

#6

# ICE & STONE 2020

Week 6: February 2-8, 2020

*Presented by The Earthrise Institute*



# THIS WEEK IN HISTORY



**FEBRUARY 2, 1106:** Sky-watchers around the world see a brilliant comet during the daytime hours. In subsequent days it becomes visible in the evening sky, initially very bright with an extremely long tail, and although it faded rapidly it remained visible until mid-March. The available information is not enough to allow a valid orbit calculation, but it is widely believed to have been a Kreutz sungrazer; moreover, it possibly was the progenitor of the Great Comet of 1882 and Comet Ikeya-Seki 1965f. Both of these comets are future “Comets of the Week,” and Kreutz sungrazers as a group will be discussed in a future “Special Topics” presentation.

**FEBRUARY 2, 1970:** I make my very first comet observation, of Comet Tago-Sato-Kosaka 1969g, at that time a 5th-magnitude object in Aries. This was also the first comet ever to be observed from space, and it is this week’s “Comet of the Week.” The observations from space are discussed in this week’s “Special Topics” presentation.

**FEBRUARY 2, 2006:** UCLA astronomer Franck Marchis and his colleagues [announce](#) that the binary Trojan asteroid (617) Patroclus has an average density less than that of water, suggesting that it – and presumably many other Trojan asteroids – are made up primarily of water and thus may be extinct cometary nuclei. Trojan asteroids are discussed in a future “Special Topics” presentation.

**FEBRUARY 2, 2020:** The main-belt asteroid (894) Erda will [occurt](#) the 7th-magnitude star HD 29376 in Taurus. The [predicted path](#) of the occultation passes over open waters of the western Indian Ocean, north central India (just south of Mumbai), central Nepal, eastern Tibet, and west-central China.



**FEBRUARY 3, 1661:** The Polish astronomer Johannes Hevelius spots a bright comet in the morning sky. This comet is now known to be a previous return of Comet Ikeya-Zhang which was discovered in 2002, and is currently the longest-period comet to have been seen on two returns. Comet 153P/Ikeya-Zhang is a future “Comet of the Week.”

**FEBRUARY 3, 2020:** The main-belt asteroid (19306) Voves will [occurt](#) the 7th-magnitude star HD 147119 in Scorpius. The [predicted path](#) of the occultation crosses south-central Australia from northwest to southeast and the northwestern shore of New Zealand’s South Island.

## COVER IMAGES CREDITS:

Front cover (top): Image of C/2014 Q2 (Lovejoy), a long-period comet discovered on 17 August 2014 by Terry Lovejoy. This photograph was taken from Tucson, Arizona, using a Sky-Watcher 100mm APO telescope and SBIG STL-11000M camera. Courtesy John Vermette.

Front cover (bottom): Artist’s impression of NASA’s Dawn spacecraft arrival at the giant asteroid Vesta on July 15, 2011. Courtesy NASA/JPL-Caltech.

Back cover: Composite image taken by JAXA’s Hayabusa-2 spacecraft just before touchdown on the Ryugu asteroid to collect a sample in 2019. Courtesy JAXA, Chiba Institute of Technology, University of Tokyo, Kochi University, Rikkyo University, Nagoya University, Meiji University, University of Aizu, AIST).



**FEBRUARY 6, 1943:** Comet Whipple-Fedtke-Tevezadze 1942g passes through perihelion at a heliocentric distance of 1.354 AU. Although it did not become especially bright, it was nevertheless easy to see with the unaided eye and is a future “Comet of the Week.”

**FEBRUARY 6, 2018:** The private rocket company Space Exploration Technologies, or [SpaceX](#), successfully [launches](#) its Falcon Heavy heavy-lift rocket from Cape Canaveral, Florida. The Falcon Heavy’s payload was SpaceX founder Elon Musk’s Tesla Roadster, which became an artificial Apollo-type asteroid with an orbital period of 1.52 years, a perihelion distance of 0.99 AU, and an orbital eccentricity of 0.26.

**FEBRUARY 6, 2018:** Spanish astronomers Carlos and Raul de la Fuente Marcos [publish](#) a paper in the Monthly Notices of the Royal Astronomical Society which discusses, among other things, how the passage of a recently-discovered nearby star (WISE 0720-0846, unofficially known as “Scholz’s Star”) through the Oort Cloud 70,000 years ago disturbed the cometary population there and may create a future shower of long-period comets in the inner solar system. This subject will be treated in more detail in a future “Special Topics” presentation.



**FEBRUARY 7, 1999:** NASA’s [Stardust](#) mission is launched from Cape Canaveral, Florida. After passing by the main-belt asteroid (5535) Annefrank in November 2002 Stardust flew through the coma of Comet 81P/Wild 2 in January 2004, collecting material samples in the process. After returning these samples to Earth in January 2006 Stardust flew on to an encounter with Comet 9P/Tempel 1 in February 2011. Comet 81P/Wild 2 was the Week One “[Comet of the Week](#)” and some of the Stardust results were discussed there.

**FEBRUARY 7, 2020:** The main-belt asteroid (1714) Sy will [occurt](#) the 7th-magnitude star HD 88315 in Sextans. The [predicted path](#) of the occultation crosses south-central Canada from southeast to northwest, far southern Alaska, and southeastern Siberia.

