TWO STATION TELEVISION METEOR STUDIES

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Single station studies cannot provide detailed information such as zenith angle, velocity, heights and magnitude for individual meteors and Ceplecha (1976) has stressed the need for two station television observations which could provide such information through triangulation analyses. This paper deals with some of the results of the first two station television intensifier study of faint meteors, and the implications of these results concerning the validity of the current theories of the structure and ablation of dustball meteors.

The first of our systems was a 3 stage Varo 8586 image intensifier fiber-optically coupled to a MTI type VC-1 vidicon television camera with a 50 mm f/1.4 by Hawkes & Jones (1975). The second system consisted of a two stage image intensifier coupled to a vidicon tube, which we successfully operated well in excess of the manufacturer's specifications. When a 50 mm f/0.95 lens was used limiting sensitivity was about $+7.5^m$. The spectral responses of both systems were approximately visual.

The first system was located near Delaware, Ontario (longitude = 81° 23.3'; W; latitude = 42° 51.4' N; height above sea level = 230 m). The second system was located in Auburn, Ontario (longitude = 81° 31.9' W; latitude = 43° 46.3' N; height above sea level = 290 m). This resulted in a baseline of 102.6 km. The cameras were oriented to intersect at a point 95 km above sea level, and about 20° offset from the center line joining the two stations since simulations had indicated that this configuration was near optimum for minimizing errors in the measured heights.

In order to achieve best sensitivity it was necessary to operate during times of little or no visible moon, because of effects due to light scattered from the atmosphere. Furthermore, clear skies were, of course, required at both stations. These considerations severely limited occasions on which observations could be made. The data presented in this paper were collected over six nights in July, September and October, 1976.

Video recordings were made at each station, with 1 second time markers imposed on the audio channels. The video tapes were then visually analyzed, and meteor occurrences noted. The time information was used to determine meteor coincidences from the two station. In the present study 77 such meteors were observed.

The apparent meteor magnitudes were converted to absolute meteor magnitudes using the formulae developed by Hawkes & Jones (1975) to

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account for movement of the meteor image through more than one resolution cell, the persistence of the television-intensifier system, and the distance of the meteor from the observing station. A least squares fit of these light curve magnitudes (about 15 points per meteor) was performed using a fourth order Chebyshev polynomial. The maximum value of this fitted function yielded a maximum luminosity value for each meteor. The absolute magnitudes at peak luminosity for our meteors were in the range of 0.5^m to $+ 5^m$ and were accurate to $.5^m$.

Meteoroid masses were determined using the formula

$$m = 2 \int I dt/(\tau_{op} v^3)$$

with $\tau_{op}=1\times10^{-19}$(c.g.s.) when the intensity is expressed in units of a zero magnitude star. The masses of the meteoroids in our sample were in the range 10^{-1} to 10^{-4} g and were accurate within a factor of 2.

A preliminary analysis of the radiants and velocities for our sample of television meteors indicated that the majority did not belong to any of the recognized meteor streams.

Following Jacchia et al.(1967) we assumed the variation of height of maximum light with mass, velocity and zenith distance to be of the form

$$H_{max} = c_0 + c_1 \log (m) + c_2 \log (v) + c_3 \log (\cos \chi)$$

and we found the coefficients c_0 - c_3 using the standard least squares method with all points being equally weighted. From this analysis we found:

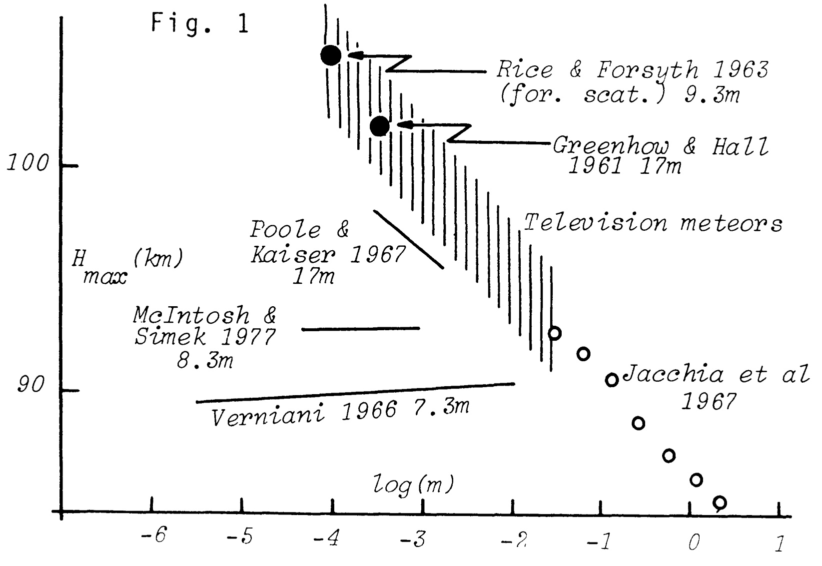
$$c_0 = 68.74 \pm .56 \qquad c_2 = 9.4 \pm 6.17$$

$$c_1 = -5.45 \pm 2.01 \qquad c_3 = -8.34 \pm 6.31$$

for H_{max} in km, m in g and v in km s^{-1}

For the sake of comparison with other data we show the variation of H_{max} with m for v=30 km s^{-1} and log(cos χ)=-.2 in Figure 1 below,

Fig. 1



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together with the data for the standard Super-Schmidt meteors and also several sets of radio meteor data. The agreement between the two sets of optical data is excellent but the discrepancy between the radio and optical data increases with decreasing radio wavelength. We will discuss this point in more detail later.

