



# ICE & STONE 2020

WEEK 19: MAY 3-9, 2020

*Presented by The Earthrise Institute*

#19

*Authored by Alan Hale*

# THIS WEEK IN HISTORY



**MAY 3, 1998:** Solar scientist Shane Stezelberger discovers a bright comet traversing the northern field of view of the LASCO C3 coronagraph aboard the SOLar and Heliospheric Observatory (SOHO) spacecraft. Comet SOHO C/1998 J1, which passed through perihelion five days later at a heliocentric distance of 0.153 AU and then became a naked-eye object visible from the southern hemisphere, is the brightest of the “non-group” comets discovered via the LASCO coronagraphs.



**MAY 4, 2020:** Comet PANSTARRS C/2017 T2 will pass through perihelion at a heliocentric distance of 1.615 AU. This comet is currently visible in the northern hemisphere’s evening sky and is bright enough to be detected with binoculars, and is a previous “Comet of the Week.”

**MAY 4, 2020:** The Amor-type asteroid (85184) 1991 JG1 will pass 0.150 AU from Earth. It is currently near opposition and close to its expected peak brightness of 15th magnitude.



**MAY 5, 2020:** The Eta Aquarid meteor shower, associated with Comet 1P/Halley, is predicted to be at its peak. The shower, best viewed from the southern hemisphere, can produce a peak rate of 35 to 50 meteors per hour. A bright waxing gibbous moon (Full on the 7th) may interfere with viewing the shower this year.

## COVER IMAGE CREDIT:

Front and back cover: This artist's conception shows how families of asteroids are created. Over the history of our solar system, catastrophic collisions between asteroids located in the belt between Mars and Jupiter have formed families of objects on similar orbits around the sun.

Data from NASA's NEOWISE project, based on observations made by the Wide-field Infrared Survey Explorer (WISE), have revealed the sizes and reflectivity of members of these asteroids families. The findings are helping scientists better understand how the families formed and evolved. NEOWISE is the asteroid-hunting portion of NASA's Wide-field Infrared Survey Explorer, or WISE, mission. Courtesy of NASA/JPL-Caltech.



**MAY 6, 2004:** Michael Brown and his team obtain their discovery images of the “dwarf planet” now known as (136108) Haumea, although they did not notice it until 7½ months later. Haumea and other “dwarf planets” in the Kuiper Belt are discussed in a future “Special Topics” presentation.

**MAY 6, 2134:** Comet 1P/Halley is predicted to pass just 0.096 AU from Earth, the fourth-closest approach it has made to our planet in history, and the closest approach since A.D. 837. At the time of its closest approach it will be located in southern circumpolar skies and perhaps as bright as magnitude -2. Past and future returns of Comet Halley are discussed in a previous “[Special Topics](#)” presentation.



**MAY 9, 2003:** JAXA's [Hayabusa](#) mission is launched from the Uchinoura Space Center on the island of Kyushu, Japan. Hayabusa traveled to the near-Earth asteroid (25143) Itokawa and successfully collected a few soil samples, but contact was lost thereafter. Contact was re-established over a year later and Hayabusa successfully delivered its samples to Earth in June 2010. Hayabusa, along with other spacecraft missions, will be discussed in more detail in a future “Special Topics” presentation.



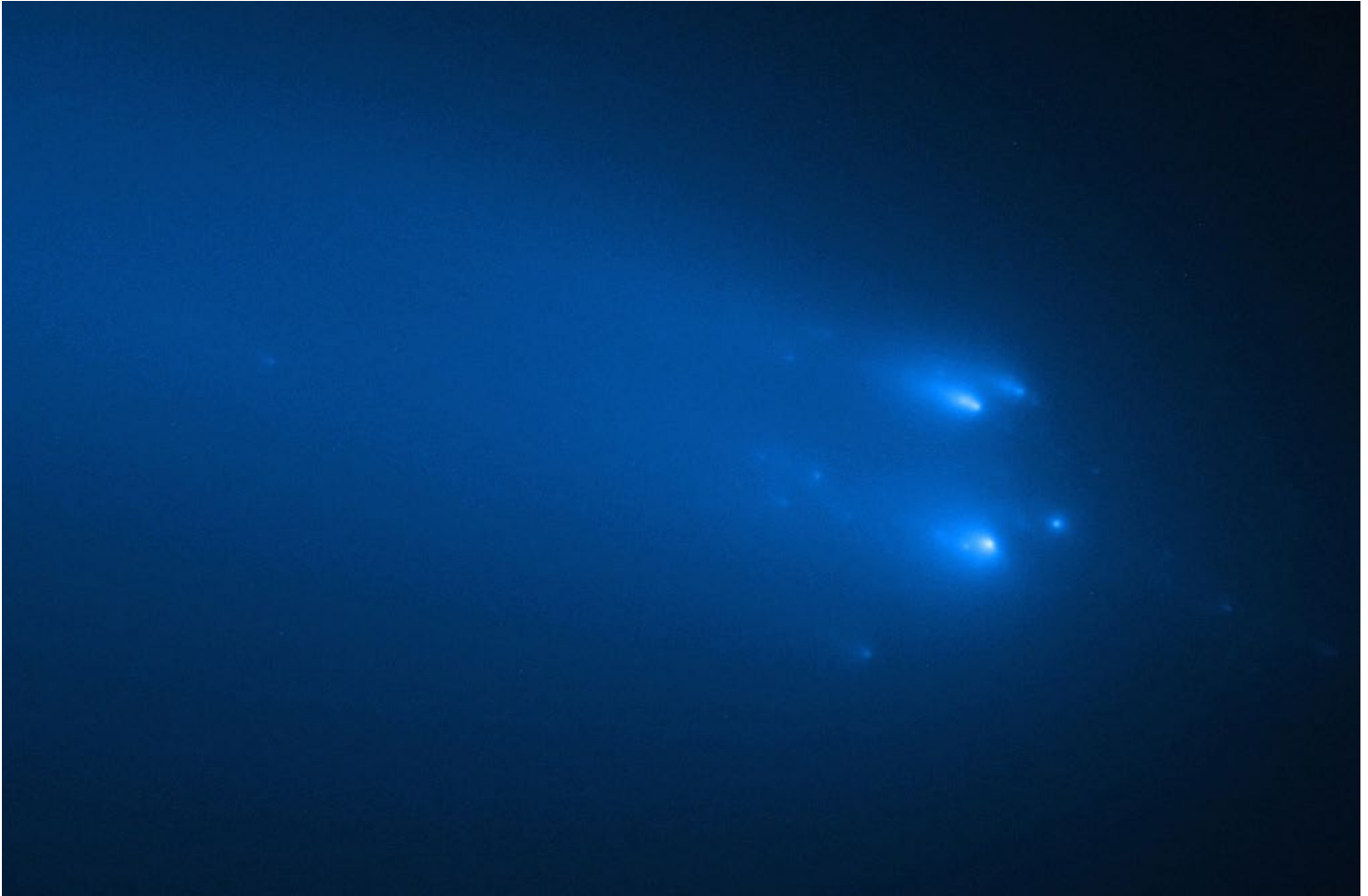
*Artist's concept of Hayabusa at an asteroid.*

