Dust from beyond the Solar System

David W. Hughes

A sensitive radar in New Zealand has for the first time detected the faint meteors produced by interstellar dust grains hitting the Earth. It even points to nearby, young stars as being among the sources.

DUST particles are continually striking the Earth's upper atmosphere. Each meteoroid rapidly loses mass and velocity, leaving behind it a train of excited and ionized gas. This train can be seen as a meteor (colloquially known as a shooting star), and can also reflect radar pulses (when it is known as a radio meteor).

Almost all meteoroids have incident velocities between 11 and 73 km s⁻¹. The former is the Earth's escape velocity, so anything falling to Earth will be travelling at least that fast. The latter velocity is reached in a head-on collision with a meteoroid in a parabolic orbit around the Sun; that is, one with just enough energy to be on the border between a bound, closed orbit and an unbound one. Meteoroids in the above velocity range are members of the Solar System, and have been produced by the decay of comets and by collisions between asteroids.

Throughout the history of meteor science, people have wondered whether any incident meteoroids have hyperbolic orbits (with enough energy to be unbound). Rather than being miniature planets of our own Sun, hyperbolic meteoroids would have an origin beyond the Solar System. The easiest way of detecting them is by looking for a geocentric velocity in excess of the upper limit of 73 km s⁻¹ given above. Öpik estimated¹ that between 60 and 70 per cent of the meteoroids that were not associated with the well-known showers were hyperbolic. Lovell² thought that this value was far too high, and by the 1960s Öpik^{3,4} had reduced his value to around 3 per cent.

It is clear that our Solar System must be a source of hyperbolic meteoroids for other planetary systems. Consider comet Swift-Tuttle, the parent of the Perseid meteor shower that is active throughout most of August. Swift-Tuttle has an orbital period of 130 years and at perihelion it has a velocity of 42.2 km s⁻¹, very close to the parabolic limit. At perihelion the 'dirty snowball' cometary nucleus is sublimating furiously, and millimetre and submillimetre dust particles are being blown away from its surface at a relative velocity of around 0.9 km s⁻¹. Any dust that is emitted in the direction of the comet's motion moves off on a hyperbolic orbit⁵, and typically 40 per cent of the dust lost by this comet leaves the Solar System and moves off through the Galactic disk.

The proportion of hyperbolic meteoroids produced increases as the meteoroid mass decreases. Comets with shorter orbital periods and with nuclei that have direct rather than retrograde spin will be considerably less prolific when it comes to producing hyperbolic meteoroids.

On page 323 of this issue, Taylor, Baggaley and Steel⁶ recount how they have used a powerful radar telescope near

fast-spinning A- and B-type stars are unlikely to have planetary systems because their original stellar nebulae are too hot for planets to condense⁷. Planetary systems with large numbers of gas giant planets, and thus decaying comets, are prevalent around single G and K stars with masses in the 1 to 0.25 solar mass range. Maybe the New Zealand high-velocity particles are produced by a differ-

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The trail of a Perseid meteor at dusk. The dust particle that produced this meteor came from a comet within our Solar System, but tiny meteors from other stars have now been detected by radar. No visible shooting stars have yet been shown to be of interstellar origin.

Christchurch, New Zealand, to measure the orbits and sizes of incident meteoroids. Just under 1 per cent of all the meteoroids they detected had velocities in excess of 100 km s⁻¹. As this is far above the parabolic limit, the authors are confident that these meteoroids are from beyond the Solar System. The typical diameters of the detected meteoroids were between 15 and 40 µm.

What is even more exciting is that the annual variability of the hyperbolic meteoroid flux reveals the direction of the sources of these particles. Three major sources are identified. One is a group of nearby luminous A-type stars; another is a local group of even brighter B-type stars and young star clusters moving past the Sun; and the third is associated with the direction in which the Sun is moving around the Galaxy.

It is interesting to note that massive,

ent mechanism from the one seen in our own Solar System.

It also seems that the fraction of hyperbolic meteoroids decreases as the particle size goes up. Still, it is refreshing to know that even though more than 99 per cent of the dust in the Solar System is 'home grown', at least a fraction of a per cent comes from beyond. □

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