reflecting point and made perpendicular to the main axis of the diagram at a distance of R from a radar.

Equation (3) uses the average <u>effective</u> length factor $(S - 1)$ $1.8\sqrt{R\lambda}/(S - 1.25)$ instead of the average length of the meteor trail, because in order to scale mass according to duration, one observes only a fraction of the trails which have reflecting points close to the ionization maximum. From observations with our interferometer we have found that on average R = 146 km, ℓ = 150 km, cos Z = 0.643. These observations also showed that all meteors whose radiants were in an area of 0.6 of a sky hemisphere were recorded. Therefore, for radar observations the adopted value for K is 0.6.

Our final solution for sporadic meteors with masses of from 10^{-3} to 10^{2}g is

$$\log N_o(m) = 0\ 13.712 - 1.1 \log m \tag{4}$$

where m is in g, and $N_o(m)$ in $m^{-2}\ s^{-1}\ (2\pi\ \text{ster})^{-1}$.

The incident flux density was also estimated using double photographic observations of bright meteors carried out by the Dushanbe meteor patrol in 1957-1967.

Pre-atmospheric meteoroid masses were determined by:

$$m = \frac{2}{\tau v^2} \int_{-\infty}^{+\infty} I dt$$

where $\tau = \tau_o v$ is the luminous efficiency, v the velocity of a meteoroid, I the luminous intensity.

Meteors having masses of 0.02 to 160g were recorded. The mass range of meteors corresponding to the linear part of the cumulative distribution was 16-160g. In this mass range S was found to be 2.1. The effective area covered by meteor patrol cameras at the height of 100 km was of the order of 10^4 km^2. During 1,000 hours of observation 170 sporadic meteors were recorded with the result that we detected 0.78 of all the meteors whose radiants were in an area of 0.85 of the celestial hemisphere. Thus, for photographic observations K was assumed to be 0.68.

The solution for our photographic observations was

$$\log N_o(m) = - 13.689 - 1.1 \log m \tag{5}$$

As an average from (4) and (5) we may adopt

$$\log N_o(m) = - 13.7 - 1.1 \log m$$

For comparison, this method was also used to analyze Super-Schmidt data on faint meteors (MCCROSKY, et al., 1961). For their sporadic meteor sample we obtained.

$$\log N_o(m) = -13.913 - 1.12 \log m \qquad (6)$$

If we adopt a more extreme model for the luminosity coefficient ($\tau \propto v^{-5}$) then for their bright meteor data we get

$$\log N_o(m) = -13.39 - 1.1 \log m \qquad (7)$$

while for their faint meteors the result is

$$\log N_o(m) = -13.698 - 1.12 \log m \qquad (8)$$

The fact that in (5), (6), (7), and (8), S is constant confirms indirectly the assumed lack of a meteor velocity dependence.

Since (4), (5), and (8) are in best agreement we suggest that for bright meteors the luminous efficiency is indeed proportional to the meteor velocity but for faint meteors the extremal model $\tau \propto v$ is more suitable.

Analogous calculations were made for the Perseides using observation data obtained in Dushanbe. Meteoroids of masses of 0.025 up to 25 g were recorded. The linear portion corresponded to masses of 1 to 10 g with

$$S = 1.67 \text{ and } \log >_o(m) = -14.2 - 0.67 \log m.$$

The calculation using the extremal model value of luminous efficiency yielded

$$\log N_o(m) = -13.6 - 0.67 \log m$$

where for meteor showers $N_o(m)$ is measured in $m^{-2}s^{-1}$.

These results may be compared with those of other authors. Thus, LEBEDINETS (1970) obtained $N_o(m) = 1.1 \times 10^{-10}\, m^{-2}\, s^{-1}\, (2\pi\ ster)^{-1}$ from radar observations of sporadic meteors with $m \geq 2 \times 10^{-4}$ g. For the same mass and using (4) we obtain $N_o(m) = 1.1 \times 10^{-10}\, m^{-2}\, s^{-1}\, 0\ m^{-2}\, s^{-1}\, (2\pi\ ster)^{-1}$. PECIAN (1984) from radar observations of overdense meteor trains with $T \geq 0.6$ s for $m \geq 10^{-2}$ g obtained $N_o(m) = 3.7 \cdot 10^{-12}\, m^{-2}\, s^{-1}\, (2\pi\ ster)^{-1}$. For the same mass, using (4) we derived $N_o(m) = 3.2 \cdot 10^{-12}\, m^{-2}\, s^{-1}\, (2\pi\ ster)^{-1}$. According to LINDBLAD (1967), for $m \geq 10^{-3}$ g, $N_o(m) = 3.2 \times 10^{-11}\, m^{-2}\, s^{-1}\, (2\pi\ ster)^{-1}$, and for $m \geq 1$ g, $N_o(m) = 1.26 \cdot 10^{-16}\, m^{-2}\, s^{-1}\, (2\pi\ ster)^{-1}$. For the same mass range using (4) and (5) we have $N_o(m) = 4 \times 10^{-11}\, m^{-2}\, s^{-1}\, (2\pi\ ster)^{-1}$ and $N_o(m) = 2 \times 10^{-14}\, m^{-2}\, s^{-1}\, (2\pi\ ster)^{-1}$ respectively.

In other references too numerous to mention, one can find the results of one or two orders of magnitude less than the results cited here. As shown by LEBEDINETS (1970), these differences can be explained by the fact that various factors of meteor detectability are not properly taken into account. If this is done the results obtained by different authors using different techniques agree well.

References

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