Asteroid from 'rare species' sighted in the cosmic wild

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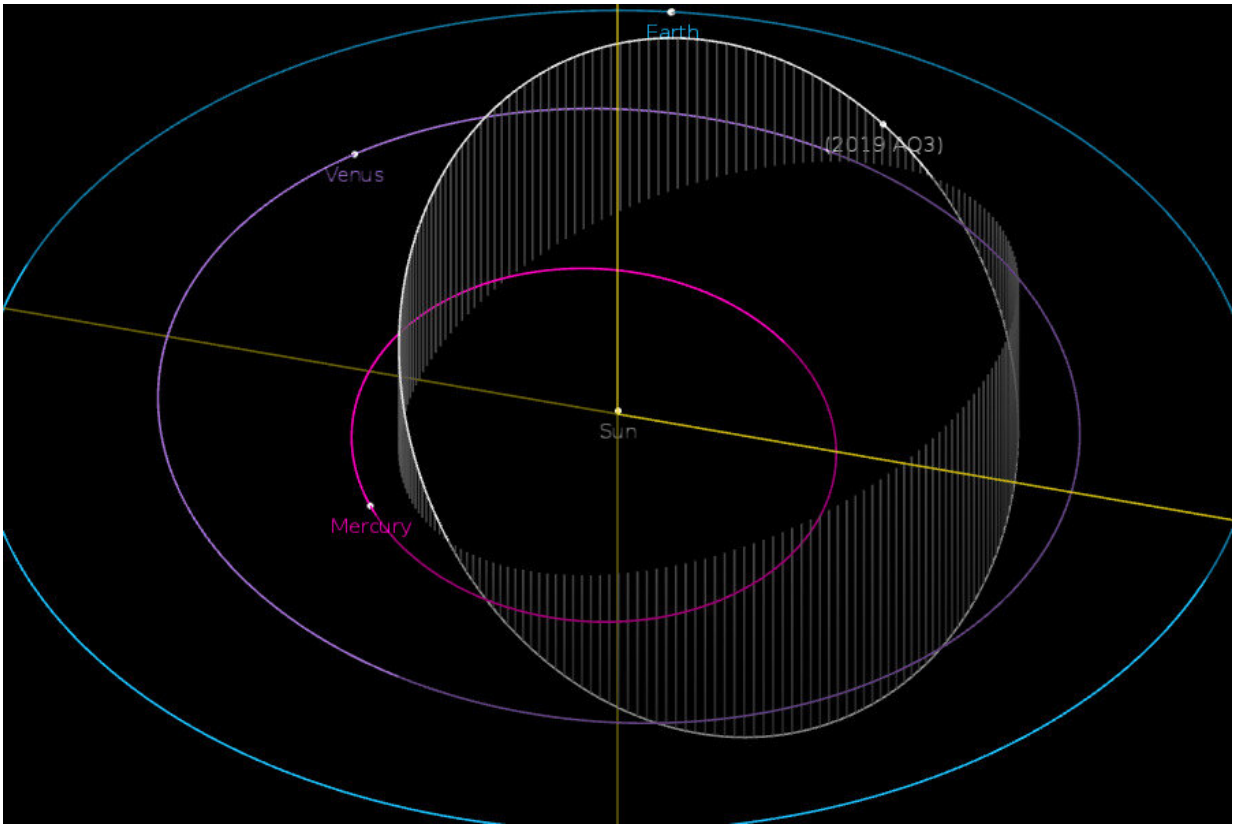

Credit: Zwicky Transient Facility

Astronomers have discovered an asteroid looping through the inner solar system on an exotic orbit. The unusual object is among the first asteroids ever found whose orbit is confined almost entirely within the orbit of

Venus. The asteroid's existence hints at potentially significant numbers of space rocks arcing unseen in uncharted regions nearer to the sun.

A state-of-the-art sky-surveying camera, the Zwicky Transient Facility, or ZTF, detected the asteroid on January 4, 2019. Designated 2019 AQ3, the object has the shortest "year" of any recorded asteroid, with an orbital period of just 165 days. It also appears to be an unusually big asteroidal specimen.

"We have found an extraordinary object whose orbit barely strays beyond Venus' orbit—that's a big deal," said Quanzhi Ye, a postdoctoral scholar at IPAC, a data and science center for astronomy at Caltech. Ye called 2019 AQ3 a "very rare species," further noting that "there might be many more undiscovered asteroids out there like it."

ZTF is installed on the 48-inch Samuel Oschin Telescope at the Palomar Observatory, located about 122 miles south-east of Los Angeles. It began operations in March 2018 and has already observed more than a billion Milky Way stars, as well as over a thousand of supernovae outside the Milky Way, and other extreme transient cosmic events. ZTF was made possible by funding from the National Science Foundation (NSF). Asteroid research with ZTF is also directly funded by NSF through support of Ye as a Caltech postdoctoral scholar.

A chief science goal of ZTF is rounding up near-Earth asteroids (NEAs), which along with comets that buzz our planet are known as near-Earth objects (NEOs). Scientists at ZTF are especially interested in finding NEAs between about 10 and 100 meters in diameter—not monstrous in size, but that could still be large enough to severely impact a city should they collide with Earth. Of this potentially Earth-bound set of space rocks, the most concerning are those that come from the direction of the sun, which get lost in the glare and are difficult to measure.

