ICE & STONE 2020

WEEK 35: AUGUST 23-29

Presented by The Earthrise Institute

#35

Authored by Alan Hale

THIS WEEK IN HISTORY

AUGUST 23, 1862: The comet now known as Comet 109P/Swift-Tuttle passes through perihelion at a heliocentric distance of 0.963 AU. The comet had been discovered the previous month independently by Lewis Swift and Horace Tuttle, and became a conspicuous naked-eye object. It is the parent comet of the Perseid meteor shower and is a future "Comet of the Week."

AUGUST 23, 2007: British astronomer Brian May, best known for being guitarist of the rock band Queen, successfully defends his doctoral dissertation on the subject of the motions of dust streams within the zodiacal light. Dust in the solar system is the subject of this week's "Special Topics" presentation.

AUGUST 24, 2006: On the last day of its General Assembly in Prague, Czech Republic, the members of the International Astronomical Union remaining in attendance vote on a definition of "planet" that excludes Pluto and introduces a new category of solar system object, the "dwarf planet," into which Pluto and several other worlds, including the main-belt asteroid (1) Ceres, are placed. Pluto is discussed in a previous "Special Topics" presentation, and the Kuiper Belt objects whose discovery precipitated this issue are discussed in next week's "Special Topics" presentation.

AUGUST 24, 2020: The Amor-type asteroid (85275) 1994 LY will pass 0.115 AU from Earth. It is currently traveling towards the south-southeast through the constellations of Sagittarius and Corona Australis and is near magnitude 13.5; it will enter southern circumpolar skies by the end of this month and will pass within 10 degrees of the South Celestial Pole – still at 15th magnitude – in mid-September.

AUGUST 24, 2261: Comet 109P/Swift-Tuttle, the parent comet of the Perseid meteors, will pass 0.147 AU from Earth and should become a bright and conspicuous naked-eye object.

AUGUST 25, 1865: A 5-kg meteorite falls to the ground near the town of Shergotty (now Sherghati) in northeastern India. The Shergotty meteorite is now known to have come from Mars and is the prototype of the largest sub-classification of Martian meteorites.

AUGUST 25, 2003: NASA's Spitzer Space Telescope is launched from Cape Canaveral, Florida. Spitzer, which was retired from service earlier this year, examined the universe in the infrared, and throughout its lifetime it observed numerous comets and performed many important examinations of them.

23 24 25 AUGUST 26 27 28 29

AUGUST 26, 2020: The main-belt asteroid (30523) 2001 MK23 will occult the 7th-magnitude star HD 22317 in Taurus. The predicted path of the occultation crosses central Algeria, the islands of Sardinia and Corsica, northern Italy, far eastern Switzerland, central Germany, far western Denmark, the southern tip of Norway, and southern Greenland.

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AUGUST 28, 1758: While examining the comet of that year – Comet de la Nux C/1758 K1 – the French astronomer Charles Messier notices a diffuse object in the same field of view, which did not move from night to night. This was the object now known as the Crab Nebula, and it inspired Messier, who would later become the top comet-discovering astronomer of his time, to compile a catalog of deep-sky objects that might otherwise distract him and other comet-hunters. Messier's brightest comet is this week's "Comet of the Week."

AUGUST 28, 1993: While traversing the main asteroid belt, NASA's Galileo spacecraft passes by the asteroid (243) Ida. The images returned by Galileo reveal the presence of a small moon, since named Dactyl, orbiting around Ida. This was the first confirmed discovery of a moon accompanying an asteroid, and these objects are discussed in a future "Special Topics" presentation.

AUGUST 28, 2020: The first-known and largest main-belt asteroid, (1) Ceres – also a "dwarf planet" – will be at opposition. It is currently traveling towards the west-southwest through southern Aquarius and is slightly brighter than 8th magnitude.

23 24 25 26 27 28 AUGUST 29

AUGUST 29, 2011: Astronomers at Mauna Kea Observatory in Hawaii discover the asteroid 2011 QF99, which was later identified as being the first-known "Uranus Trojan" asteroid – of only two that are known so far. Trojan asteroids are the subject of a future "Special Topics" presentation.

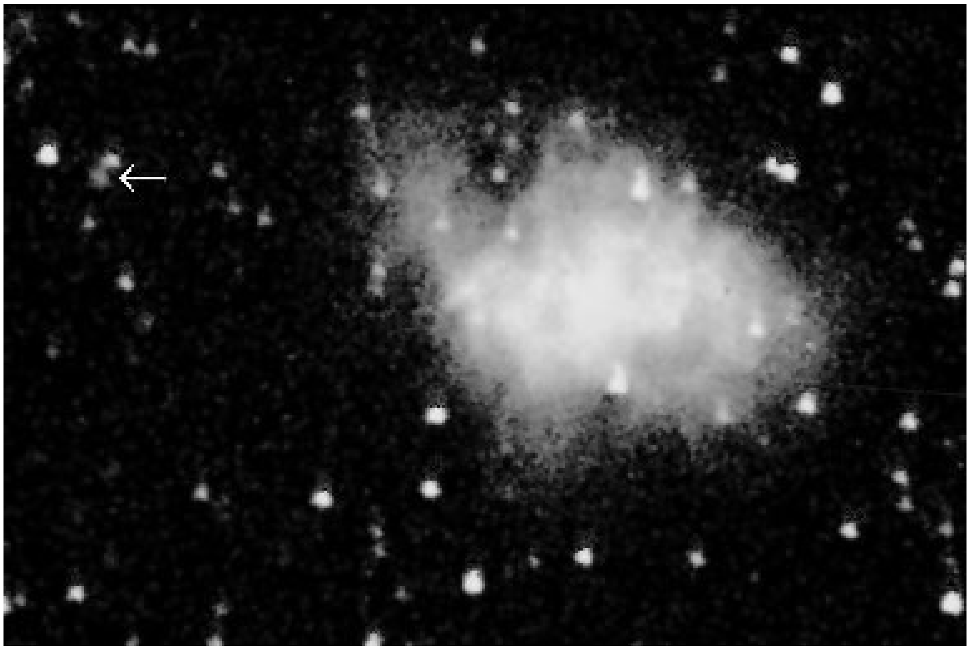
COVER IMAGE CREDIT:

Front and back cover: An artist's concept depicting a view of comet Wild 2 as seen from NASA's Stardust spacecraft during its flyby of the comet on Jan. 2, 2004..