**FEBRUARY 7, 2036:** The Apollo-type asteroid (2101) Adonis will pass 0.036 AU from Earth. Adonis, the second-known Apollo-type asteroid, was discovered in 1936 but subsequently lost until recovered in 1977; it was discussed in a previous “[Special Topics](#)” presentation.



**FEBRUARY 8, 1969:** A bright meteor passes over the Mexican State of Chihuahua and falls to Earth near the village of Pueblito de Allende. Over two tons of meteorite fragments have since been recovered. The Allende meteorite is the largest known example of a carbonaceous chondrite, and has been called “the best-studied meteorite in history.” Carbonaceous chondrites are the subject of a future “Special Topics” presentation.

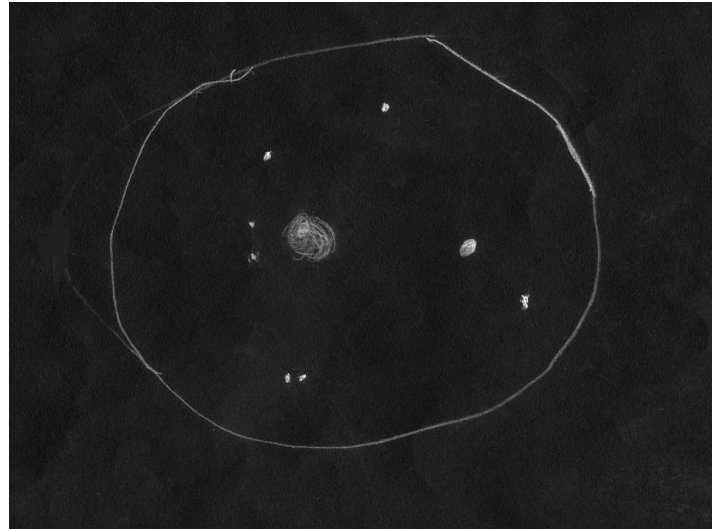
**\*THERE ARE NO CALENDAR ENTRIES FOR FEBRUARY 4 AND 5.**

# COMET OF THE WEEK: TAGO-SATO-KOSAKA 1969G

Perihelion: 1969 December 21.27,  $q = 0.473$  AU

Everyone fondly remembers their “first.” When it comes to comets, my “first” came exactly 50 years ago on Monday evening, February 2, 1970, when I was 11 years old and in the 6th Grade, and involved a 5th-magnitude fuzball located close to the 2nd-magnitude star Hamal in the constellation Aries. My best friend, Mark Bakke – who was every bit as much into astronomy as I was – came over and brought his 60-mm refractor, and by using information within the magazine [Sky & Telescope](#) and a pair of 7x35 binoculars I easily located the comet. I could faintly see it with my unaided eye, and through the 11-cm reflector I had recently acquired it appeared as a bright, diffuse coma with a distinct central condensation. In addition to Mark, I successfully convinced the various members of my family, which included my father, my mother, my paternal grandmother, and my older brother Barry (then 16 years old) to come out and look at it, although to be honest I think I they were a bit underwhelmed. Mark and I, on the other hand, were about as excited as one can be, and we shared our observation with our teacher and classmates at school the following day.

The comet in question had been discovered on October 10, 1969, by a Japanese amateur astronomer, Akihiko Tago. He waited two nights to confirm it, and when he did so it was independently picked up by two more (quite young) Japanese amateur astronomers, Yasuo Sato (age 19) and Kozo Kosaka (age 17). At the time of its discovery Comet Tago-Sato-Kosaka was about 10th magnitude and visible in the western sky after dusk; it traveled southward and brightened, becoming inaccessible from the northern hemisphere in early November and disappearing into twilight from the southern



*My very first comet observation. This is the sketch I made of Comet Tago-Sato-Kosaka as it appeared through my 11-cm reflector on the evening of February 2, 1970.*

hemisphere in early December, by which time it was about 6th magnitude.

The comet became observable from the southern hemisphere again during the latter part of December, and was reported as being as bright as magnitude 2 ½ to 3, and with a distinct tail. In early January 1970 it started heading back north, and for a while its brightness held fairly steady as it was still approaching Earth (closest approach being 0.38 AU on January 20). It was still around 4th magnitude when it became accessible again from the northern hemisphere in mid-January.

Comet Tago-Sato-Kosaka became the first comet



*A sequence of photographs of Comet Tago-Sato-Kosaka taken on the evenings of January 31, February 2, 6, and 7, 1970. The increased brightness on the evening of the 6th is obvious. These photographs were taken by J.D. “Del” Wiseman, Jr., of Portland, Oregon.*



*Comet Tago-Sato-Kosaka on January 11, 1970, as photographed by Merv Jones in Marysborough, Queensland.*

ever to be observed from space, when beginning on January 14 and continuing for the next two weeks a team of astronomers led by Arthur Code at the University of Wisconsin observed it with the Orbiting Astronomical Observatory 2 (OAO-2) spacecraft that had been launched in late 1968. OAO-2's ultraviolet detectors recorded a large cloud of hydrogen almost three degrees across –  $1\frac{1}{4}$  times the diameter of the sun in physical terms. The existence of such a cloud was not unexpected, in fact it had been predicted by the German astronomer Ludwig Biermann in 1964. These "Lyman-alpha clouds" have now been detected surrounding many other comets, and indeed they are now known to accompany most comets visiting the inner solar system. These and other spacecraft observations of comets are discussed in this week's "Special Topics" presentation.

