New look at meteor streams?

from David W. Hughes

METEOR streams are elliptical rings of dust containing a myriad of particles all moving with orbits very similar to that of the comet which ejected them as it decayed. The stream particles move through the general Solar System dust cloud which is made up of particles with random orbits. Cloud particles were once in streams but they have been perturbed from their specific orbits by interparticle collisions, close approaches to planets and radiation effects.

The Earth passes through many of these streams each year at relative velocities of between 11 and 74 km s^{-1}. Stream particles which hit the atmosphere burn up, forming visual meteor trains (shooting stars) if they are 0.1 g or more in mass, or radio meteor trains (detectable as reflectors of radar pulses) if they have masses greater than 10^{-7} g. Smaller stream particles are more difficult to observe. Some space-vehicle experiments have reported large increases in microparticle fluxes associated with streams. However, extrapolations of radio meteoroid fluxes to smaller masses indicate that streams contain very few of these particles. It has been suggested that the satellite borne detectors are registering micrometre-sized lunar ejecta produced by the impact of larger stream meteoroids.

Over the past few years a new method of observing meteor streams has been suggested which relies on detecting the solar radiation reflected by the orbiting stream dust particles. These should scatter radiation in a similar way to the particles in the Solar System dust cloud. The scattering from this cloud produces the zodiacal light and the streams should produce localised enhancements in this light. The problem can be approached in two ways. A. C. Levasseur-Regourd and J. E. Blamont (*Space Res.* **15**, 295; 1975) measured the zodiacal light brightness using the French satellite D2A. They found localised enhancements of brightness at specific points in the Earth's orbit. They concluded that these variations were caused by a local excess of scatters produced by the Earth's passage through a meteor stream. The photometer can point in nine directions which are all in a plane perpendicular to the Earth–Sun line. The field of view is about 3°×3°. Sometimes the enhancement only occurred in one direction, at others in two diametrically opposite directions and in certain cases the enhancement could be detected all around the satellite. From year to year enhancements were found at the same time and in the same directions. The brightness usually increases by about 25% (that is, by between 10 and 50 $S_{10}(V)$ units on a signal of 140 $S_{10}(V)$ this lasting for between 1 and 17 days). (A brightness of 1 $S_{10}(V)$ unit is equivalent to the brightness produced by having one star of visual magnitude +10.0 per square degree of the field of view or an energy flux of 1.31×10^{-9} erg cm^{-2} s^{-1} $star^{-1}$ $Å^{-1}$). The authors conclude that the average size of the inhomogeneity in the plane of view is about 0.15 AU. By assuming that the particles in the meteor stream have the same size and reflecting properties as sporadic zodiacal cloud particles and by measuring the spatial extent of the stream of scatters Levasseur-Regourd and R. Dumont (*COSPAR, XX Plenary meeting, Tel Aviv,* paper III C.3.2.) could estimate the ratio of the particle number density in streams to that outside. This ratio was found to be as high as 18.

W. J. Baggaley of the University of Canterbury, New Zealand, approaches the problem from another direction. He uses the known properties of the particles in meteor streams and considers how effectively they will produce zodiacal light enhancements. His theoretical calculations are given in a recent edition of *The Observatory* (**97**, 123; 1977). Meteor stream dust is optically thin, the particle number density being so low that mutual eclipsing is rare. During an Earth–stream interception (which occurs every time we have a meteor shower) an observer looking in the direction of the true geocentric shower radiant will be observing tangentially to the stream orbit and his line of sight will intersect a large volume of dust particles. The numbers of micrometre-sized particles present have been estimated by extrapolating from particle size distribution measurements made using radar techniques. Using experimentally determined phase functions and an albedo of 0.1 Baggaley integrates along the tangent and calculates the brightness that should be observed in the geocentric radiant direction. For the Quadrantid, Perseid and Geminid streams these brightnesses are 0.57, 3.44 and 1.09 $S_{10}(V)$ units respectively. The total sky brightnesses in these directions, caused by zodiacal light, integrated starlight and atmospheric airglow are 178, 222 and 229 $S_{10}(V)$ units. So the streams theoretically produce an increase of at most 1.5%. The bright patches of light should be elliptical in shape because meteor streams are more dispersed in the plane of the orbit than normal to this plane (by a factor of about 10). The Quadrantids, Perseids and Geminids would produce bright patches of maximum angular extent around 10, 10 and 5 degrees respectively.

Baggaley concludes that the major annual meteor streams would not produce any observable radiant glow, assuming of course that the extrapolation of flux *versus* size data is applicable and that the measured spatial particle-number density (about 10^{-16} cm^{-3}) is correct. The fact that Levasseur-Regourd and Blamont do see streams in the zodiacal light indicates that the radio meteor flux and size distribution data must be re-examined. Either that or the collisional fragmentation which perturbs stream particles into the sporadic background changes their reflecting properties.

David W. Hughes is a Lecturer in the Department of Physics, University of Sheffield.

to analysis by optical diffraction and three-dimensional reconstruction.

Since the filaments lie in a hexagonal lattice, exactly equivalent bonds could be made between each filament and its neighbours if actin subunits were to occur at azimuthal intervals of 60°. Although the non-integral helical symmetry of the actin filaments does not satisfy this condition, the symmetry is such that actin subunits present many different azimuths during one axial repeat of the structure. By building models of filaments with the symmetries established by optical diffraction, DeRosier *et al.* have shown that the departure from 60° is small at certain points along the filament. Placing these filaments on a hexagonal lattice in the arrangement deduced from the diffraction patterns, they conclude that bonds between filaments can be made at these points if distortions are allowed. The distortions required are small—of the same order as those discussed by Caspar and Klug for quasi-equivalent bonding between the subunits of spherical viruses (*Cold Spring Harbor Symp. quant. Biol.* **27**, 1; 1962). As pointed out by these authors, such an ordered structure need not have all identical molecules in exactly identical environments. 'The important point is that the lowest energy structure will have the maximum number of most stable bonds formed—and this may be