Courtesy NASA/JPL-Caltech

COMET OF THE WEEK: MESSIER C/1769 P1

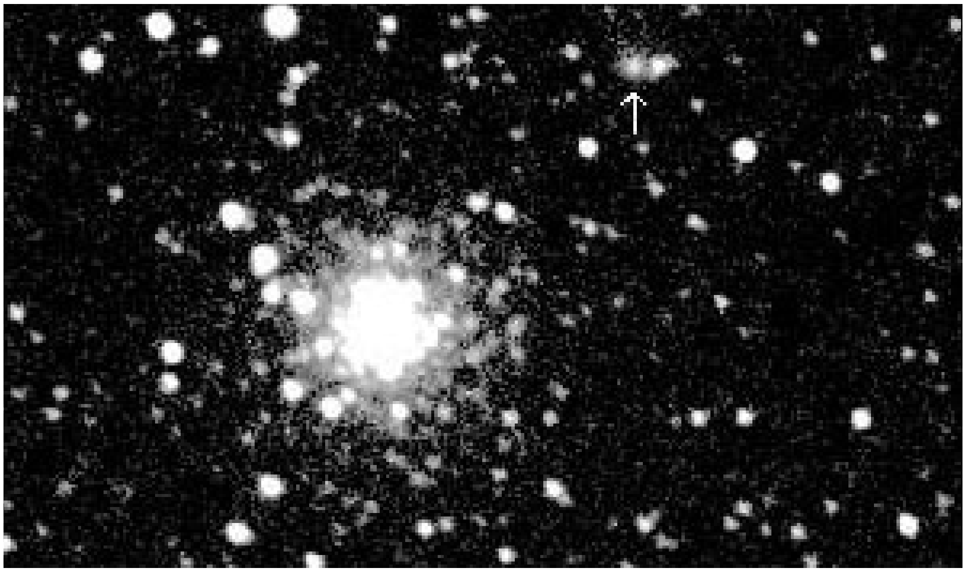
Perihelion: 1769 October 8.12, q = 0.123 AU



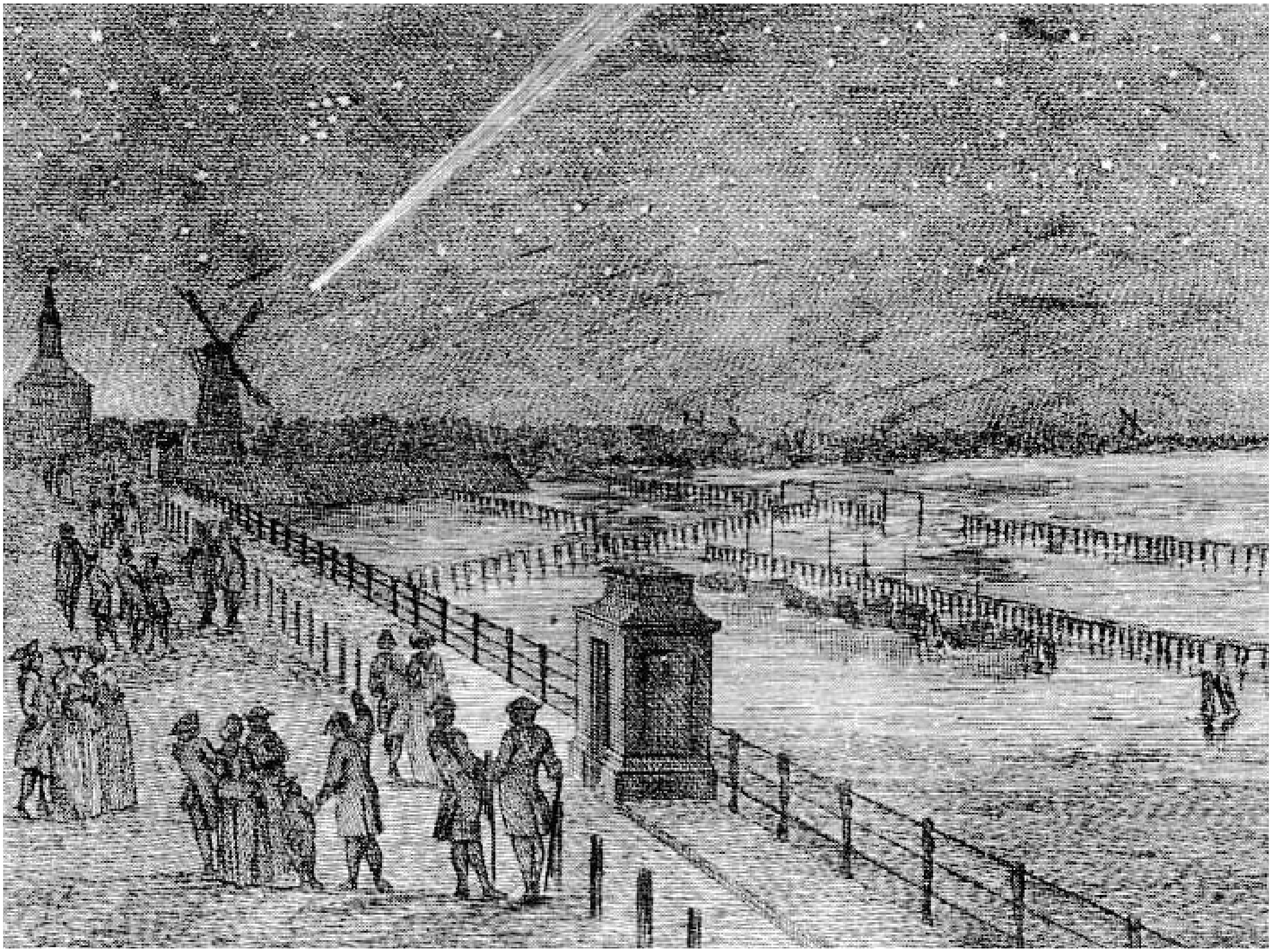
A comet passing by the Crab Nebula, M1. This is a CCD image of Comet 81P/Wild 2 – the Week 1 "Comet of the Week" – I took on the evening of April 28, 2003.