**MAY 9, 2018:** Comet PANSTARRS C/2016 R2 passes through perihelion at a heliocentric distance of 2.602 AU. This is an example of the rare carbon monoxide-rich comets, which are discussed in a future “Comet of the Week” presentation on Comet Humason 1961e.

**\* THERE ARE NO ENTRIES FOR MAY 7 AND 8.**

# COMET OF THE WEEK: ATLAS C/2019 Y4

Perihelion: 2020 May 31.04,  $q = 0.251$  AU



*Hubble Space Telescope* image taken April 20, 2020, of the central region of Comet ATLAS, showing the individual nuclear fragments. Courtesy NASA/ESA/STScI/David Jewitt.

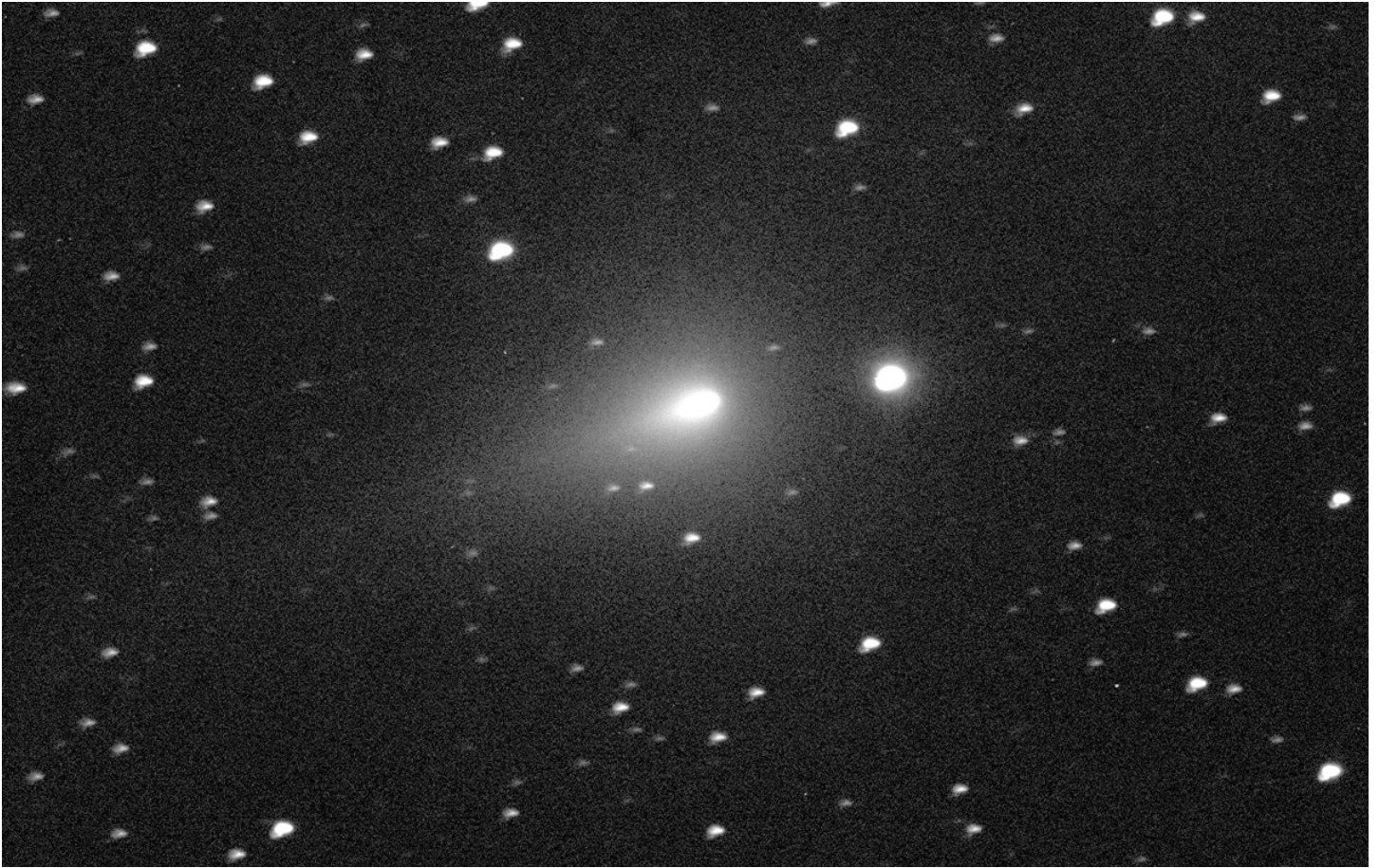
Last year, when I selected the various comets I would be using for "Ice and Stone 2020"'s "[Comets of the Week](#)," I did so with the knowledge – and even hope – that I might find it necessary to swap one or more such selections for current comets that showed potential for becoming bright. I am doing so this week, although unfortunately it does not appear that the comet in question is going to be as bright or spectacular as we might have hoped. Still, it is turning out to be a very interesting object that is attracting a lot of attention right now.

