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Light curves of very faint meteors

THE variation of brightness as a function of height when a meteoroid burns up (ablates) in the Earth's atmosphere is governed by the physical properties of the meteoroid. The basic theory of the ablation of a solid meteoroid to due to Öpik[1], and the theoretical light curves are in fairly good agreement with the observed light-curves of very bright meteors[2]. In contrast to this the observations of Jacchia[3] and Hawkins and Southworth[4] of faint photographic meteors show that the train lengths of these meteors are much shorter than predicted by the classical theory, and it is principally due to evidence of this sort that the "dustball" theory of Whipple[5] which supposes the original meteoroid to consist of an aggregate of many small solid particles, has become very popular. Nevertheless Jones and Kaiser[6] found that by extending the classical ablation theory to include the effects of the meteoroid's thermal capacity, conduction and radiation they could explain many features of the experimental data in terms of compact meteoroids which fragment as a result of thermal shock. According to Jones and Kaiser[6] it is possible to choose between the two theories on the basis of observations of very faint meteors (magnitude $M > +3$) since these meteoroids should not fragment due to thermal shock if they are compact; on the other hand if they are fragile conglomerates they will probably continue to show the effects of severe disintegration.

To this end we have developed an observing system[7] using sensitive television equipment which has a limiting sensitivity of +8.5 mag for stars when operating with an $f/0.95$, 50 mm lens.

On the night of September 31/October 1, 1973 in London, Ontario, 179 meteors were observed with the system between 11 p.m. and 6 a.m. with the camera pointing north at an elevation of 50°.

Analysis of the video tapes enabled the train lengths perpendicular to the line of sight to be determined assuming the meteors to occur at an altitude of 95 km. The apparent train length l_a is related to the height interval between the starting and finishing height dh by the relation

$$dh = rl_a$$

where r is a random variable depending on the geometry of the camera and the meteor trains. Since at that time of year the activity of meteor showers is expected to be low, we tried two assumptions in order to estimate the mean value of r; a random distribution of radiants and also a point radiant such that all the meteors were supposed to come from the apex of the Earth's way. Fortunately each of these assumptions yielded a mean value of r very close to unity.

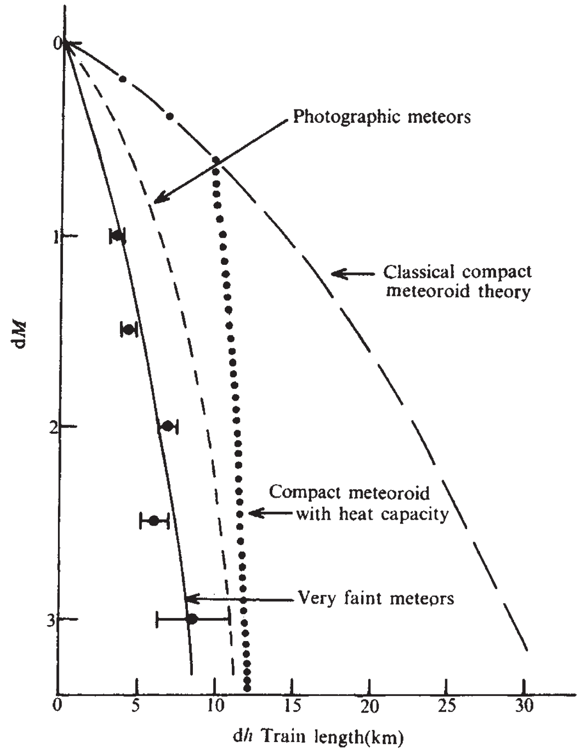

FIG. 1. The difference dM between the magnitude of the meteors and the limiting magnitude of the observing system plotted against dh, the height interval between the starting and finishing height of the meteors.

In this way we obtained the results in Fig. 1 which shows dh as a function of dM, the difference between the magnitude of the meteor and the limiting magnitude of the system. For the sake of comparison we have also shown the theoretical predictions for the compact meteoroid model and the curve of dh against dM computed using the photographic data of Hawkins and Southworth.

It is clear that not only are the train lengths of the television meteors considerably shorter than predicted by the compact meteoroid model but they are also significantly shorter than those of the photographic meteors. We interpret this as indicating that fragmentation is even more severe for the very faint meteors than for the meteors of Hawkins and Southworth observed using Super-Schmidt cameras. On the basis of these results we conclude, albeit reluctantly, that the compact meteoroid model is no longer tenable.

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