troublesome since all meteorites have been filtered during atmospheric entry and only the more durable masses are available for structural studies. Stony meteorites, in space, may have substantial structural weaknesses produced by collision processes, according to Gault and Wedekind (02.105. 167). Optical observations may still be required to investigate structural differences. As an immediate goal, one would like to be able to distinguish between ordinary chondrites and carbonaceous chondrites, both because the known physical differences of these two materials make it seem likely that a separation is possible from optical observations and, more importantly, because the orbital distributions of these two kinds of meteoroids may suggest important differences in their origin.

The increased number of fireball observations now verifies an earlier suggestion that there exists a distinct class of large objects that show remarkably high end heights as compared to other meteors of comparable brightness and velocity. The high-altitude events penetrate no more than 1% of the atmosphere traversed by more usual meteors. Their orbits universally have aphelia in the vicinity of Jupiter and probably are associated with short-period comets. Similar orbits are comparatively rare among other fireballs. It is inconceivable that the high-altitude meteors ever produced a meteorite, and even the carbonaceous chondrites must be searched for among bodies of greater strength or lower ablation coefficients (McIntosh, 04.104.038).

A new form of meteor study has been recently proposed: meteor sound observations, as discussed theoretically by Tsikuzin (02.003.121) and amplified by Revelle and Bartman (1972). The latter propose to make acoustical records of large meteoroids in the atmosphere, including some objects that may be observed photographically by the Prairie Network.

REFERENCE

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RADAR METEORS

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This Section primarily reports on progress in understanding physical processes in the ionized column left by the moving meteoroid. There have been substantial accomplishments here, but there has not been time for meteor radar workers to integrate all the results into a coherent theory. Furthermore, it is likely that there is more to learn, particularly about the mass dependence of several parameters.

Fragmentation in faint radar meteors has been inferred from details of the Fresnel diffraction patterns. At Kharkov, division into two fragments of comparable size was observed, as well as irregularities in the ionization curve interpretable as flares (06.104.023). At Havana (U.S.A.), disappearance or reduced amplitude of the later oscillations of the Fresnel patterns showed that a substantial fraction of the meteors had fragmented into at least several pieces, which were spread up to a few hundred meters along the ionized column. It is to be expected that the fragments must then also be spread across the ionized column; to radar apparatus this has the appearance of a larger initial radius for fragmented meteors. The Havana-Sidell simultaneous radar-television observations (Cook *et al.*, *Coll.* **13**) confirm the effect in the following way. From the shape of the light curve, roughly half the meteors observed by both radar and television could be recognized as fragmenting, and the radar return at some or all stations from these fragmenting meteors was anomalously low compared to the optical brightness.

Dissociative recombination of electrons with O_2^+ and N_2^+ has been inferred from the Havana observations (Southworth, *Coll.*, **13**), using analysis of the Fresnel patterns and the distribution of height vs apparent radar magnitude. Recombination occurs in the first few milliseconds after formation of a sufficiently dense ionized column – i.e., a column with sufficiently large electron line density and sufficiently small initial radius. Recombination places a lower bound on observable heights; this lower bound is higher for bright meteors and lower for faint meteors. Since slow meteor are low, they are missing from radar surveys that do not reach below 10^{10} electrons m^{-1}.

The Havana-Sidell simultaneous radar-television observations determined ionizing probabilities for meteors with photographic absolute magnitudes +4 to +8, velocities 14–36 km s^{-1}, and heights 82–101 km (Cook *et al.*, *Coll.*, **13**). As stated above, fragmenting meteors were omitted from the analysis. Observed ionizing probabilities for other magnitudes and velocities are, of course, much to be desired. It will be necessary but difficult to eliminate the effects of dissociative recombination from ionizing probabilities derived from radar-visual and radar-photographic observations.

The 'initial radius' of the ionized column (the radius after a millisecond or so) has been measured using observations at two or three wavelengths (03.104.020; 06.104.030; 06.104.011). Contrary to simplified physical theories, the initial radius was found to be approximately proportional to the 0.5 power of the atmospheric meanfree path. Fragmentation, however, needs to be taken into account in the analysis of initial-radius data. The upper bound to heights observed at Havana appeared to be diffusion rather than initial radius (Southworth, *Coll.*, **13**); this suggests that initial radius may depend on magnitude. At Kiev (06.104.010), the radial distribution of electrons in the ionized column was observed to fall off slightly faster, in the mean, than in a Gaussian distribution.

Deceleration of radar meteors was observed at Kharkov (03.104.051; 04.104.036) and at Havana. The ionization curve has been determined statistically at Kharkov (06.104.109) and has been routinely observed at Havana.

Electron attachment rates have been observed in enduring echoes at Dushanbe (05.104.021; 06.104.063), as well as a semidiurnal variation in the attachment rate (06.104.049). A diurnal variation in the attachment rate below 90 km has been predicted on aeronomic grounds (Baggaley, 1972).

Any agreement on the distribution of orbital elements of radar meteors must await agreement on the physical selection effect. No distribution corrected for all defects seems to have been published. However, the distribution of orbits observed in Havana from October 1968 to December 1969 has been corrected to yield the orbital distribution of meteors of equal mass, using the ionizing probability determined there. It is possible, however, that there is still a selection effect against fragmenting meteors. This corrected distribution contains less than 1% retrograde meteors and mostly with inclinations under 20°; the majority of aphelia are <3 AU and the majority of perihelia <0·7 AU; the mean velocity outside the Earth's atmosphere is under 20 km s^{-1}.

REFERENCE

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METEOR SPECTROSCOPY

P. M. Millman

Programs of meteor spectroscopy have been continued vigorously in the U.S.A., Canada, Czechoslovakia, and the U.S.S.R. In particular, in North America, the use of batteries of Maksutov-type optical systems equipped with shutters triggered by photomultipliers, and the employment of image-intensifying electronic devices, have resulted in the recording of large numbers of faint-meteor spectra in the 2- to 5-mag. range (05.104.042, 3; Harvey, *Coll.* **13**). These, together with the records of the faint upper portions of bright-meteor trajectories, show promise of giving important informations about the contribution of the lines and the band systems of the lightweight elements hydrogen, carbon, nitrogen, and oxygen to the visible radiation of meteors. In this connection, further improvement of electronic image-intensifier systems, together with the use of these devices in spectrophotometry, is a pressing need for the immediate future. The possibility of extending these investigations into the near ultraviolet and the near infrared should not be overlooked.

No less important is the detailed photometry of faint features in the many-lined spectra of very brilliant fireballs. Research in Czechoslovakia has demonstrated that the band structures of lightweight molecules can be detected in the background among the bright atomic lines, if the dispersion is high enough (06.104.039). Further work in this field should be encouraged as it will contribute