As discussed in the "Special Topics" presentation on that object, in the early 18th Century the British astronomer Edmond Halley predicted that the comet that now bears his name would be returning around 1758. As that time approached several astronomers became involved in the effort to search for it. One of these was an enthusiastic French astronomer, Charles Messier, who worked at the Marine Observatory in Paris (funded by the French Navy) under the supervision of astronomer Joseph-Nicolas Delisle. In mid-August 1758 he did manage to find a comet, however this one had been discovered three months earlier by a fellow French astronomer, Jean Baptiste de la Nux. Messier nevertheless followed de la Nux's comet, and on August 28 he noticed a similar diffuse object in the same telescopic field of view; unlike a comet, however, this object stayed in the same location night after night. Messier eventually did find Comet Halley in January 1759, however he had been beaten to it almost a month earlier by German amateur astronomer Johann Palitzsch.

This entire series of events inspired Messier to devote his life to comet hunting, and over the next four decades he became the champion comet discoverer of his era. He claimed a total of 21 comet discoveries, although some of these were made after they had been found by other astronomers, and modern catalogs generally credit him with somewhere between 12 and 15 discoveries. He apparently went about this effort single-mindedly, and an oft-repeated anecdote – which may very well be apocryphal – relates how when he had to tend to his wife during a long illness (to which she eventually succumbed), one of his competitors, Jacques Montaigne, discovered a comet. After his wife's passing, when a friend stopped by to console him for his "loss," he supposedly replied "Alas, I have discovered a dozen comets, only to be robbed of my thirteenth by that Montaigne!" Then, realizing what he had just said, he corrected himself, "Ah, the poor woman."

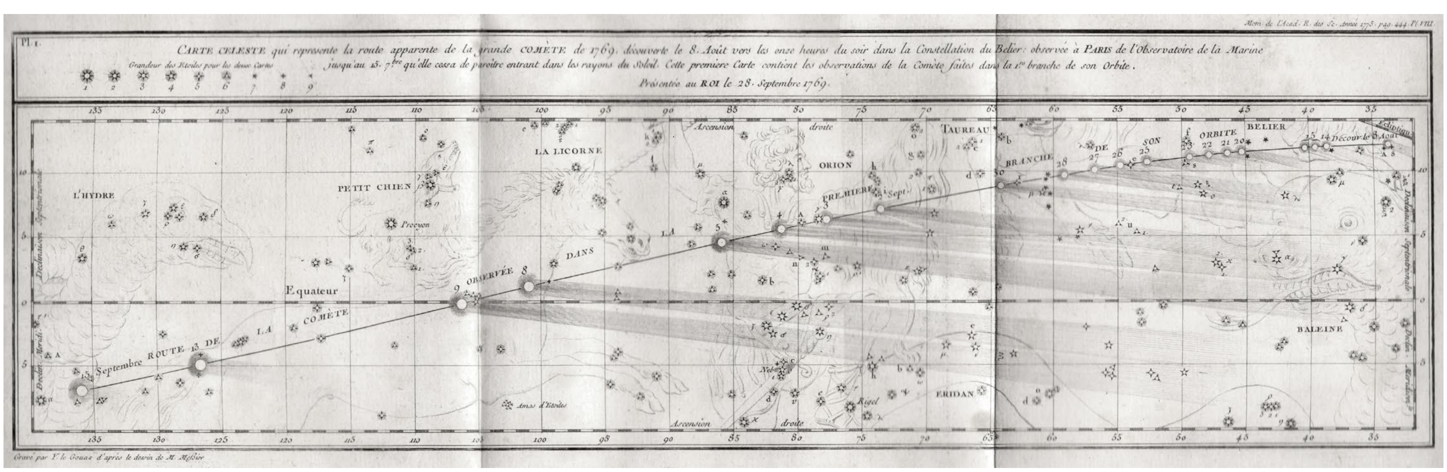


Images I have taken of comets passing by deep-sky objects in Messier's catalog. CCD image of Comet 65P/Gunn passing by the globular star cluster M70 on July 2, 2003.

