# Why meteors light up the night sky

February 9 2015, by Jonti Horner, Donna Burton And Tanya Hill

A bright fireball over the Atacama Large Millimeter/submillimeter Array, ALMA, in Chile, marks the fiery death of a small grain of space debris, high in the atmosphere. Credit: ESO/C. Malin, CC BY-SA

Meteors have been seen since people first looked at the night sky. They are comprised of small pieces of debris, typically no larger than a grain of dust or sand, which continually crash into the Earth's atmosphere.

As that debris plunges deeper and deeper, friction with the atmosphere causes it to ablate – burning up from the outside in. This usually occurs within the mesosphere, typically at a height of about 80km.

The larger the debris, or the faster it is moving, the brighter the resulting meteor. The slowest particles hit our atmosphere at a speed of about

12km/s, with the fastest travelling at up to 72km/s.

This extreme speed is what allows these tiny objects to burn so brightly. The kinetic energy an object carries is proportional to its mass multiplied by its velocity squared, meaning that minuscule grains moving really fast carry vast amounts of energy.

That energy is converted to light, which is what we see when a meteor flashes in the night sky.

## First, some terminology

There is some confusion over what is meant by particular terms, which are often mixed up in casual conversation, and the popular press. So here's the breakdown:

**Meteoroid:** Any piece of small rock, metal or ice moving through space. The closer you look, the more pieces of debris there are, although the smallest are quickly blown to interstellar space by the radiation pouring from our sun.

**Meteor:** The visible flash of light observed as a meteoroid ablates in the Earth's atmosphere.

**Meteorite:** If an object makes it through the atmosphere to reach the ground, it is called a meteorite. Meteorites range from a few grams to many tonnes in mass, with the smallest and lightest falling most frequently. The most massive meteorite found to date is the Hoba meteorite, from Namibia, with a mass of about 66 tonnes.

**Fireball:** A meteor that is unusually bright, outshining almost everything in the night sky. Typically, any meteor brighter than magnitude -4 (i.e. brighter than Venus) is considered a fireball.

**Micrometeoroid:** The smallest meteoroids – effectively cosmic dust – so tiny that they can enter the Earth's atmosphere without ablating, as friction with the most tenuous layers of Earth's atmosphere rapidly slows their entry. These minuscule grains are more like particles of smoke. They can reach Earth's surface intact, and many have been collected by aircraft for scientific study.

## Meteorite: fall vs find

When scientists study newly recovered meteorites, they break them up into two types – falls and finds.

Most meteorites are located long after they fell, often years or even centuries ago, so they will have suffered the effect of weathering and chemical processes here on Earth. Known as "finds", these make up the bulk of meteorites collected, and include many found on the icy surface of Antarctica.

"Falls" are far more valuable and rarer. These are meteorites whose passage through the atmosphere has been observed and reported. This allows scientists to find them before they have been affected by weathering or other processes on Earth.

So valuable are "falls" that networks are being set up to try to track and recover such objects. One such is the Australian Desert Fireball Network which you can help by reporting any particularly spectacular fireball you see, just in case something fell that can be recovered.

## Meteor showers

On any clear dark night, a keen-eyed observer can see between five and ten meteors per hour, with the rates increasing toward dawn (see graphic below for why). These "sporadics" occur when Earth collides with random debris as it follows its orbit around the Sun.

At certain times of the year the dust through which Earth moves is significantly denser and so meteor showers occur.

Comets (and some asteroids) shed material as they swing close to the sun, and that debris continues to move on an orbit similar to that of its parent.

After a comet's orbit first brings it close enough to the sun to out-gas, it will continue to shed dust and gas with every perihelion passage. This dust slowly spreads around the comet's orbit, following almost identical paths but with slightly longer or shorter orbital periods.

Consequently, the orbits of these objects become clad in debris. The density of material increases as you approach the parent's orbit, and the source itself. If the orbital orientation is just right, the Earth will move through those swathes at the same time each year, and an annual meteor shower is born.

Because the debris is moving in the same direction as it hits the Earth, the meteors in a given shower will appear to radiate from a small area on the night sky, known as the radiant.

This is purely a matter of perspective. As the debris moves towards our vantage point, the particles appear to diverge as they burn up in the mesosphere.

With one exception (the Quadrantids), meteor showers are named for the constellation from which they appear to radiate – the Geminids radiate from Gemini while the Leonids come from Leo.

The Quadrantids are instead named in memory of a dead constellation – Quadrans Muralis – which was subsumed into Boötes when the current approved list of 88 constellations was finalised by the International Astronomical Union, in 1922.