The comet was discovered on December 28, 2019 by the Asteroid Terrestrial-impact Last Alert System ([ATLAS](#)) survey based in Hawaii; at that time it was a dim object of 19th magnitude. While its small perihelion distance attracted attention almost right away, what really caught astronomers' attention was the fact that its orbit bears a striking resemblance to the Great

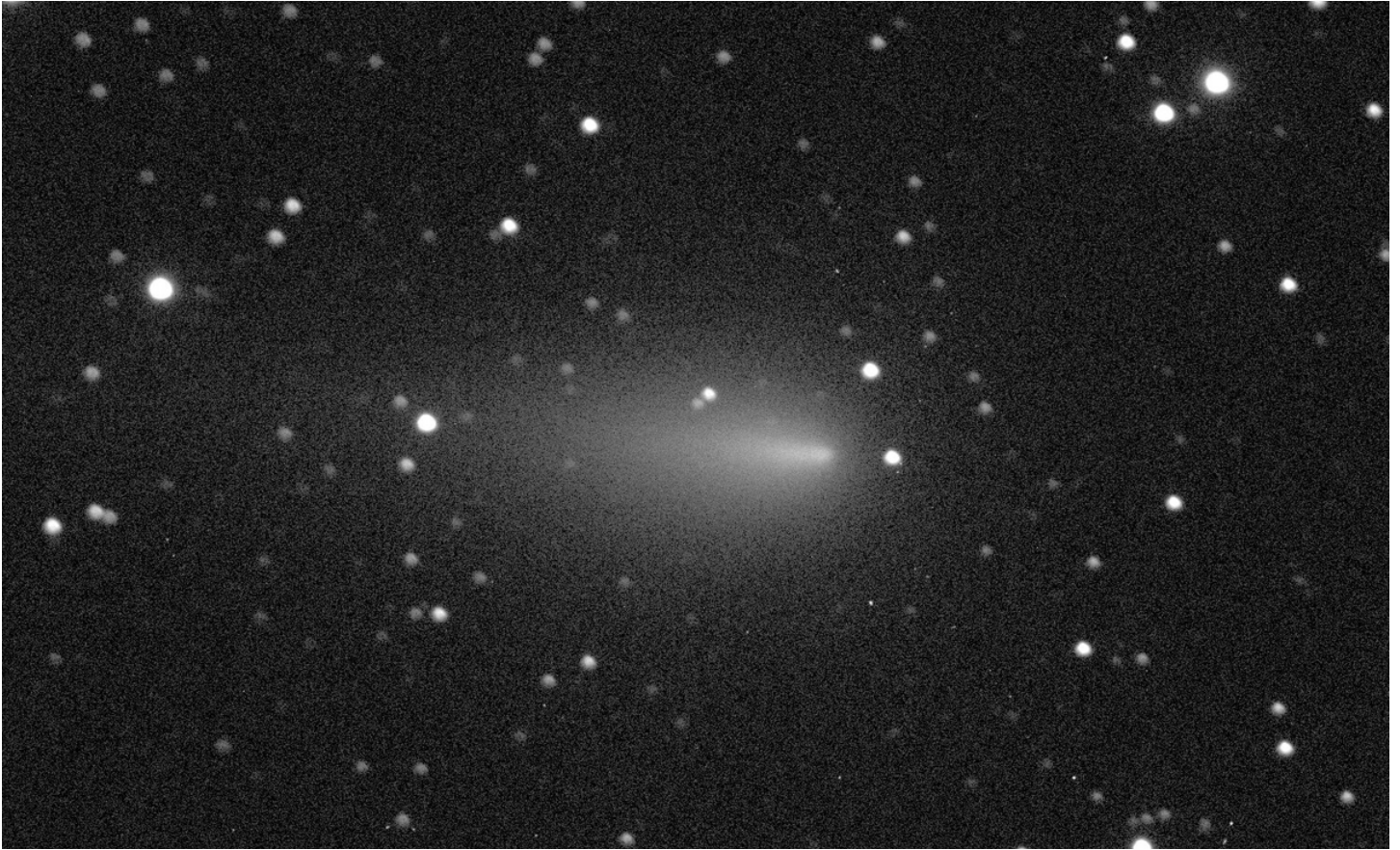
Comet of 1844 (old style designation 1844 III, new style C/1844 Y1). Both comets have orbital periods in the neighborhood of 4000 to 4500 years, and it is thus very likely that they are two components of a single comet that split up in the past, perhaps around the time of its previous perihelion passage.