As I indicated, the comet had faded to 5th magnitude by early February. I followed it every night for the next week, and on the evening of February 6 it seemed surprisingly bright, and was easily detectable with the unaided eye. I would later learn that the comet had undergone a brief outburst at

that time, and there is some evidence that it might have undergone a small fragmenting event then. On the next two nights the comet had faded back to its normal brightness, and after being clouded out on the evening of the 9th I didn't look for it again. According to other observers, it faded steadily, to around 11th magnitude in early April, and the final photographs were obtained in early May.

50 years later, it occurs to me that, of the five people who shared that initial comet observation with me, only one is still alive. My grandmother passed away in 1973, my father in 2002, and my mother in 2013; Mark, meanwhile, was tragically killed in a gunshot accident in 1984 at the age of 27. My brother Barry is still going strong at age 66 and I hope he continues doing so.

Orbital calculations indicate that Comet Tago-Sato-Kosaka is traveling in a very elongated orbit that will bring it back in about 110,000 years. Perhaps any beginning comet observers from whoever, or whatever, will be living on Earth at that time will once again be able to view it.

# SPECIAL TOPIC: COMET OBSERVATIONS FROM SPACE

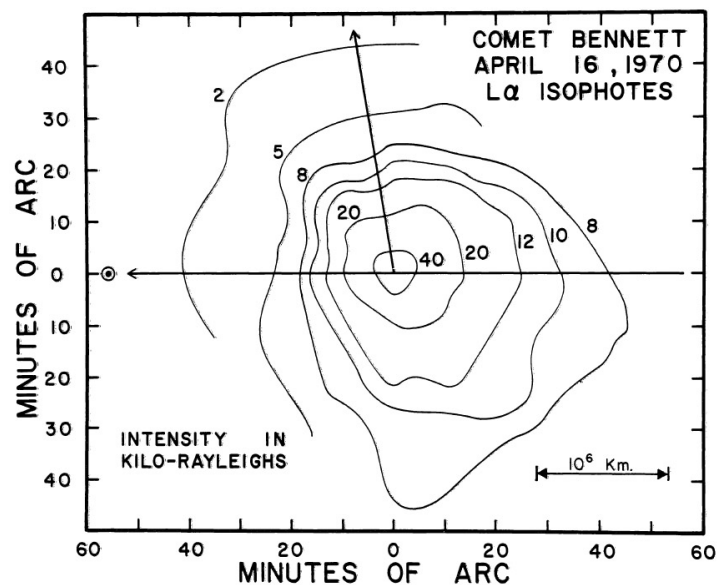
All astronomers, be they professional or amateur, or even just casual sky-watchers, have often had to contend with the vagaries of the earth's atmosphere. Clouds will often get in the way, especially at inopportune times; almost every astronomer can recite stories of important observations that were precluded by cloudy weather. Even if the skies are "clear," a large concentration of atmospheric moisture, or (especially in desert environments) dust can affect observations, sometimes severely. Turbulence in the atmosphere can also affect observations, in that it can make an apparent point source of light (such as star) spread out into a disk. (The term "seeing" is usually applied to this phenomenon; the stronger the turbulence, and thus the more spread-out a point source becomes as a result, produces worse "seeing.") The relatively recent development of "adaptive optics" technology can overcome "seeing" issues to an extent, but of course can do nothing about clouds and poor transparency due to moisture and/or dust.

Another way that Earth's atmosphere affects astronomical observations is that it is opaque to various regions of the electromagnetic spectrum. There is one significant "window" in the "visible light" or "optical" part of the spectrum, which is what our eyes detect; this "window" extends slightly into the ultraviolet and into the infrared but only to a small extent. Another, larger "window" in the radio part of the spectrum allows radio waves from space to reach Earth's surface – hence, the development and usage of radio telescopes. A handful of quasi-"windows" exist in the infrared, and can be accessed from high elevations where the atmosphere is thinner and drier – hence, the existence of such telescopes at high elevation sites like Mauna Kea in Hawaii. Most of the rest of the electromagnetic spectrum is blocked entirely, especially the shorter-wavelength, higher-energy regions like gamma-rays, x-rays, and the ultraviolet. This is good news for life on Earth – we wouldn't be here otherwise – but this prevents ground-based astronomical observations in these regions of the spectrum.

For these reasons astronomers had long desired the opportunity to have telescopes in space. Sounding rockets equipped with special detectors can make observations possible for a few minutes, but an orbiting telescope would be free of such time constraints, and accordingly once the first satellites began being placed into orbit it was only a matter of time until telescopes would be among these.

