ON TIME-DEPENDENT MODELS OF THE METEORIC BACKGROUND COMPLEX

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Abstract. Continuous models of the meteoric background complex are discussed and analysed on the basis of observational data on radiants and hourly rates of sporadic meteors. A time-dependent, bi-elliptical model of the true radiant distribution fits the observational results.

Our present knowledge of the meteoric background complex is based on two sets of observational data of sporadic meteors: hourly rates, and distribution of orbits. As yet we do not have a model which satisfactorily unifies these data. Any plausible model of the sporadic background complex must explain the following features:
(a) Four areas of the sky (in the northern hemisphere) in which the density of apparent radiants is increased relative to the rest of the sky; one in the direction of the apex (denoted hereafter as AP), and three with elongations from the apex of about 60°-70° each, two of these on the ecliptic (helion HE and antihelion AH sources), and one with ecliptical latitude of 60°-70° (northern toroid TO source). The sources HE and AH are symmetrical about the apex, both in their position and their yearly-averaged strength.
(b) The strengths of the four sources exhibit definite and different seasonal variations, with clearly asymmetric features in the case of the HE and AH sources: in most observational data the HE source is most prominent from April to June, while the AH source is most prominent from October to December. This is especially marked for the southern data.
(c) Relative strengths of the sources seem to depend considerably on the luminosity of the meteors, and therefore on the masses of the meteoroids. For example, the strength of the AP source relative to the HE and AH sources varies from about 0.5 for meteors of 4 magn. through about 0.7-1.0 for meteors of 7 magn. to about 2.0-4.0 for meteors of 13 magn.

In this paper attention will be paid to the HE and AH sources. The feature (a) by itself sets a very strong limitation on possible models of the true radiant distribution (Štohl 1975). The present

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analysis is restricted to the plane of the ecliptic and neglects the physical factor. The limitation (a) may then be converted into the condition

$$\frac{d(\ln T(\varepsilon'))}{d\varepsilon'} = \frac{\sin\xi}{u}\left(2 - \frac{\cos\xi}{u-\cos\xi}\right), \qquad (1)$$

where T is the number density of radiants as a function of true elongation ε' and u is the geocentric velocity corresponding to the maximum in the apparent radiant density distribution at elongation ξ from the apex. Taking into account the known geometrical relation between the geocentric and heliocentric velocities, this condition shows that only meteors with heliocentric velocities $w>\sin\xi$ and semi-major axes $a>(1+\cos^2\xi)^{-1}$ can contribute to the observed maxima in the apparent radiant distribution. The observed value $\xi=65°$ leads to the limiting values a=0.85 and w=0.9. Also, if the position of a maximum in the apparent radiant distribution is the same for all meteors, then the true radiant distribution cannot be the same for meteors of different heliocentric velocities. On the other hand, when the true radiant distribution is the same for all meteors, we should expect different positions of the maxima in the apparent radiant distribution for meteors of different heliocentric velocities.

One of the models of the true radiant distribution $T(\varepsilon')$ commonly used is the elliptical model suggested by Lazarev (1965):

$$T(\varepsilon') = A(1-E^2)[1-E\cos(\varepsilon'-\eta)]^{-1} \qquad (2)$$

where E is the eccentricity of the distribution ellipse, A is its semi-major axis, oriented towards the true elongation η. Lazarev's model is oriented towards the antapex, $\eta=180°$. Such a position of the

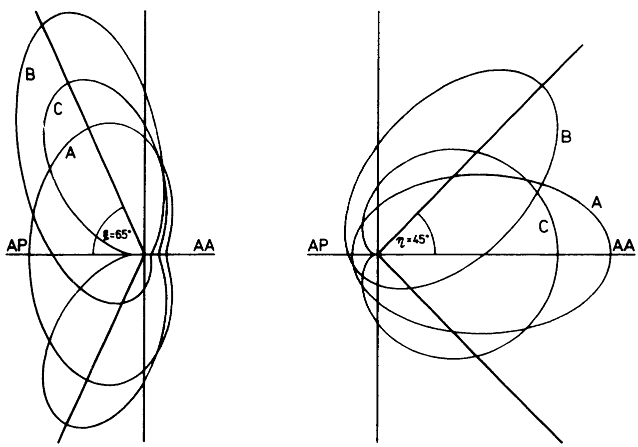

Fig. 1. Models of the elliptical (A,B) and exponential (C) distribution of the true (right) and apparent (left) radiants. Parameters: (A) E=0.8, $\eta=180°$; (B) E=0.8, $\eta=135°$; (C) K=0.4, $\eta=180°$. AP is apex, AA antapex. All distributions are normalized to equal areas.