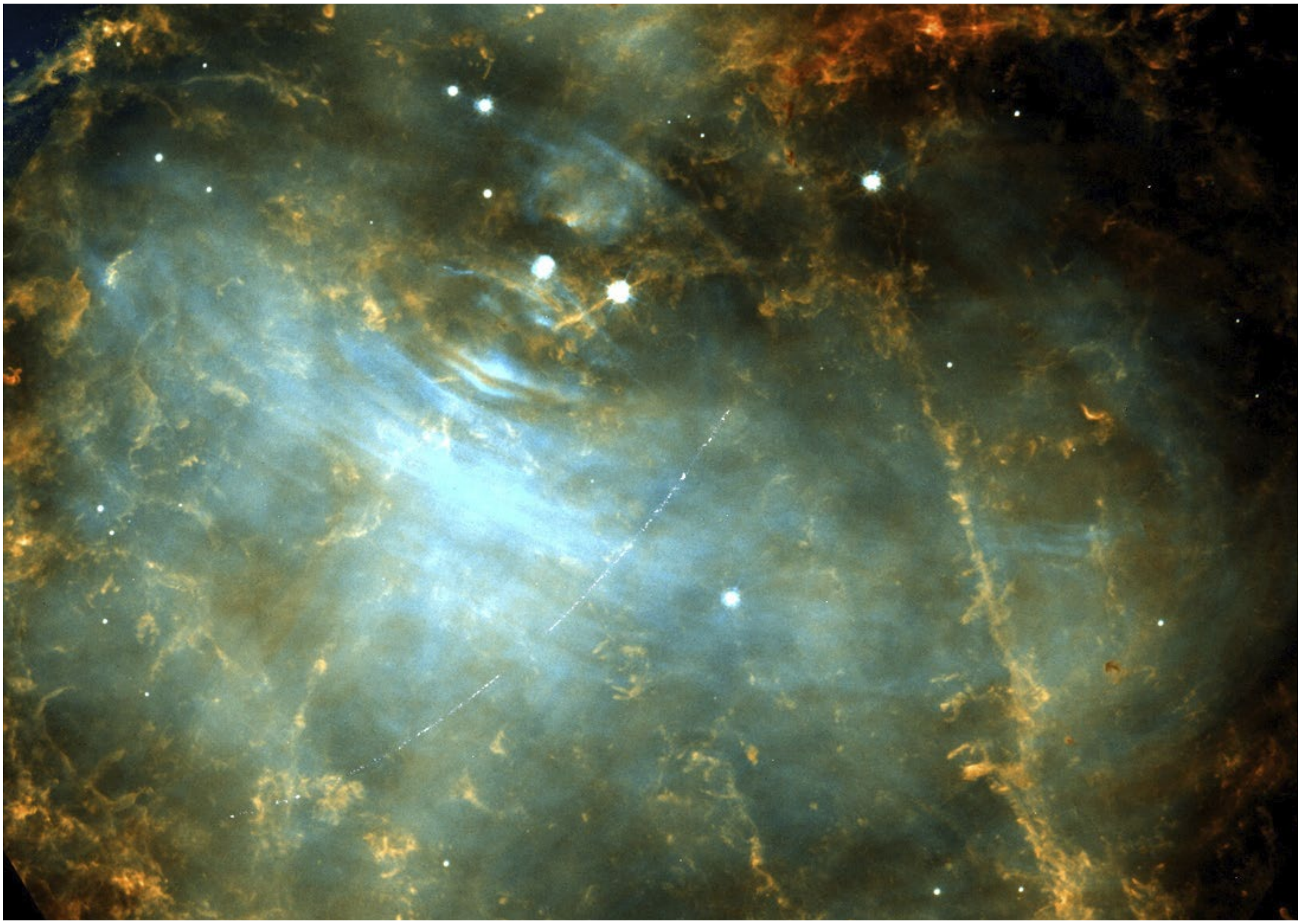


Comet Messier as it appeared from Amsterdam, September 1769. The exact date is uncertain.

The object that Messier found on August 28, 1758 while he was examining Comet de la Nux was what we now call the Crab Nebula, located in Taurus. It is a large cloud of glowing gas, created by a massive star that exploded as a supernova in 1054 and which was observed by Chinese astronomers as well as in Europe and Arabia and by Native Americans (where it appears on a pictograph at Chaco Canyon in New Mexico). As an aid for himself and other comet-hunters Messier compiled a list of these stationary "nuisance objects" as he came across them in his search efforts, so that he and others would not



A chart constructed by Charles Messier showing the path of his 1769 comet through the constellations, along with its approximate appearance. Courtesy Henk Bril.



Hubble Space Telescope image showing the curved trail of the main-belt asteroid (190838) 2001 SE101 crossing the central regions of the Crab Nebula on December 5, 2005. Courtesy NASA/ESA HST ACS/Melina Thevenot.

waste their time on them. He eventually cataloged 103 such objects, although in more recent years astronomers have identified additional objects in Messier's notes and have added seven more to the overall catalog.

In a rather ironic twist of fate, Messier today is primarily known not for the comets he so single-mindedly hunted, but rather for this list of "nuisance objects" that he compiled while engaged in that activity. Indeed, Messier's catalog contains many of the nighttime sky's brightest and/or scientifically most important star clusters, gaseous and dusty nebulae, and galaxies, and continues to be referenced by astronomers all the time.

Some of Messier's comets were nevertheless bright or otherwise important in some way. One of the most important ones is a comet he discovered on June 14, 1770, which then passed just 0.015 AU from Earth at the beginning of July, the closest confirmed cometary approach to Earth in history. The story of this comet, which was named for the mathematician who computed its orbit, Anders Lexell, is related in a previous "Special Topics" presentation.

Messier discovered what would be his best and brightest comet on the evening of August 8, 1769. At that time it was located within the constellation Aries and dimly visible to the unaided eye, and was slowly traveling eastward. It brightened rapidly, being 4th magnitude with a 6-degree tail in mid-August, and by the end of that month had brightened to almost 2nd magnitude and was exhibiting a tail at least 15 degrees long. Around that time it was independently spotted by the British naval explorer Captain James Cook aboard the HMS Endeavour in the South Pacific, who reported the tail as being over 40 degrees long.

The comet continued to brighten rapidly, and accelerate its travel towards the east-southeast, as it approached Earth, with the minimum distance being 0.32 AU on September 10. At that time the comet, then located a few degrees southwest of the bright star Procyon, was close to magnitude 0, with reported tail length measurements being from 60 to over 90 degrees. Thereafter it traveled rapidly towards morning twilight, being last detected on September

Images I have taken of comets passing by deep-sky objects in Messier's catalog. Las Cumbres Observatory image (taken from Cerro Tololo Inter-American Observatory in Chile) of Comet 68P/Klemola passing by the galactic star cluster M16 and crossing the Eagle Nebula on September 30, 2019. The comet is the small diffuse object to the upper left of center; it forms a triangle with two brighter stars to its right and lower right.

26, by which time it was close to magnitude -1 (albeit in the dawn sky) and still exhibiting a bright tail several degrees long.