The Great Comet of 1844 passed through perihelion in mid-December of that year and was first observed from the southern hemisphere a few days later. It remained exclusively visible from the southern hemisphere, and was at its best during late December and in early January 1845, when according to the accounts of the time it perhaps reached a peak brightness of magnitude 0 and exhibited a bright tail up to 10 degrees long. Unfortunately, there do not seem to be any surviving paintings or sketches of it from that time.

In general, trailing components of split comets tend



*Las Cumbres Observatory* images of Comet ATLAS during April 2020, illustrating the rapid change in the comet's brightness and the appearance of its central region. Top: April 2, from Haleakala Observatory in Hawaii. Bottom: April 15, from Teide Observatory in the Canary Islands.





One of the two inbound potential bright comets mentioned in the text. Comet SWAN C/2020 F8, as photographed on April 27, 2020, by [Michael Mattiazzo](#) in Australia, who made the original discovery in [SWAN images](#). Used with permission.

to be smaller, and thus fainter, than the leading components, and indeed Comet ATLAS initially appeared to be much fainter, intrinsically, than its predecessor. However, it underwent a dramatic rapid brightening as it approached perihelion, and I personally observed an increase in brightness of four magnitudes (from 13th magnitude to 9th magnitude) between late February 2020 and mid-March. By the latter part of March it was approaching 8th magnitude and was exhibiting a large gaseous coma up to 12 arcminutes or more in diameter. While there was no reason to expect it would maintain that rate of brightening up until perihelion passage, at the time it seemed rather likely that it would at least become moderately conspicuous to the unaided eye.

However, in early April various observers began to report that the comet's nucleus appeared to be breaking up. Within a couple of weeks several distinct nuclei were apparent in the inner coma, and the comet itself had faded by over a magnitude; visually, instead of a relatively bright central condensation like it had exhibited earlier, the central region

appeared as a dim, elongated "streak" – a sure sign of disintegration.

High-resolution images of Comet ATLAS' nuclear region currently show several distinct fragments, and as time goes by it appears that some of these are continuing to fragment "cascade"-style. A very preliminary [analysis](#) by comet scientist Zdenek Sekanina suggests that the first splitting event occurred around or just before mid-March – right around the time that the rapid brightness increase began slowing down – although a more recent [analysis](#) (incorporating observations made with the [Hubble Space Telescope](#)) raises the possibility that the fragmenting process may have actually started many years ago.

At this writing Comet ATLAS is about 10th magnitude and is located in the northern hemisphere's northwestern sky during the evening hours. Whatever might be left of the comet drops rapidly towards the northwestern horizon over the next couple of weeks, and after being in conjunction with the sun (24 degrees north of it) on May 20 it is better visible in the



*The other inbound potential bright comet mentioned in the text. Comet NEOWISE C/2020 F3, imaged by the [Las Cumbres Observatory](#) facility at Siding Spring Observatory in New South Wales on April 25, 2020.*

morning sky, although it will be close to the horizon in twilight and at best will be difficult to observe. If the comet survives perihelion passage it will be in the southern hemisphere's morning sky beginning in early June, although during the subsequent weeks it remains at a fairly small elongation from the sun as it recedes from the sun and Earth.

It currently thus appears rather likely that we will not be getting any kind of bright and conspicuous showing from Comet ATLAS. However, perhaps in compensation there have been two comets discovered within the recent past that both show some potential of becoming somewhat bright within the near future. The first of these is Comet SWAN C/2020 F8, which was discovered by Australian amateur astronomer Michael Mattiazzo in [images](#) taken with the Solar Wind ANisotropies ([SWAN](#)) ultraviolet telescope aboard [SOHO](#) beginning on March 26, 2020. It is currently visible in the southern hemisphere's morning sky, already as bright as 5th magnitude and visible to the unaided eye; it is traveling northward, en route to perihelion passage (at a heliocentric distance of 0.43 AU) on May 27, and becomes accessible from the northern hemisphere around the middle of May when it may be as bright as 4th magnitude although it will remain close to the eastern horizon before dawn. Comet SWAN will be in conjunction with the sun (25 degrees north of it) on May 26 and thereafter technically becomes

an evening-sky object, although its elongation from the sun remains small and it will soon disappear into twilight.

Meanwhile, there is also Comet NEOWISE C/2020 F3, discovered by the [NEOWISE](#) mission on March 27, 2020. At present it is about 11th magnitude and best visible from the southern hemisphere, and is traveling northward as it approaches perihelion on July 3 at a heliocentric distance of 0.30 AU. After perihelion, during July it is accessible from the northern hemisphere in the northwestern evening sky, and depending upon how it brightens between now and then there is a possibility that it could be at least somewhat bright. Furthermore, it will be appearing at a moderately high phase angle, and if there is any kind of substantial dust tail there could be some brightness enhancement due to forward scattering of sunlight. It so happens that Comet NEOWISE will be closest to Earth (0.69 AU) on July 23, i.e., the 25th anniversary of the Hale-Bopp discovery, and thus it is least somewhat possible that there could be a moderately bright comet in the sky to mark this important anniversary of one of the biggest events of my life.