## Showers and storms, young and old

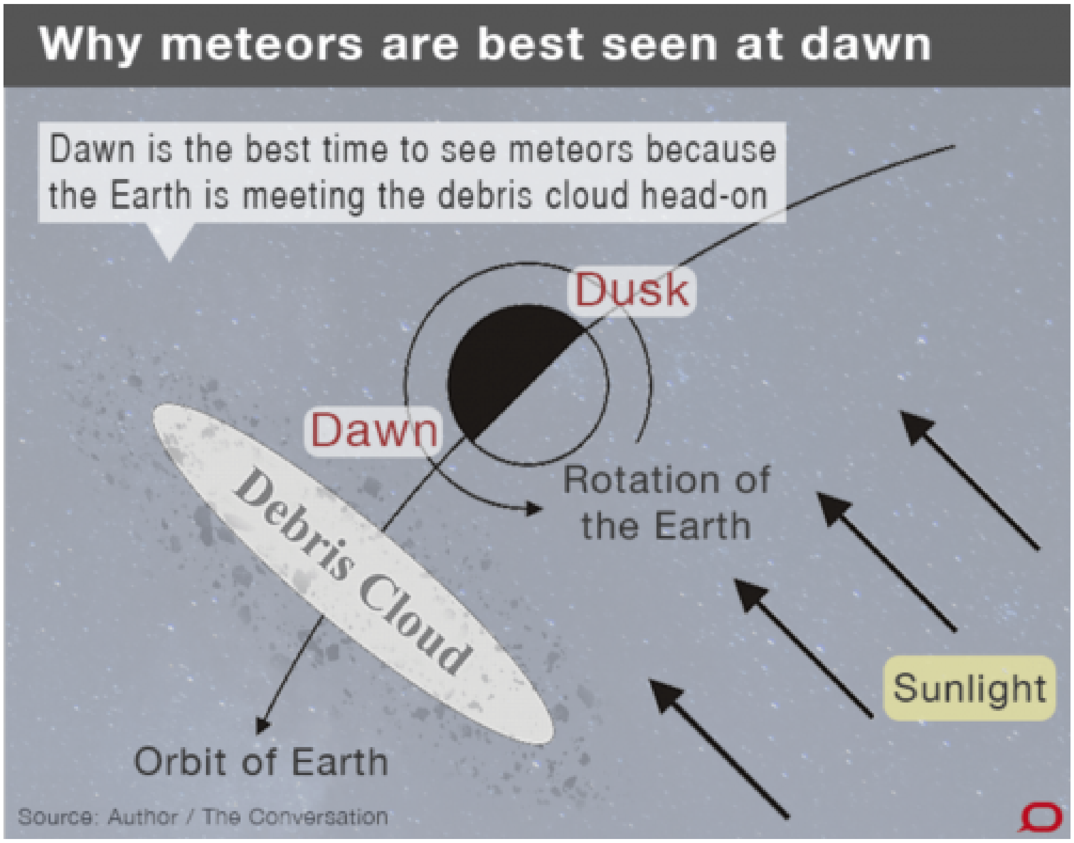
With each swing around the sun, the parent of a meteor shower adds more material to its debris stream, which continues to spread and disperse to space. As a result, meteor showers change as they age.

Young meteor streams are often narrow, containing a high density of material near to their parent object, with little elsewhere. If the Earth intersects one of these narrow, dense filaments, a meteor storm can result, with thousands or even tens of thousands of meteors per hour. Such storms are rare, but can sometimes be predicted in advance.

In years without a meter storm, young meteor showers typically display low rates, with activity that varies depending on the distance from the parent in a given year. Famous examples include the Leonids and the Draconids.

Meteor showers in their prime are relatively broad, with the Earth encountering debris for a week or more. They provide a long period of low rates, and gradually build to a relatively sharp maximum.

At their centre, such showers retain a relatively dense stream of material, released too recently to have fully dispersed, leading to rates of up to (or in excess of) a hundred meteors per hour.




The main meteor showers of a normal year, such as the Eta Aquariids, Orionids and Geminids, are good examples.

Old meteor streams, laid down in the distant past, are typically very dispersed and take the Earth a month or more to cross. Within those streams, debris is well spread out, and only a few meteors per hour can be seen.

If the parent of a given shower is deflected to a new orbit, or runs out of volatiles, its stream continues to disperse with rates gradually falling until they are indistinguishable from the sporadic background.

A woodcut depicting the great Leonid storm of 1833, when up to a hundred thousand meteors per hour were observed from the United States. Credit: Adolf Vollmy/Wikimedia

The Taurid shower, visible from September to December each year, is the most famous example of an old meteor stream, albeit one that can still offer surprises!

## Ghosts of comets past

Sometimes a comet falls apart, fragmenting and disintegrating to nothingness. A great example of this was comet 3D/Biela, which fell apart in spectacular fashion in the 19th century.

The debris of that disintegration continued to orbit the sun and provided a spectacular epitaph for the comet with the Andromedid meteor storms.

Meteors streak outwards from the top of Orion's head as seen in 2012 from central Victoria. Credit: Phil Hart, CC BY

Two particularly spectacular outbursts of meteors were seen in 1872 and 1885 from the shower tied to the comet, as the Earth passed through its slowly dispersing remains.

## Meteor showers to come

Over the centuries, meteor showers wax and wane. The orbits of some showers rotate so that they no longer encounter Earth, and their rates peter out to nothing.

Sketch of Comet 3D/Biela made in February 1846, a few weeks after the comet had split into two pieces. After its next apparition, in 1852, the comet was never seen again, and is thought to have disintegrated. Credit: E. Weiß/Wikimedia

Others streams rotate in, birthing new showers, and fresh streams are born as comets are flung onto new orbits.

As a result, astronomers are continually alert to the birth of new showers.

With every newly discovered asteroid or comet whose orbit approaches the Earth, astronomers check whether a meteor shower could result. This leads to predictions of potential new showers, such as last year's Camelopardalids.

Even given everything we know, however, we can still be caught by surprise. So it can be well worth gazing at the sky on any clear night, just in case you get to catch the birth of a new shower.

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