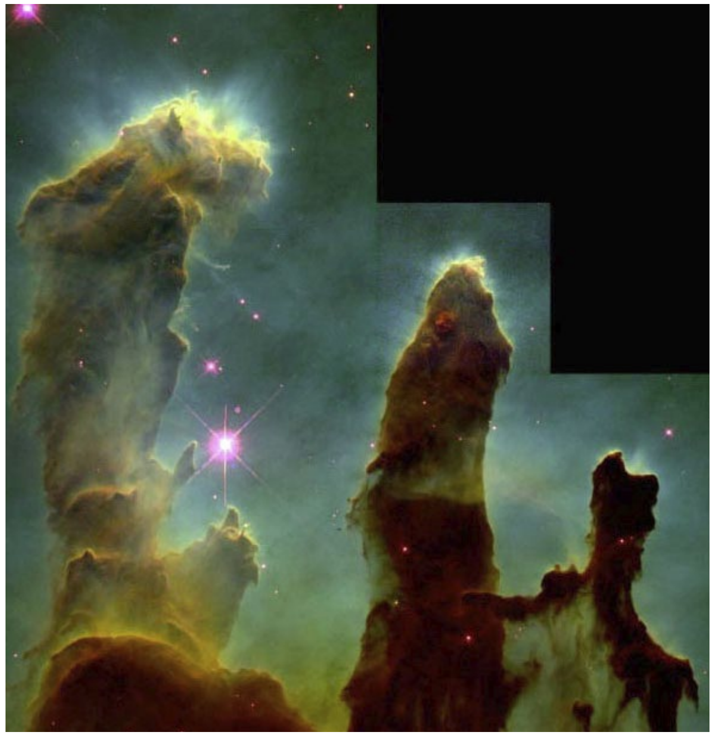
Comet Messier remained hidden in sunlight for the next four weeks, and was finally picked up again on the evening of October 23, still visible to the unaided eye close to the horizon, with a tail approximately 2 degrees long. It remained on the far side of the sun from Earth as it receded and faded, with the last observations being obtained on December 1.

The French ruler Napoleon Bonaparte was born on August 15, 1769, just one week after Messier's discovery of this comet, and supposedly referred to this object as his "protecting genie." Messier himself was well aware of this "connection," and in 1808 while facing declining health and financial difficulties self-published a memoir linking his 1769 comet with the Emperor in an apparent attempt to curry favor with him. There is no real evidence that Napoleon took much notice of this memoir, however. For whatever it's worth, another comet – the Great Comet of 1811, which is a future "Comet of the Week" – is the comet most associated with Napoleon.

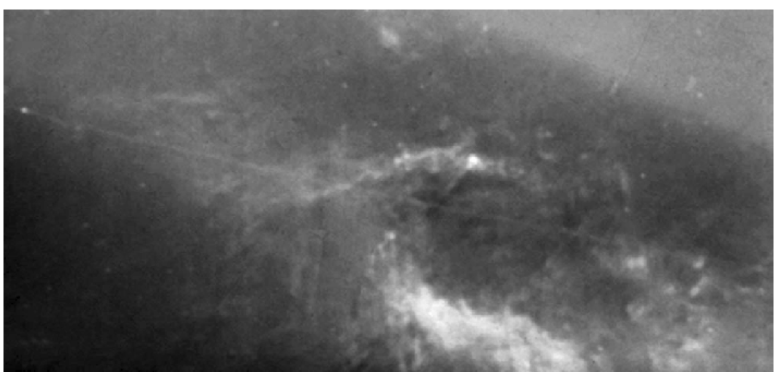
In a true final irony to Messier's legacy there have been approximately half a dozen comets that have been discovered by astronomers, both professional and amateur, while observing deep-sky objects in Messier's catalog. For example, in 1892 a British amateur astronomer, Edwin Holmes, was engaged in observing the Andromeda Galaxy, M31, when he noticed a bright comet nearby; that object, now known as Comet 17P/Holmes, has turned out to be a most remarkable short-period comet that is a future "Comet of the Week." And, of course, it was while observing the globular star cluster M70 in Sagittarius in July 1995 that Thomas Bopp in Arizona and I independently discovered the comet that bears our names, which would become one of the brightest comets of the 20th Century.

SPECIAL TOPIC: INTERPLANETARY DUST

Examples of interstellar dust clouds. Above: On the larger scale, this is a photograph I took of the center of our galaxy from Australia; dark dust clouds blocking the light of stars behind them are evident throughout the entire plane of the Milky Way. Right: On the smaller scale, the famous "Pillars of Creation" image (within the Eagle Nebula next to the galactic star cluster M16) taken by the Hubble Space Telescope in 1995. Courtesy NASA.



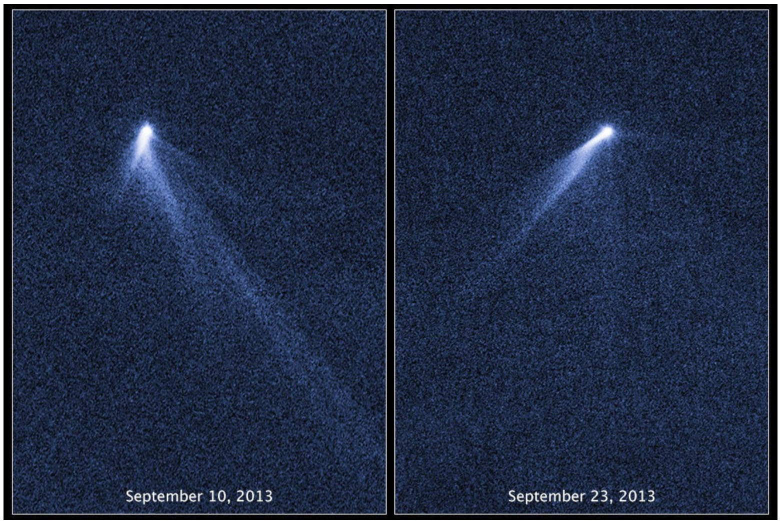
The "Special Topics" presentation two weeks ago pointed out that the term "small bodies" of the solar system generally refers to objects like comets and asteroids, although that particular presentation discussed another class of such objects, i.e., the small moons of the planets. To carry the term "small bodies" to an extreme, we could examine what are certainly the "smallest bodies" of all, i.e., the individual grains of dust that are within the solar system, the majority of which are in orbit around the sun like most of the other objects. It turns out that these dust grains are inextricably linked with the more conventional "small bodies" of the solar system, and thus it is entirely appropriate to include some discussion about them.



