Meteoroid Structure and Fragmentation

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The physical composition and structure of meteoroids gives us insight into the formation processes of their parent asteroids and comets. The strength of and fundamental grain sizes in meteoroids tell us about the environment in which small solar system bodies formed, and the processes which built up these basic planetary building blocks. The structure of meteorites can be studied directly, but the set of objects which survive entry through the atmosphere is biased toward large, strong objects with slow encounter speeds. Fragile objects, small objects and objects with high relative speeds are very unlikely to survive impact with the atmosphere. Objects between 100 microns and 1 meter, which are not strong enough to survive the ablation process, must be studied by radar or optical methods.

When radar waves scatter from the ionization around the head of a meteoroid, or off the ionized trail it leaves in the atmosphere, the echo may be modified if there are several discrete fragments present. Interference between waves reflected from different fragments may smooth out the Fresnel oscillations, or introduce oscillations of different frequencies [1].

Many bright fireballs observed with all-sky cameras fragment into many discrete pieces. From the speed at which they separate, the height of fragmentation can be determined, and the dynamic pressure on the meteoroid at this point gives a measure of the compressive strength of the material. More indirectly, the strength of bright meteors can be inferred from the relative end height and the speed at which ablation proceeds [2].

Smaller meteoroids are typically not observed to have resolved fragments in ordinary wide-field cameras, because the fragments do not spread significantly compared to the resolution of the system. Light curves have been used as proxies to determine the fragmentation behaviour and fundamental grain sizes of meteoroids, though the link between light curve shape and fragmentation behaviour is more complicated than classical models suggest [3]. The strength and compostion of faint meteors also influence the begin heighs, which can be used to estimate the relative strength of meteoroids in the absence of clear fragmentation [4].

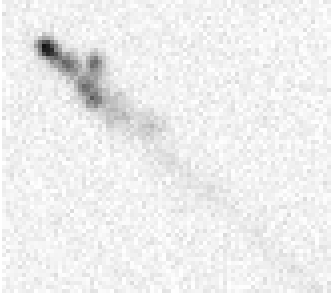

Figure 1: Fragmenting meteor observed with the Canadian Automated Meteor Observatory.

The Canadian Automated Meteor Observatory, with its narrow field tracking camera, can distinguish meteoroid fragments less than 10 metres apart. Hundreds of meteors observed with this system are being used to probe the fragmentation behaviour of millimeter-sized meteoroids.

References

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[4] Ceplecha, Z. (1988). Earth's influx of different populations of sporadic meteoroids from photographic and television data. Astronomical Institutes of Czechoslovakia, Bulletin, 39, 221–236.