The first comet ever to be observed from space

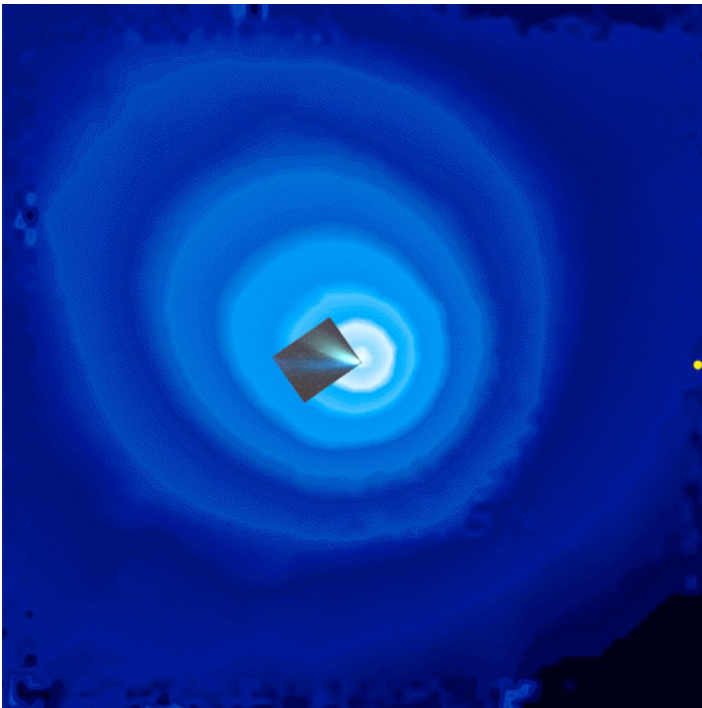
is Comet Tago-Sato-Kosaka 1969g, which is this week's "Comet of the Week" (and which, as I've pointed out there and elsewhere, is the first comet I ever observed). Beginning on January 14, 1970 and extending for the next two weeks, a team led by Arthur Code at the University of Wisconsin observed this comet with the Orbiting Astronomical Observatory 2 (OAO-2) spacecraft that had been launched in late 1968. The ultraviolet detectors aboard OAO-2 recorded a large cloud almost three degrees across –  $1\frac{1}{4}$  times the diameter of the sun in physical terms – surrounding the comet, with this being prominent at a wavelength of 1216 Angstroms, the so-called "Lyman-alpha" line of hydrogen (the strongest spectral line in the hydrogen atom).



Isophotes of the Lyman-alpha cloud around Comet Bennett 1969i taken by the OAO-2 spacecraft on April 16, 1970. The direction to the sun is indicated to the left. From Code et al. (1972).

This was not a surprise: in 1964 the German physicist Ludwig Biermann had pointed out that, if water is indeed the primary constituent of a comet's nucleus (as Fred Whipple's "icy conglomerate" model – which will be the subject of a future "Special Topics" presentation – predicted), then ultraviolet radiation from the sun would dissociate water molecules into their constituent hydrogen and oxygen atoms. The hydrogen would then be visible in ultraviolet as a large cloud – which is precisely what Code's team detected with OAO-2's instruments.

Two months later Code and his team detected a large hydrogen cloud – ten times the sun's diameter)



The Lyman-alpha cloud around Comet Hale-Bopp, as imaged by the [SWAN](#) telescope aboard [SOHO](#). The inset is a photograph (to scale) of the comet's visual appearance; the yellow dot at right represents (to scale) the sun. Image courtesy NASA/ESA/Mike Combi (University of Michigan); inset photograph courtesy Dennis di Cicco.

around Comet Bennett 1969i (which will be a future "Comet of the Week") and this cloud was also detected by another orbiting telescope, the Orbiting Geophysical Observatory 5 ([OGO-5](#)) satellite. Later that year OGO-5 detected a smaller cloud around the short-period Comet 2P/Encke (another future "Comet of the Week") as it was en route to its perihelion passage in early 1971.

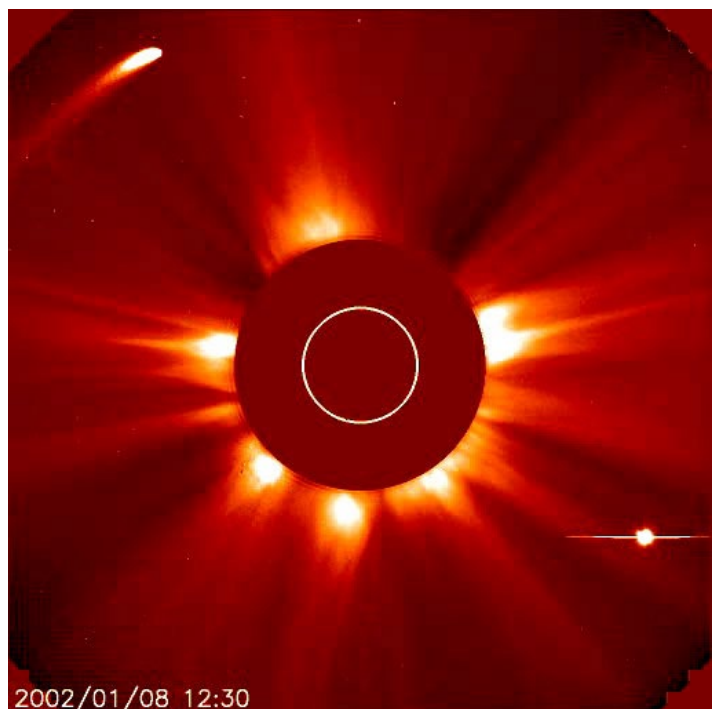
Today these "Lyman-alpha clouds" have been found to accompany most comets that visit the inner solar system. Perhaps the most prolific detector of this phenomenon is the Solar Wind ANisotropies ([SWAN](#)) ultraviolet telescope aboard the joint NASA/ESA Solar and Heliospheric Observatory ([SOHO](#)) mission that was launched in late 1995. Although, as its name implies, SWAN was primarily designed to examine large-scale changes in the speed and intensity of the solar wind, its detectors are quite sensitive to Lyman-alpha radiation and it has become quite adept at detecting the hydrogen clouds accompanying visiting comets. The largest Lyman-alpha cloud that SWAN has detected was the one accompanying Comet Hale-Bopp in 1997, which was 2/3 of an Astronomical Unit (70 times the diameter of the sun) across.