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maximum in the true radiant distribution for the values $\xi=65°$ and $w=1.34$, used by Lazarev, is possible only in the case $E=0.803$. This value is lower than that derived by Lazarev from Hawkins' data by the least squares method, $E=0.886$. Furthermore, the reverse calculation using $E=0.886$ yields $\xi=80°$, in disagreement with the observed and accepted value $\xi=65°$. As can be seen from Fig. 1, A, the apparent radiant distribution derived from Lazarev's elliptical model, with its very broad HE and AH lobes, cannot be taken as a sufficiently good approximation to the true radiant distribution. An experimental model (Štohl 1975) of the form

$$T(\varepsilon') = A \exp(-K(\varepsilon'-\eta)^2), \tag{3}$$

where A and K are parameters of this distribution, leads to better results regarding the lobes of the HE and AH sources. For the values $\xi=65°$ and $w=1.34$ the maximum of the true distribution in the antapex direction is obtained for $K=0.4$ (cf. Fig. 1, C). Neither of these models, however, with their symmetric distribution of the true radiants and their maxima oriented towards the antapex, is able to explain the observed feature (b), the clearly asymmetric activity of the HE and AH sources.

The radiant distribution obtained from 2310 orbits of faint meteors recorded by radar observations in Kharkov shows, instead of one maximum in the antapex direction, two maxima, each lying about 45° from the antapex in the ecliptic (Tkachuk 1978). This phenomenon has been revealed by other series of observations as well. Reality of the two true maxima is supported by the antapex deviations ζ of the true radiants for orbits of different eccentricity e and semi-major axis a (Fig. 2). For the most frequent values $a=1.5$ and $e=0.75$ of the orbits of meteors constituting the apparent HE and AH sources, antapex deviation $\zeta=45°$ is obtained (+ on Fig.2). An elliptical model with $\zeta=45°$ is presented on Fig. 1, B. It is seen that the lobe of its apparent maximum is more prominent than for the elliptical model A.

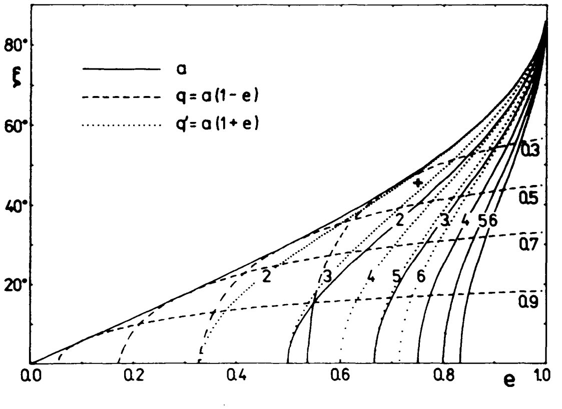

Fig. 2. Antapex deviations ζ of the true radiants for meteor orbits in the plane of the ecliptic as a function of e with a,q, and q' as parameters.

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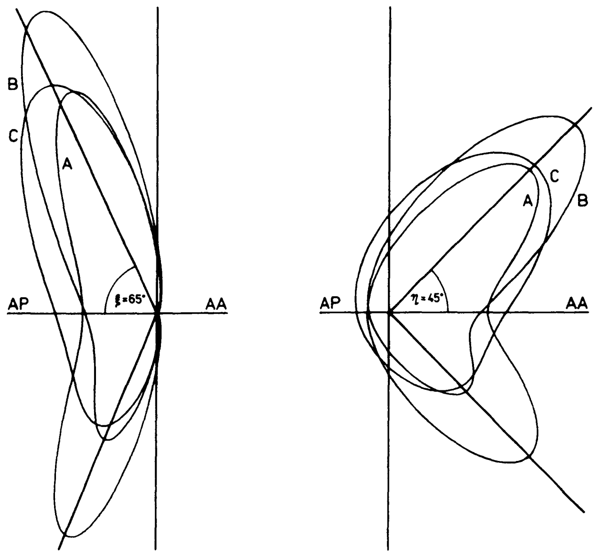

Fig. 3. Bi-elliptical models of the true (right) and apparent (left) radiant distribution. E=0.9 for A and B, E=0.8 for C; ratio of the maximum radius vector of ellipses 1:1 for A, 1:3 for B and C; w=1.1.

Figure 3 illustrates a model which consits of two ellipses oriented at about 45° on either side of the antapex, and changing their parameters A and E with the same amplitude but with a shift in phase. It is apparent that such a bi-elliptical model is able to explain satisfactorily the variations in the HE and AH sources provided the values for the parameters of the ellipses are time dependent and chosen in accordance with the seasonal variation of the apparent radiant sources.

Such a bi-elliptical model might be thought of, physically, as an extremely broad stream of sporadic meteors, including minor showers and associations of Sekanina's type (Sekanina 1973), with orbits concentrated in the ecliptic and distributed elliptically around the mean values a=1.5 and e=0.75. The HE and AH sources can then be looked upon as extremely broad twin showers of this single stream, meeting the Earth twice: in April-June (HE), and in October-December (AH).

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