InfraRed Astronomical Satellite (IRAS) image of the dust trail following Comet 10P/Tempel 2 (in upper left) in 1983. The dust trail extends over 30 degrees. From Campins et al. (1990).

Dust has been within our solar system since the very beginning. Indeed, it was out of large interstellar clouds of dust and gas that the solar system formed in the first place, and we see numerous examples of these structures all over the sky, especially within the plane of our Galaxy (which appears as the hazy band of light that we call the "Milky Way," which is made up of the combined light of multitudes of distant stars in the galactic plane). Much of that dust was used in forming the sun and the planets, much of it by way of the smaller objects, i.e., the planetesimals that combined to build the planets; the "leftover" such objects survive today as comets and asteroids. While a fair amount of that original dust would also have been left over, various processes including solar radiation pressure and "sweeping up" by the planets, as well as the solar system's overall travels through interstellar space, would have removed the vast majority of it during the solar system's lifetime. Meanwhile, since dust pervades interstellar space the solar system is constantly passing through it in the course of its travels. Such interstellar dust can be detected via its compositional and isotopic structure, and a few of the dust samples returned to Earth by the Stardust mission – which had flown through the coma of Comet 81P/Wild 2 in early 2004 and returned to Earth two years later – have been found to be interstellar in origin.

Since there is undoubtedly a lot of dust in our solar system today, there must accordingly be means of producing dust that remain operational. One of the largest sources of dust in the solar system is comets. As discussed in a previous "Special Topics" presentation on the structure of a comet's nucleus, one of the biggest constituents of a nucleus is dust, usually embedded within the ices that are another one of the major constituents. As a comet approaches the sun and this ice begins to sublimate and erupt off the nucleus, the embedded dust grains are ejected as well. While some of this dust may eventually fall back upon the nucleus, the rest of it – which we may see as the comet's dust tail – never returns, but instead follows along with the comet in the same basic orbit. In 1983 the InfraRed Astronomical Satellite (IRAS) spacecraft detected some of these dust trails accompanying various comets.



Hubble Space Telescope images of "Comet" 311P/PANSTARRS, in actuality an "active asteroid" spewing streams of dust due to sunlight-induced rapid rotation. Courtesy NASA/ESA/David Jewitt.

If Earth should encounter these streams of cometary dust during its annual orbit around the sun, we see this as a meteor shower. The relationship between comets and meteor showers is examined more thoroughly in a future "Special Topics" presentation.

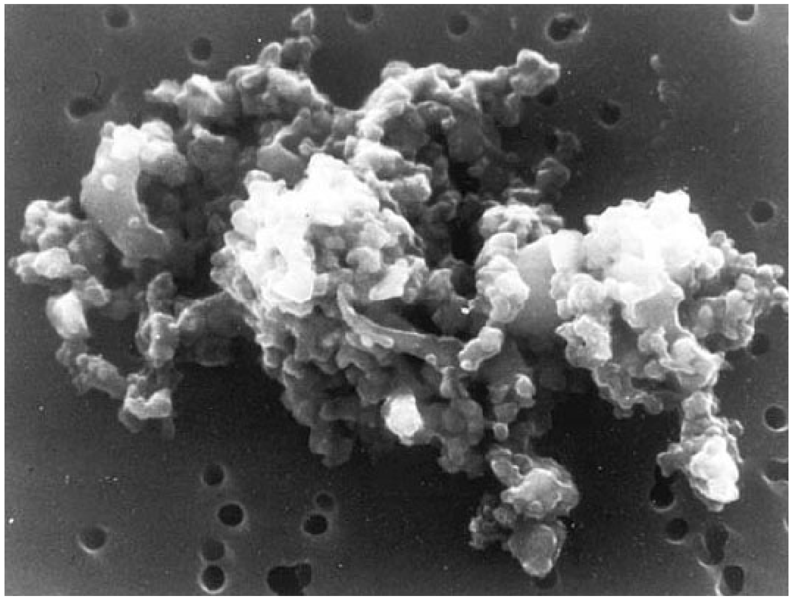
Over the lifetime of the solar system many, many comets have visited the inner solar system and have become active – many comets doing so repeatedly – and over time these dust streams spread out. By now, the entire inner solar system is awash in cometary dust. The "sporadic" meteors, i.e., those meteors that do not appear to be associated with any known shower, that we see throughout the course of any given night are reminders of the presence of this dust.

Collisions and impacts between asteroids are another source of interplanetary dust. The various asteroids that have been examined by spacecraft all exhibit craters that attest to impact events, and over the fairly recent past we have witnessed the aftermath of apparent impacts. (These events are discussed more thoroughly in a future "Special Topics" presentation on "active asteroids.") The existence of asteroid "families" – which will be discussed in another future "Special Topics" presentation – also attests to such impact events. Meanwhile, other "active asteroids" appear to be spewing dust as a result of a rapid rotation, which in turn is driven at least in part by the pressure of sunlight.

As already mentioned, when Earth encounters these grains of dust we see them – at least, the larger ones – as meteors. The relative speeds are on the order of

Noctilucent clouds over Wisconsin, July 2008. Courtesy Bob King.

ten km per second, and the grains begin to disintegrate as a result of friction with the atmosphere. In truth, what we actually observe when we see a meteor are the molecules of the surrounding air that have been ionized by the heat generated by this friction. The dust grains themselves do not completely disintegrate but instead are broken down into even smaller particles that remain in the upper atmosphere, eventually raining down onto the surface – which anyone who has ever tried to keep any space clean and free of dust has encountered. The amount of dust that rains onto the surface has been measured by various means, all the way from radar observations of meteors to dust extracted from core samples of polar ice, with somewhat discordant results that range from 5 to as high as 100 to 200 tons per day. The resolution of these various measurements remains an area of active research.