"These small asteroids are only bright enough to be detected during the short period that they are very close to the Earth," said Tom Prince, the Ira S. Bowen Professor of Physics at Caltech with a joint appointment as a senior research scientist at the Jet Propulsion Laboratory, managed by Caltech for NASA, who works on finding NEOs using ZTF. "During this brief window, the asteroids are moving very fast, posing challenges for astronomers to find and track them."

To have any hope of locating such objects, the sky must be scanned very frequently. ZTF surveys the entire northern visible sky every three nights. This excellent coverage comes courtesy of its vast field of view, which in a single exposure, can image approximately two hundred and thirty times the size of the full moon. "The large field-of-view makes ZTF an ideal instrument to find and track rare objects, such as near-Earth asteroids," said Frank Masci, a Staff Scientist at Caltech / IPAC, who oversees and manages the ZTF science data processing system, which is located at IPAC. "ZTF is definitely up to the game."

Leveraging ZTF's capabilities, Ye and Wing-Huen Ip—a professor of astronomy and space science at the Institute of Astronomy and Space Science at the National Central University in Taiwan—proposed the Twilight Survey, which looks for asteroids inbound from the sun. This survey turned up 2019 AQ3 and could yield other interesting asteroids down the road.

A history of asteroidal and cometary successes

Finding NEOs before they find us has long been a major topic at Caltech / IPAC. The center has led the science operations and data processing for NASA's Wide-field Infrared Survey Explorer (WISE) and NEOWISE missions since their launch in 2009. This asteroid hunter has discovered more than 34,000 new asteroids, including nearly 300 NEAs. ZTF"s predecessor, the Palomar Transient Factory, likewise revealed a

bevy of NEOs during its sky survey.

"The sizes of NEOs are best estimated by combining visible and infrared data, which is precisely what we strive to do here at IPAC," said George Helou, Research Professor of Physics at Caltech and the Executive Director of IPAC. "Since its inception, IPAC has been involved in infrared studies of asteroids."

So far, ZTF has logged nearly 60 new near-Earth asteroids. Two of these were spotted in July 2018 mere hours before they gave Earth quite a close shave. Designated 2018 NW and 2018 NX, the duo of bus-sized asteroids whipped past at a distance of about 70,000 miles, or only a third of the way to the moon. Fortunately, the newfound 2019 AQ3 poses no threat; the closest it ever comes to Earth is about 22 million miles.

Tracking down 2019 AQ3

The story of how researchers nailed down 2019 AQ3's orbit begins with Ye noting the object in ZTF's images on January 4, 2019. Ye reported the object to the IAU Minor Planet Center, the official worldwide organization charged with gathering data on sun-orbiting objects that are not full planets, such as asteroids and comets. Ye then spent some time mining the ZTF images taken before and after this date to improve projections of the asteroid's orbit.

Two days later, Marco Micheli, a scientist at the European Space Agency, pointed out the target's uniqueness to the global astronomical community. Multiple other telescopes observed 2019 AQ3 on January 6 and 7, further documenting its uniqueness. A dig through the archives of the Pan-STARRS 1 telescope at the Haleakalā Observatory on the island of Maui, Hawaii, turned up evidence of 2019 AQ3 going back to 2015. With those data in hand, astronomers confidently mapped the object's

complete path around the sun.

The orbit, as it turns out, is angled vertically, taking 2019 AQ3 above and below the plane where the planets run their laps around the sun. Over its short year, 2019 AQ3 plunges inside of Mercury, then swings back up just outside of Venus' orbit.

For now, 2019 AQ3 is placed among a peculiar population usually referred to as the Atira or Apohele asteroids, which have orbits interior to Earth's orbit. Among the approximately 800,000 known asteroids, only 20 or so are Atiras. Far greater numbers of these potentially dangerous space rocks are thought to exist, however, the discovery and characterization of which are among the motivations behind the proposed Near-Earth Object Camera (NEOCam) infrared space telescope. Presently funded by NASA for an extended concept study phase, NEOCam is designed to look closer to the sun than previous surveys, which would empower it to pick out hidden asteroids that have long defied detection.

Learning more about known and newfound Atiras, for example their sizes, is an additional goal of ZTF and its fellow instruments. Although the true size of 2019 AQ3 is not yet discernible, limited readings relating to the asteroid's brightness, mass, and density suggest it could be nearly a mile across. If so, 2019 AQ3 would stack up as one of the largest members of the exclusive Atiras group. "In so many ways, 2019 AQ3 really is an oddball asteroid," said Ye.

Finding more space rocks in 2019 AQ3's neck of the woods could lend credence to the long-held idea of vulcanoids—asteroids that swarm inside the orbit of Mercury. The hypothetical population's name derives from a likewise hypothetical planet, Vulcan. Bearing no relation to the fictional home world of Mr. Spock in Star Trek, Vulcan was proposed in the 19th century as the planet closest to the sun whose gravity would

explain anomalies measured in Mercury's orbit. Albert Einstein's gravitational framework, the theory of general relativity, explained away these anomalies in 1915, nixing the Vulcan conjecture.

Although ZTF will not have the ability to find vulcanoids, its observing prowess, coupled with that of future telescopes, will enable scientists to at last examine an uncharted region in the inner solar system. ZTF should turn up fresh surprises, as well as give old ideas new chances of being substantiated. "The origin of Atiras is an intriguing and open question," said Ip. "With every additional object, we get closer to formulating and testing models about that origin, and about the history of our Solar System."

More information: For more information, see www.minorplanetcenter.net/db_s … ch/show_object?utf8=%E2%9C%93&object_id=2019+AQ3

Provided by California Institute of Technology

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