As always, I will attempt to carry updated information about each of these comets, and any others that are bright enough for visual observations, at the [Comet Resource Center](#) of the Earthrise web site.

# SPECIAL TOPIC: OCCULTATIONS BY ASTEROIDS

In astronomy, an occultation – which comes from Latin words meaning “to hide” – occurs when one body passes in front of, and thus for a time hides, another body. (In this context, a solar eclipse can be considered as a kind of occultation.) In its most common usage, an occultation usually refers to the moon passing in front of a star, or sometimes a planet, but on rarer occasions it can also refer to a planet passing in front of a background star. While such an event can be a fascinating thing to observe for its own sake, occultations are also useful for scientific purposes.

On March 10, 1977, the planet Uranus was predicted to occult the 9th-magnitude star HD 128598 in Libra. A team of astronomers was using the [Kuiper Airborne Observatory](#) to observe the occultation with the intent of determining information about Uranus' atmosphere, however before the star passed behind Uranus it briefly disappeared and reappeared several times, and then did so again after re-emerging from behind Uranus. The rather surprising conclusion was

that Uranus is accompanied by a system of thin rings, which was verified in early 1986 when the [Voyager 2](#) spacecraft flew by Uranus.

This incident produced an almost paradigmatic shift in thinking; up until that time Saturn was the only object in the solar system that was believed to have rings. This event showed that at least one other planet also has rings, and indeed, primarily as a result of spacecraft visits we now know that Jupiter and Neptune have systems of rings as well. In fact, as a result of this discovery of rings around Uranus special efforts were made to find rings around Neptune, and on May 24, 1981, a team from Villanova University detected an occultation event that was at first suspected to be due to a ring but which turned out to be a fortuitous occultation by the moon Larissa (Neptune VII), which was re-discovered by Voyager 2 when it flew by that planet in 1989. (Some faint ring arcs around Neptune were later suspected in 1984 and confirmed by the Voyager 2 encounter five years later.) More recently, when the centaur (10199) Chariklo occulted a star



*A section of Uranus' rings, as viewed by the [Voyager 2](#) spacecraft on January 22, 1986. Image courtesy NASA.*

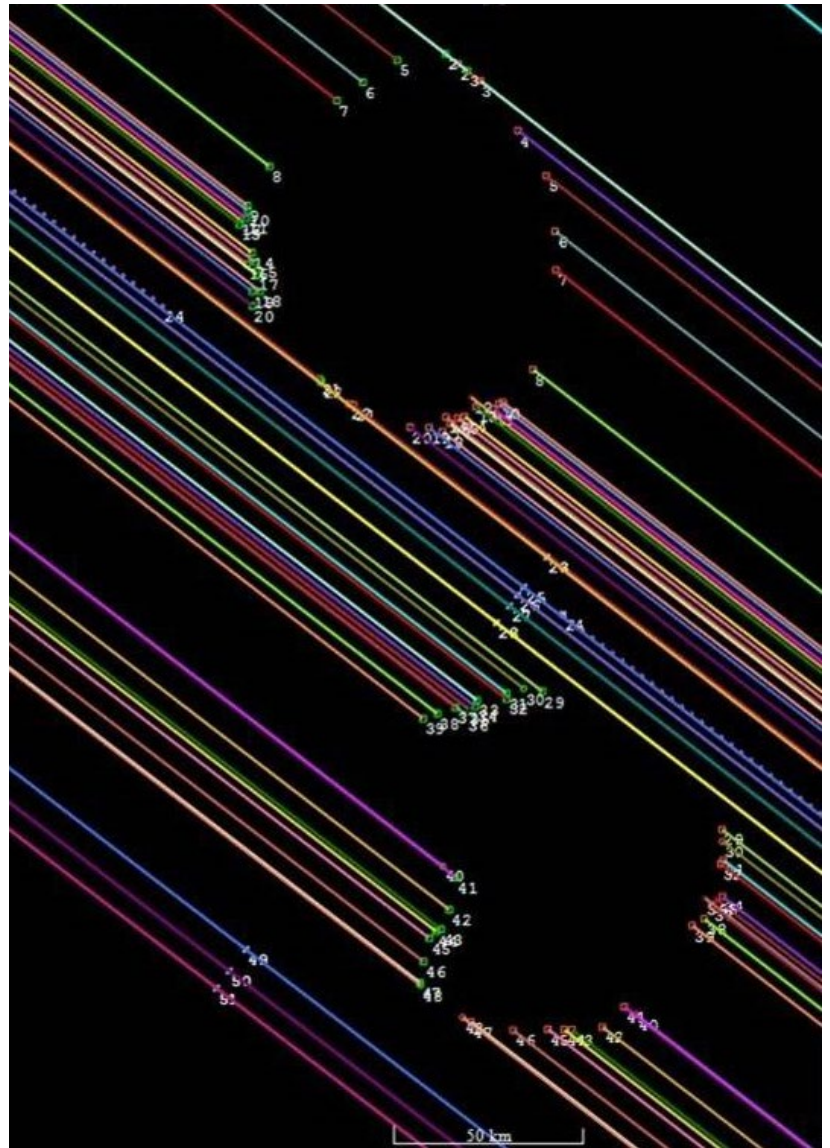


on June 3, 2013, that star underwent a series of disappearances and reappearances that showed that Chariklo is accompanied by a pair of thin rings. (Centaur's are the subject of a previous "[Special Topics](#)" presentation.)