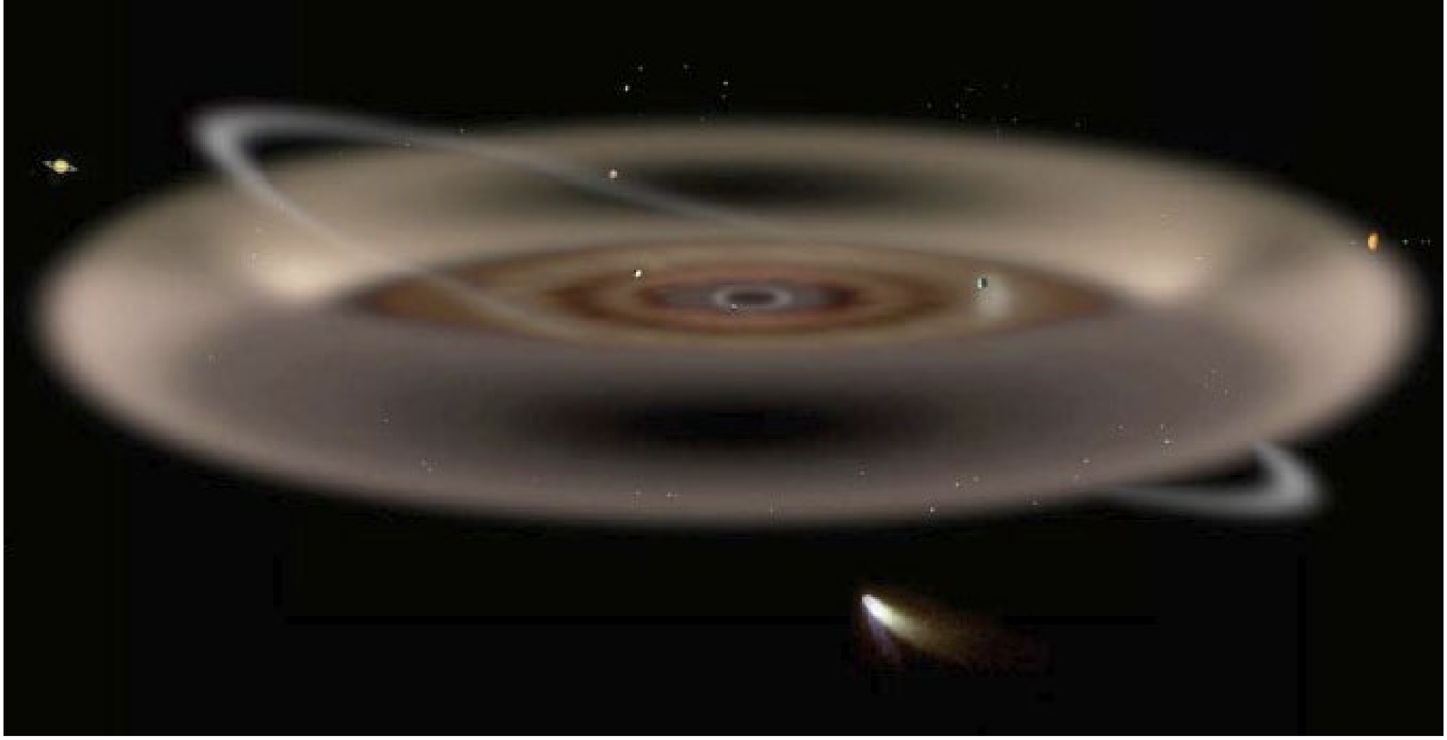


An example of a Brownlee particle, collected by a high-altitude U2 aircraft. Courtesy Herve Cottin.

The "noctilucent clouds" that are visible from higher latitudes during the respective hemispheres' summer months are formed when water vapor brought up from the lower atmosphere condenses into ice crystals around these tiny dust grains in the mesosphere 80 km above the surface. Meanwhile, during a series of high-altitude aircraft flights equipped with special collectors during the early- to mid-1970s, University of Washington scientist Donald Brownlee was able to collect and subsequently examine numerous examples of these small grains. These "Brownlee particles," as they were dubbed, were found to be, on average, a few microns in diameter, and to be puffy, porous aggregates of yet smaller particles with compositions similar to those of stony meteorites. The Brownlee particles were also found to be very dark, about as dark as soot, which has since been found to be consistent with the very dark surfaces of comet nuclei, which over time become coated with the ejected dust that manages to fall back onto the surface.

In space this dust presents a hazard to spacecraft. Even though these "micrometeoroids" are very tiny, the relative impact velocities are quite high – again, on the order of 10 km per second – and since kinetic energy goes as the square of the velocity, even tiny particles can cause damage. Orbiting scientific spacecraft, like the Hubble Space Telescope, need to be shielded from the effects of impacts by these objects, as do all space missions involving human crews.

Scenes from the European Southern Observatory in Chile. Left: The zodiacal light, as seen from the ESO's facility at Paranal. Right: The gegenschein, together with portions of the zodiacal band. Both images courtesy European Southern Observatory/Yuri Beletsky.