In late 1999 one of the SWAN team members, Teemu Makinen of the Finnish Meteorological Institute in Helsinki, detected an apparently un-discovered comet in SWAN images that had been taken in mid-1997. Two and a half years later Makinen detected

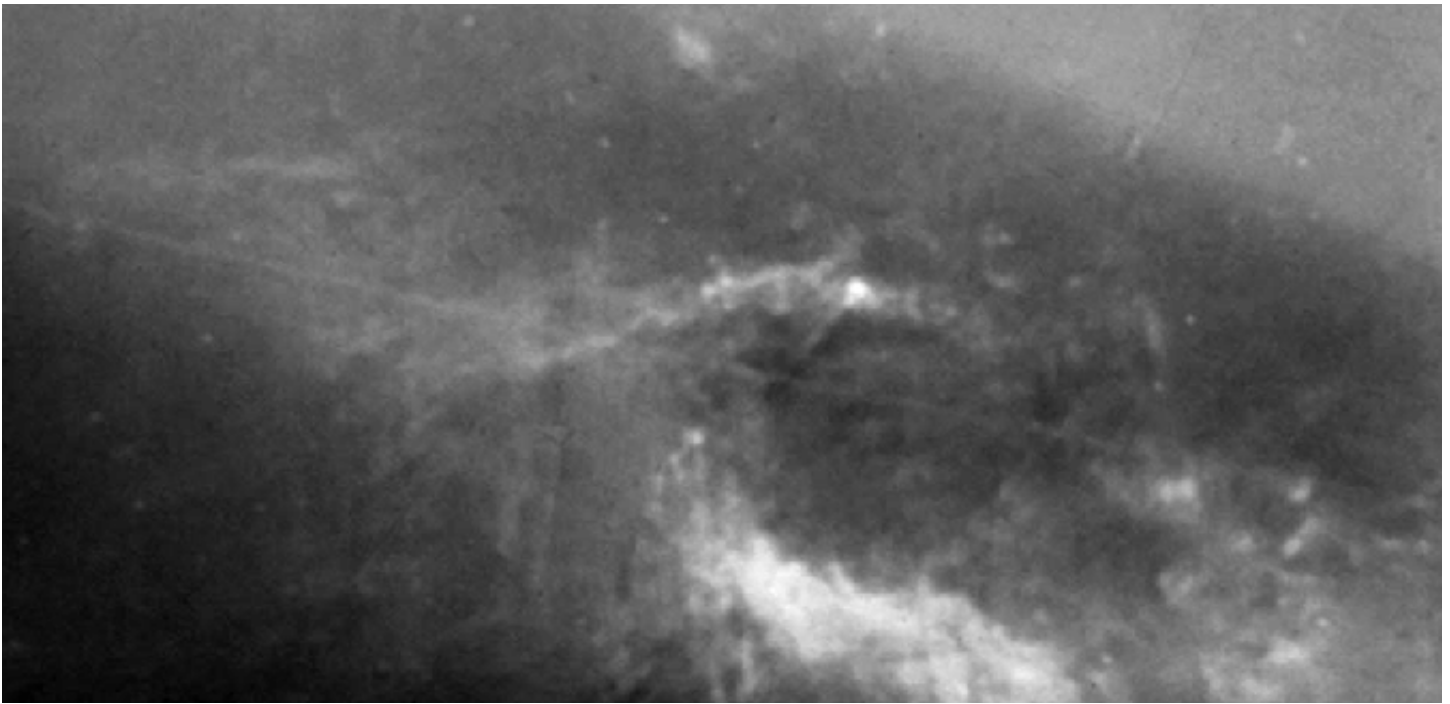
a second apparently un-discovered comet in SWAN images from mid- to late 2000. Later that year a Japanese amateur astronomer, Masayuki Suzuki, detected an apparent comet in near-real time SWAN images (which are [publicly accessible](#)); this turned out to be a real comet (designated C/2002 O6) – which in fact I helped [confirm](#) – that briefly reached 6th magnitude a month later.

Since that time several amateur astronomers routinely scan the publicly accessible SWAN images, and over the years they have discovered several previously-unknown comets. One of these (C/2006 M4) later became almost as bright as 4th magnitude four months after it was discovered, and another one (discovered in late 2012) turned out to be a seemingly "lost" Halley-type comet first seen in 1827 (273P/Pons-Gambart). SOHO is still an active mission at this writing and it is entirely possible that more "SWAN comets" remain to be discovered.