Another interesting example of a science result from an occultation occurred when Pluto occulted a 12th-magnitude star on June 9, 1988. Instead of disappearing and reappearing almost instantaneously, the star disappeared gradually and reappeared gradually as well, indicating the presence of an atmosphere. At that time Pluto was just a little over a year away from its perihelion passage, and the appearance of at least a temporary atmosphere was perhaps not especially surprising; nevertheless, this was the first definite detection of such an atmosphere.

Since planets can occult stars, it would also be logical to presume that asteroids can occult stars as well. However, given the typical asteroid's small size, such events would only be visible only along narrow strips of Earth's surface – akin to the path of a total or annular solar eclipse – and would be brief, lasting not more than a few seconds. Predicting such an event requires accurate and precise knowledge of both an asteroid's orbit and the location of the star to be occulted, and because of this the first attempts at observing asteroid occultations were pretty much hit-or-miss affairs; the first attempt to observe an occultation by an asteroid took place on February 19, 1958, when the main-belt asteroid (3) Juno occulted the 9th-magnitude star HD 32203 in Orion; there was one positive report of detecting this event but this turned out to be an apparent false alarm. The first successfully observed occultation by an asteroid took place on October 2, 1961, when (2) Pallas occulted the 9th-magnitude star HD 215764 in Aquarius; positive detections were reported from South Africa and from India.

For the next couple of decades a handful of additional occultations by asteroids were observed around the world, although such was the state of the knowledge of asteroids' orbits and stars' positions that several predicted events ended up taking place at significant distances from the expected locations. One particularly notable occultation took place on the evening of January 23, 1975, when the near-Earth asteroid (433) Eros – the subject of a previous "[Special Topics](#)" presentation – occulted the 4th-magnitude star Kappa Geminorum. While the event was successfully observed from several locations within the northeastern U.S., the constant "touch-and-go"



*Ground-track recordings of the disappearances and reappearances of the star HD 215553 (in Aquarius) during the occultation by the main-belt asteroid (90) Antiope and its moon on July 19, 2011. The moon had already been discovered in 2000. Image courtesy Kuriwa Observatory, licensed via [Creative Commons](#).*

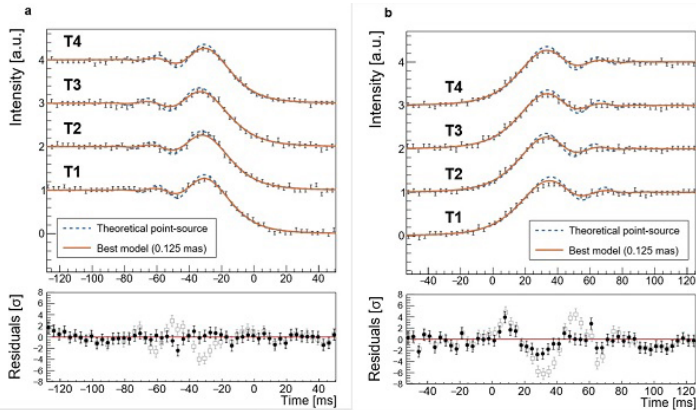
state of the predicted path illustrated the difficulties inherent in making such predictions.

The art of predicting occultations by asteroids has improved greatly since those days. This is in significant part due to the precise positions of stars provided by ESA's [Hipparcos](#) mission in the late 1980s and early 1990s, and the present ESA [Gaia](#) mission; not only have these two missions provided very precise and accurate positions of stars, they have also helped to increase dramatically the accuracy of astrometry of asteroids and other solar system bodies. This in turn has helped in providing accurate orbits for these objects. As a result, predictions of the paths of occultations by asteroids today are generally quite accurate.

With the large number of asteroids that are known nowadays, several occultations by asteroids are

usually predicted to occur on any given day. Depending upon the brightness of the star and the brightness difference between the star and the occulting asteroid, the events can be rather dramatic to witness, with a star essentially “winking out” for up to several seconds before reappearing. I have successfully witnessed one such event: on June 12, 2013 I watched the 6th-magnitude star HD 156026 in Ophiuchus disappear for four seconds when it was occulted by the main-belt asteroid (332) Siri.

The improved accuracy of occultation predictions available nowadays in turn allows for useful scientific



VERITAS plots of the background star's brightness intensity versus time during the occultation by (1156) Imprinetta on February 22, 2018. From the [paper](#) by Benbow et al. (2019).

observations to be conducted during these events. Especially when equipped with high-speed video-recorders that are accurately time-tagged, a team of observers placed along a line across the path of an occultation can determine the size and shape of the occulting asteroid by recording precise times of the star's disappearance and reappearance. In this manner we have successfully determined the shapes and sizes of numerous asteroids, all the way from near-Earth space out to the Kuiper Belt. In addition, the presence of moons or other companion objects can be gleaned as well; several asteroids' moons have in fact been discovered during occultation events.