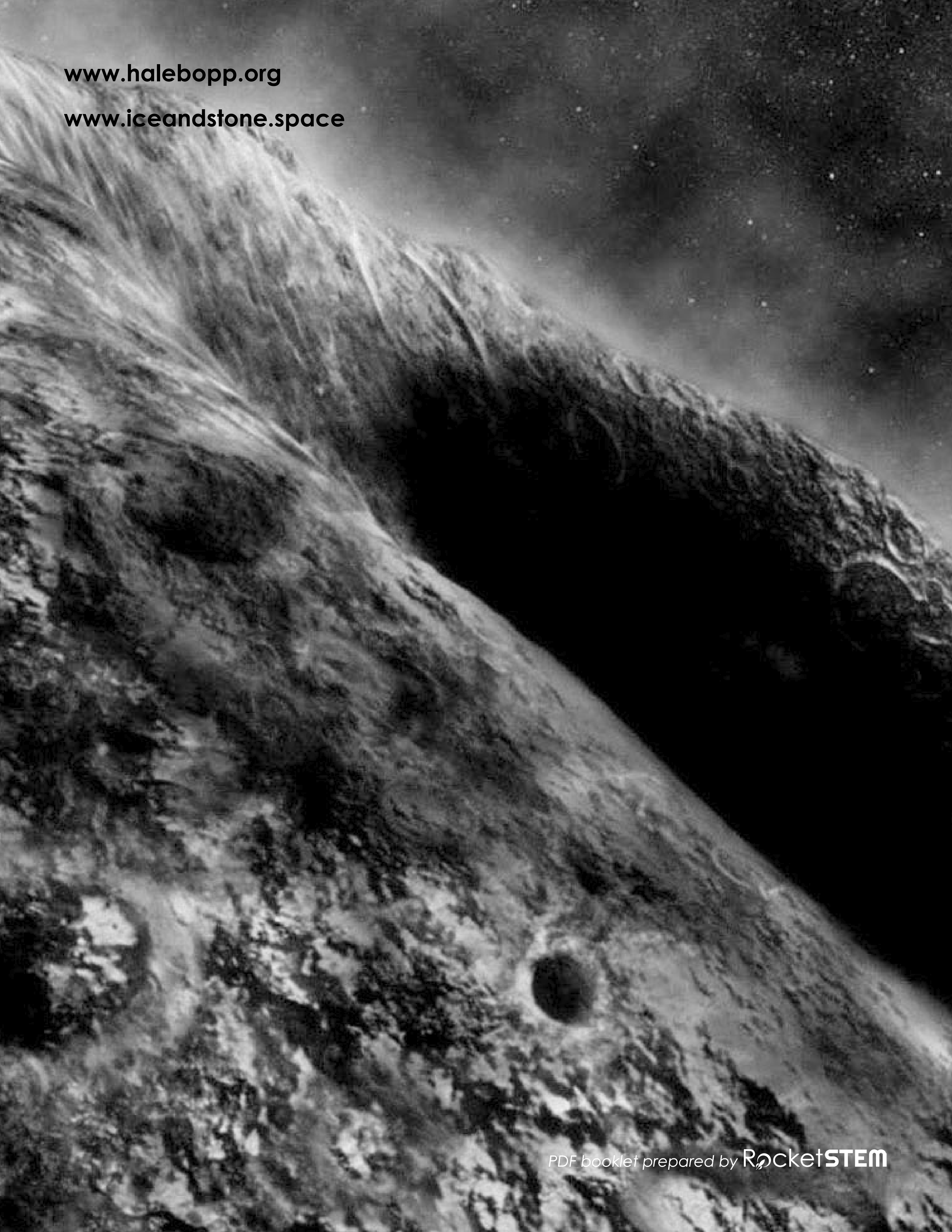
Artist's conception of the solar system's interplanetary dust cloud (with the sun excluded), some time after an asteroidal collision. From Brian May's Ph.D. dissertation (2007).

Even though the individual particles that make up the population of interplanetary dust are very dark, they still reflect the sunlight that strikes them, and thus collectively they can be visible by that reflected sunlight. They can best be detected from Earth's surface in the western sky after dusk and in the morning sky before dawn, as a vague, cone-shaped patch of light along the plane of Earth's orbit, or ecliptic, dubbed the "zodiacal light." From dark rural locations the zodiacal light can be seen on almost any clear moonless night, although the best occasions for viewing occur when the ecliptic makes a steep angle with respect to the horizon and when the zodiacal light is not superposed onto the Milky Way. From my personal experience, in the northern hemisphere (at a southern temperate latitude) the zodiacal light is most prominent in the evening sky during January and February and in the morning sky during September.

The dust that is located beyond Earth in the opposite direction from the sun can reflect sunlight back to Earth, and this is visible as a very vague and wide – on the order of ten degrees in diameter – patch of light called the "gegenschein" (from German words meaning "counter-glow"). As is the case with zodiacal light, in theory the gegenschein can be seen from dark rural sites on almost any given clear moonless night, although it is best visible when it is not superposed on the Milky Way and/or several bright stars. From my personal experience, the gegenschein is best visible around the time of the September equinox, when it is visible against a patch of relatively empty sky in Pisces south of the "Great Square" of Pegasus. On the clearest nights a very vague and weak band of light – the "zodiacal band" – can be seen connecting the zodiacal light with the gegenschein.

An even more elusive collection of interplanetary dust are the "Kordylewski clouds," first reported by the Polish astronomer Kazimierz Kordylewski in 1961 and located near the Earth-moon L4 and L5 Lagrangian points. Their existence has remained controversial ever since Kordylewski's initial reports, with many observers failing to detect them, however they appear to have been confirmed in 2018 by a team of Hungarian researchers led by Gabor Horvath of Eotvos Lorand University in Budapest. Horvath's team made their observations with a linear polarizing filter attached to a sensitive CCD and detected an extended but very diffuse cloud located at L5.

All this interplanetary dust does not remain in one place, of course, but like everything else in the solar system it is constantly in motion. The various motions exhibited by this dust have been examined by, among others, British astronomer Brian May, who first began examining it during the early 1970s before taking a few decades off during which he was the lead guitarist for the rock band Queen, but he later returned to it to complete his doctoral dissertation in 2007. May found that, as expected, the dust primarily exhibits a direct orbital motion around the sun, however this exhibits an asymmetric pattern, and there are other discrete components that indicate collisions between asteroids and/or the effects of passing comets. There is also a likely component, the strength of which is unknown, that is due to interstellar dust that the solar system is currently passing through. In essence, as is true with many other facets of science the reality is more complex than what might be apparent at first glance – which in turn creates more opportunity for study and for future discoveries.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