Since many comets contain significant amounts of dust – which glows brightly in the infrared – then infrared-sensitive orbiting telescopes would also be desirable for observing comets. During the ten months of its operation in 1983 the InfraRed Astronomical Satellite ([IRAS](#)) discovered six comets, including the Earth-approaching Comet IRAS-Araki-Alcock 1983d (a future "Comet of the Week"), the "active asteroid" now known as (3200) Phaethon which is associated with the Geminid meteor shower and which may be an "extinct" comet, and a large dust trail accompanying Comet 10P/Tempel 2. During 2010 and 2011 the Wide-field Infrared Survey



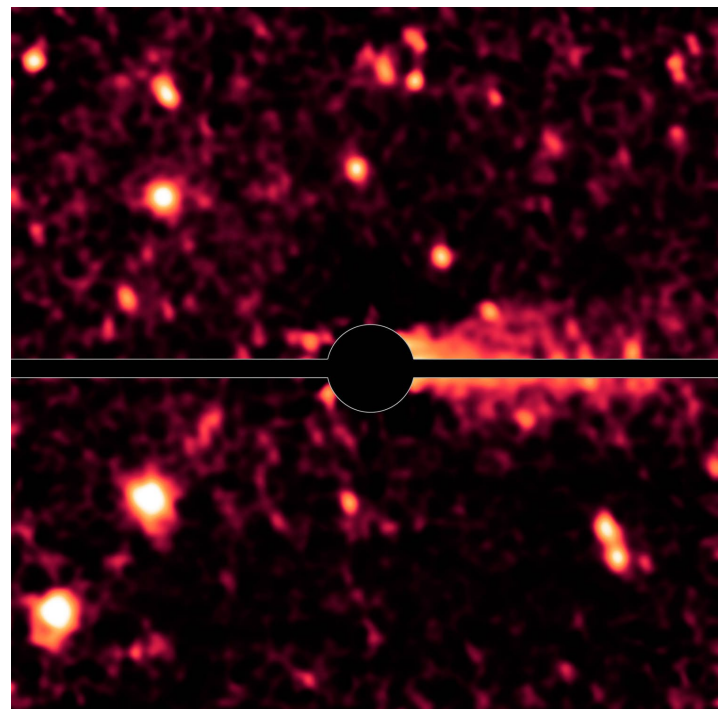
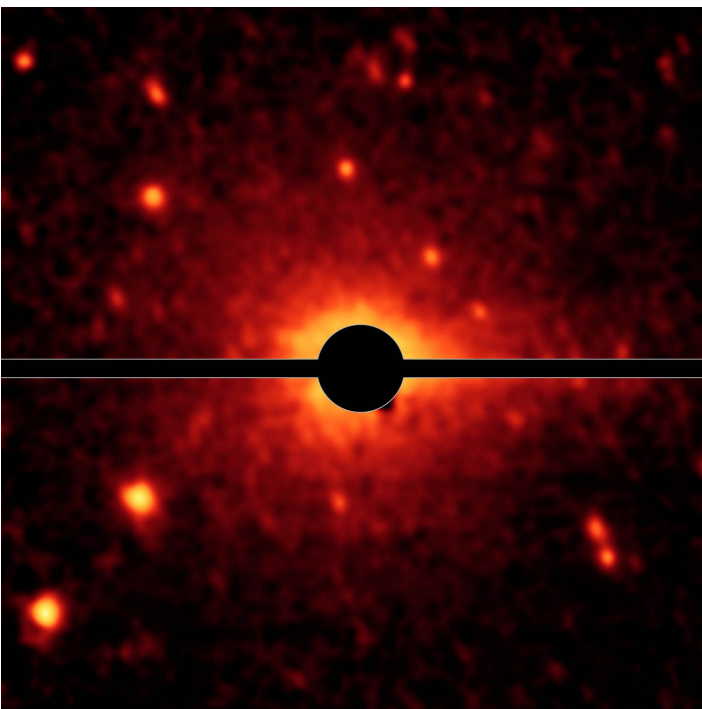
Comet 96P/Machholz 1 in the LASCO C2 coronagraph aboard [SOHO](#), on January 8, 2002. The bright object at lower right is Venus. Courtesy NASA/ESA.



IRAS image of Comet 10P/Tempel 2, with its accompanying dust trail, taken August 28, 1983. From [Campins et al. \(1990\)](#).