We have also assumed the magnitude to vary with mass, velocity and zenith distance according to the formula.

$$M = k_0 + k_1 \log m + k_2 \log v + k_3 \log \cos \chi$$

Using a standard least squares fit we found

$k_0 = 11.30 \pm .06$ $k_2 = -8.01 \pm .47$

$k_1 = -1.95 \pm .15$ $k_3 = -.99 \pm .48$

and in Figure 2 we show the variation of magnitude with mass for v=30 km s^{-1} and log (cos χ) = -.2 for both the television and Super-Schmidt data.

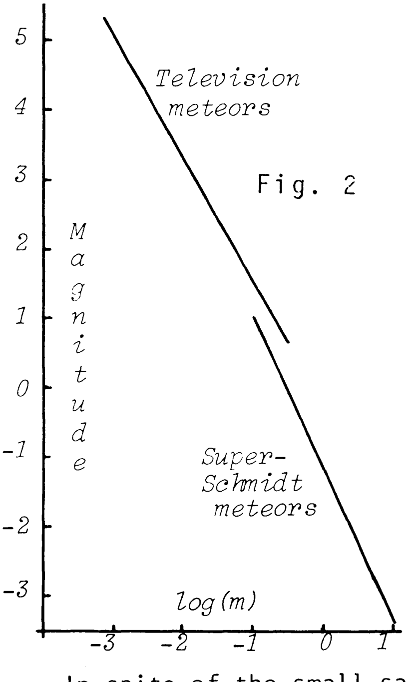

Fig. 2

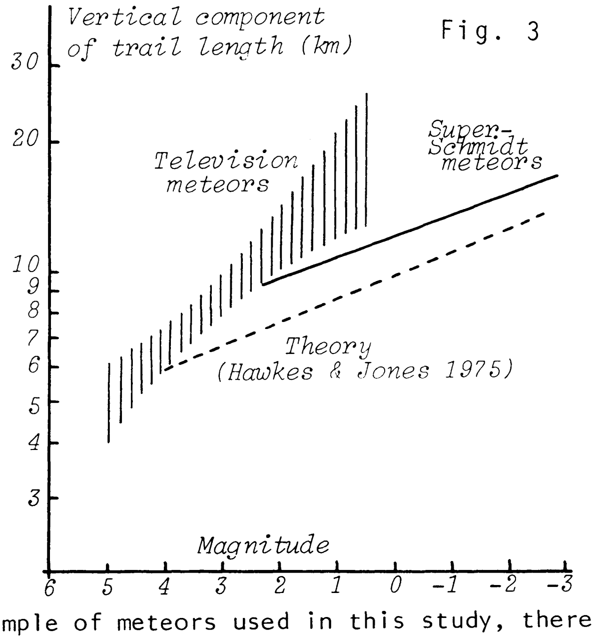

Fig. 3

In spite of the small sample of meteors used in this study, there can be no doubt that the trend of increasing height with decreasing mass seen in the Super-Schmidt meteors is maintained by the much fainter television meteors and indeed there is no hint of a flattening-off of the height-log (mass) curve as had been expected on the basis of the radio meteor data and our own theory of meteoroid ablation. Of course radiation losses must become increasingly important for very small meteoroids but it appears that the radiation ceiling, which is close to 108 km for the mean velocity of meteors in our sample, was not low enough to appreciably depress the heights of ablation of the smallest meteoroids. It

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is also possible that the emissivity of the meteoroid surface and/or the transfer coefficients are significantly less than unity so that our estimate of the height of the radiation ceiling is only a lower limit.

The very poor agreement with the short wavelength radio meteor data is most probably the result of the combined effects of initial train radius and the underdense echo ceiling which have been discussed in detail by Greenhow and Hall (1961) and Greenhow (1963). Even so it is not clear how these factors can cause the weaker echoes to come from lower heights as was observed by Verniani (1966). It is evident that to avoid the influences of these effects in radio meteor studies it is essential to work with a forward scatter system so that even at short wavelengths the geometry results in much smaller attenuation from destructive interference, or to use a backscatter system operating at a wavelength of 17 m or greater.

While we have not yet done any detailed analysis of the light curves, we did note a considerable variation (about 35% r.m.s.) in the vertical components of the trail lengths. In addition the residual errors in heights between the observations and the least squares fit amounted to about 4.6 km. Both of these fluctuations indicate that the meteoroids are fragmenting as they evaporate and this conclusion is supported by the closeness of c_1 to the theoretical value of about 5 for a single main meteoroid.

In order to show the variation of trail length with brightness we have defined a quantity which we call the effective trail length $l_e = \int I dl / I_{max}$. This has the advantage that l_e is easily obtained if the mass, magnitude, velocity and zenith distance are given as for example in Fig. 2 from which we have obtained Fig. 3. The trend of decreasing vertical trail lingth as we go to fainter meteors is in fair agreement with our theoretical model (Hawkes & Jones 1975) and suggests that even better agreement might be obtained by adjusting the parameters of the model.

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Discussion on this paper is included with the companion paper by Sarma and Jones.