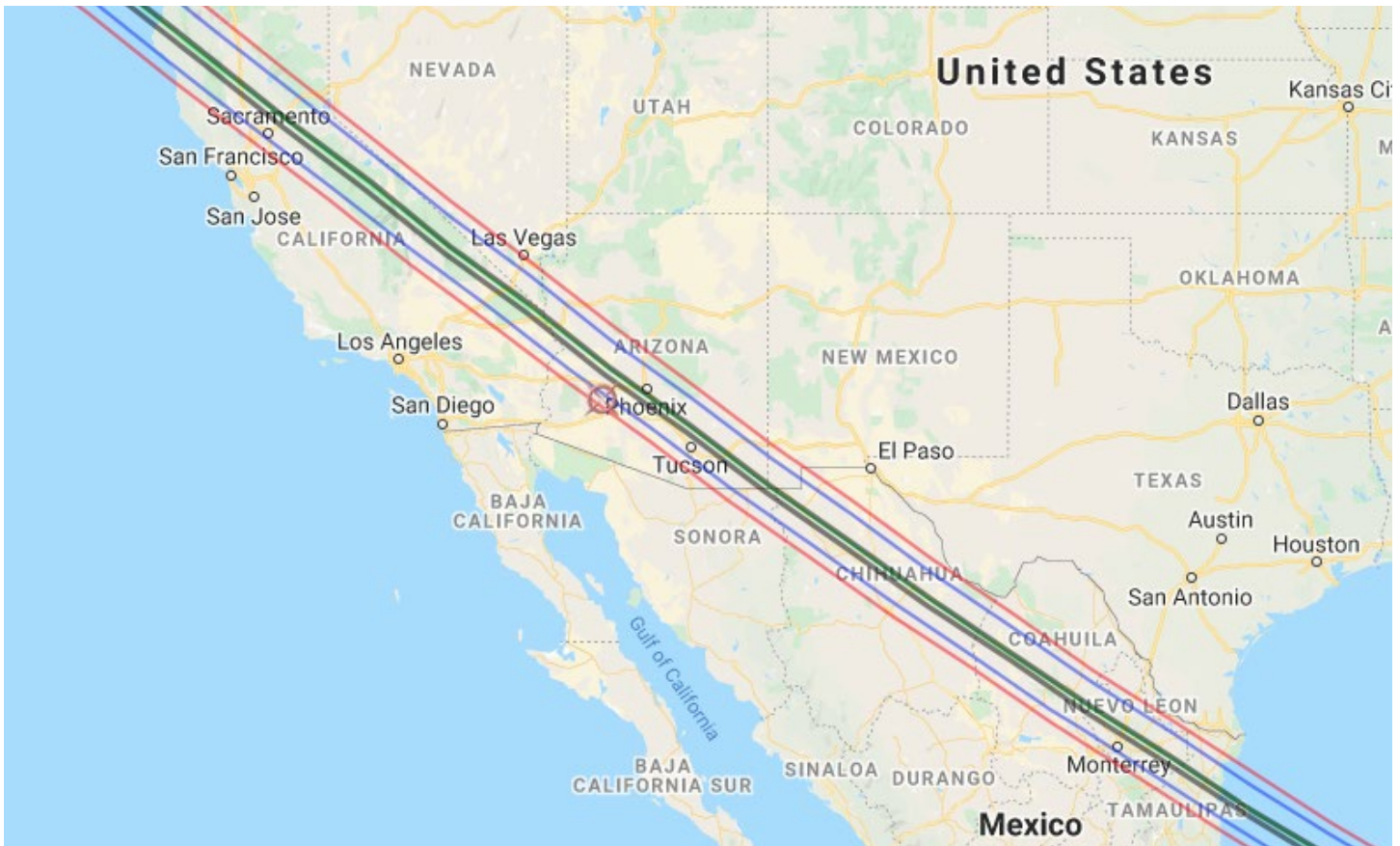
With modern telescopes it is also possible nowadays to determine information about the occulted stars from occultation events. On two occasions in 2018 – February 22, involving the main-belt asteroid (1165) Imprinetta, and May 22, involving the main-belt asteroid (201) Penelope – the paths of an occultation passed directly over the Very Energetic Radiation Imaging Telescope Array System (VERITAS) telescope in Arizona. VERITAS is an array of four 12-meter antennas sensitive to high-energy radiation (produced by gamma-rays in the atmosphere) that is capable of taking hundreds to thousands of exposures per second. By examining the stars' diffraction fringes as the asteroids were occulting them, VERITAS was

able to produce accurate size determinations of the stars in question: 11 times the sun's diameter for the Imprinetta event (for a star over 2600 light-years away) and slightly over twice the diameter of the sun for the Penelope event (for a star 700 light-years away). This type of observation is not available for most asteroid occultations – since VERITAS and telescopes of its nature are not transportable – but the construction of additional large telescopes within the foreseeable future suggests that additional opportunities for investigations like these may increase over time.