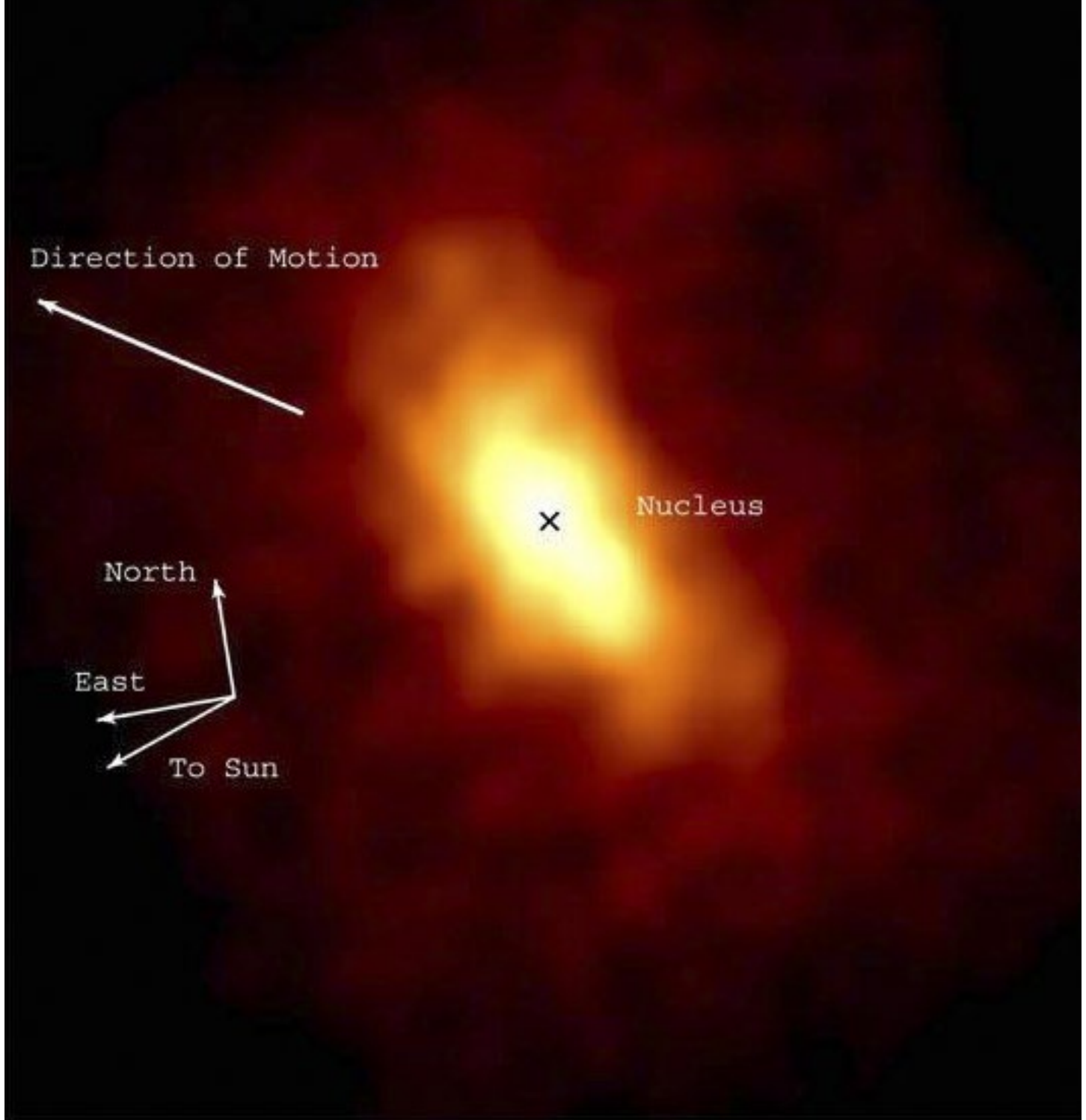
Explorer ([WISE](#)) mission – a next-generation successor to IRAS – discovered 17 comets and numerous asteroids, including the first-known (and, so far, only known) “Earth Trojan” (2010 TK7). Although its longer-wavelength detectors are no longer operational, during recent years WISE (under the mission name [NEOWISE](#)) has continued to search for comets and near-Earth asteroids, and as of this writing has discovered 14 additional comets.

One other infrared-sensitive space telescope that has been utilized for numerous comet observations is the [Spitzer Space Telescope](#), launched in 2003 and just recently retired from service. One of Spitzer's more unique observations involves the “asteroid” (3552) Don Quixote which was discovered in 2003, and which travels in a rather high-eccentricity comet-like orbit and had thus been considered a possible “extinct” comet. When Don Quixote returned in 2009 Spitzer detected



4.5-micron images of (3552) Don Quixote taken with the [Spitzer Space Telescope](#) on August 22, 2009. Left: The stellar central condensation has been subtracted out, revealing the faint surrounding coma. Right: The coma has been subtracted out, revealing a faint tail. Images courtesy NASA/JPL-Caltech-DLR/NAU.





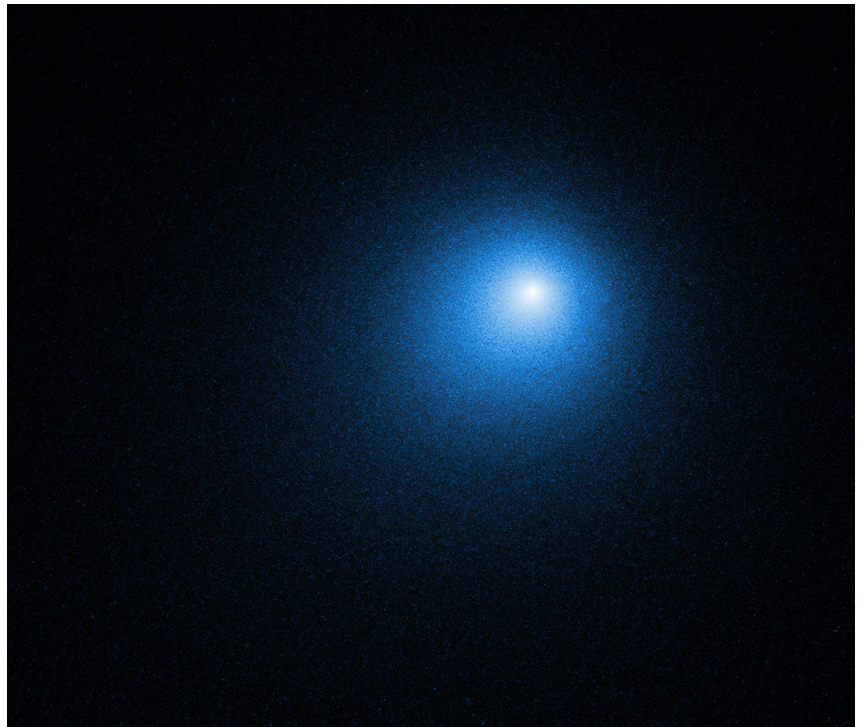
X-ray image of Comet LINEAR C/1999 S4 taken by the [Chandra X-ray Observatory](#) on July 14, 2000. Courtesy NASA.

clear signs of a small coma and a short tail, as well as possible emission of carbon dioxide. Cometary activity around Don Quixote was detected optically during its subsequent return in 2018, and this detection, combined with the Spitzer observations, show that Don Quixote is still an active comet (albeit at a low level).

The absence of the scattering effects of an atmosphere makes it at least theoretically possible to examine the region of the sky close to the sun, and accordingly space-based coronagraphs have been utilized for this purpose for some time. The first space-based coronagraph observations of a comet

came with Comet Kohoutek 1973f in late 1973, when coronagraphs aboard both the Orbiting Solar Observatory 7 ([OSO-7](#)) satellite and aboard the [Skylab](#) space station detected it as a bright object near the sun around the time of perihelion. The astronaut crew aboard Skylab also observed and photographed Comet Kohoutek around that time, and as Comet Kohoutek is a future "Comet of the Week" I will discuss these observations in that presentation.

Numerous comets have been detected in coronagraphs aboard the U.S. Defense Department satellite [P78-1](#), the [Solar Maximum Mission](#), SOHO,



Images of comets taken with the [Hubble Space Telescope](#). Left: The inner coma of Comet Levy 1990, on September 27, 1990. Right: Comet 46P/Wirtanen on December 13, 2018, one day after an approach to Earth of 0.08 AU. Both images courtesy NASA.

and the twin spacecraft of the Solar and Terrestrial RElations Observatory ([STEREO](#)) mission. Many of these comets have been discoveries by the respective missions; indeed, SOHO has as of now discovered over 3800 small comets passing close to the sun. A large number of these comets – although not all of them – have been small Kreutz sungrazers, and a couple of these objects are future “Comets of the Week” and I will discuss them more thoroughly there and in a future “Special Topics” presentation.

Somewhat surprisingly, comets have also been observed with x-ray sensitive orbiting telescopes. Cometary x-rays were first observed by the German Roentgensatellit ([ROSAT](#)) spacecraft in March 1996 near Comet Hyakutake C/1996 B2 (which was passing close to Earth at that time and which is a future “Comet of the Week”). Once these were found, astronomers combing through archived ROSAT data found x-ray emission from several previous comets, including – rather remarkably – an otherwise dim and unremarkable comet, Comet Arai 1991b, six weeks before that comet's discovery. In general, the x-rays came not from the comets themselves but rather from crescent-shaped regions sunward of their nuclei, and their origin remained a mystery for some time. Finally, observations of Comet LINEAR C/1999 S4 by the [Chandra X-ray Observatory](#) in July 2000 showed that the x-rays were due to specific ions of oxygen and nitrogen and were being produced by charge-exchange reactions between energetic particles in the solar wind and neutral atoms and molecules in the comet's environment.

Any discussion of space-based comet observations would be incomplete without mention of the [Hubble Space Telescope](#). Hubble was deployed from the Space Shuttle Discovery on April 25, 1990, although within two months a serious problem was detected in its optical system which prevented images from being brought to a proper focus. (In effect, Hubble was “nearsighted.”) The problem was corrected during a Shuttle Hubble Servicing Mission in December 1993, but in the meantime the development of sophisticated image processing techniques allowed for useful scientific images to be returned from Hubble despite the focusing issues.

The first comet observations made by Hubble were of Comet Levy 1990c – like several of the aforementioned comets, a future “Comet of the Week” – on September 27, 1990, and the images show strong jetting activity in the comet's inner coma. Since that time, and especially since the 1993 servicing mission, Hubble has taken images and other data of numerous comets, and should continue to do so up until the time it is no longer operational.

Today, quite a few orbiting satellite missions are involved in making observations of comets and have contributed enormously to our understanding of these objects, and this should continue for the foreseeable future. One other facet of space-based comet observations involves spacecraft visits to these objects, and this subject will be treated in a future “Special Topics” presentation.

# Ice and Stone **WORD SEARCH**

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