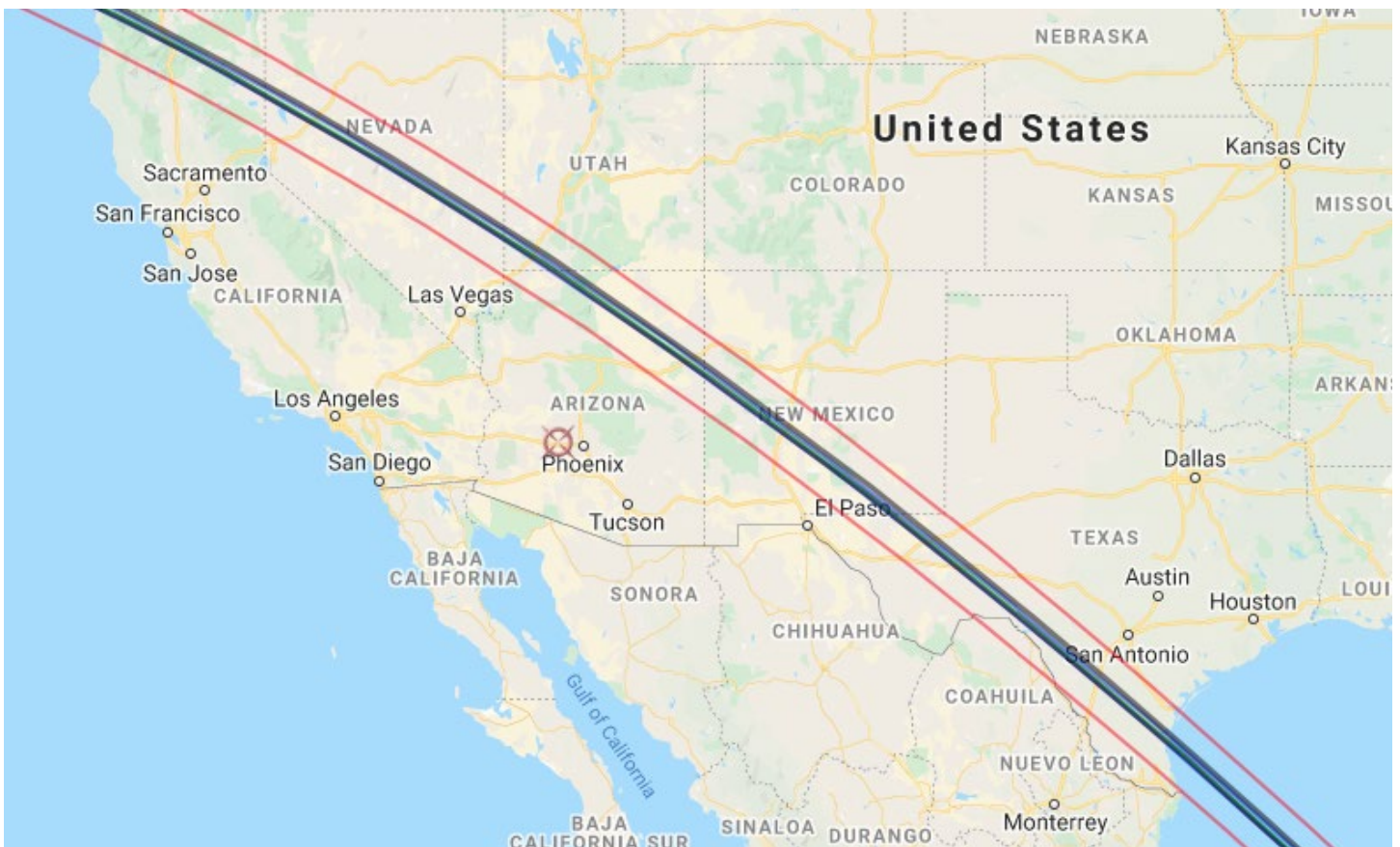
Throughout “Ice and Stone 2020” I am listing – within the weekly “[This Week in History](#)” pages – those occultations by asteroids this year that involve relatively bright stars (7th magnitude and brighter) and/or others that might be interesting in some way. Two such events take place next week, both of which are visible from close to my part of the world. On May 11 the main-belt asteroid (363) Padua will [occur](#) the 5.5-magnitude star Psi Cancri; the [predicted path](#) of the occultation crosses eastern California from northwest to southeast, then crosses central Arizona (including over the cities of Phoenix and Tucson) and northern Mexico (the city of Chihuahua is just outside the predicted path, while Monterrey is just within it). The occultation will occur around 5:15 UT and will last up to three seconds; the drop in the star's brightness will be over 8 magnitudes.

A perhaps even more interesting occultation occurs the following day, May 12, when the main-belt asteroid (3151) Talbot [occults](#) the 6th-magnitude star HD 144362 in Ophiuchus. The [predicted path](#) of the occultation crosses southeast to northwest across southwestern Brazil, central Columbia, southeastern Panama, far northeastern Nicaragua and far eastern Honduras, the Yucatan Peninsula of Mexico, southwestern Texas, central New Mexico – including almost directly over my location! – northeastern Arizona, southwestern Utah, central Nevada, northern California, and southwestern Oregon. The occultation occurs from 4:48 to 5:06 UT and will last a maximum of just 1.3 seconds with a brightness drop of over 8 magnitudes.

What makes the Talbot occultation interesting, and at the same time makes the predictions more problematical than normal, is the fact that HD 144362 is a triple system. The primary component is a close double star, with an orbital period of just under five years and an average separation of just over 0.05 arcseconds, and meanwhile the third star (9th magnitude) orbits this pair with an orbital period of 459 years (according to the most recent orbit); in 2020 it is located 0.32 arcseconds at position angle 216 degrees (towards the south-southwest) from the main pair. It thus might behoove prospective observers who might live close to, but outside, the predicted path of the occultation to keep a watch for it nevertheless.



Google Maps plots of the predicted paths within the United States and northern Mexico of the asteroid occultations next week that are discussed in the text. The green lines indicate the center of the path, the blue lines indicate the predicted path limits, and the red lines indicate the one-sigma variation from the expected path. Top: (363) Padua on May 11. Bottom: (3151) Talbot on May 12. The predictions are from [Poyntsource.com](http://Poyntsource.com).



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