Swift mission tallied water from interstellar comet Borisov

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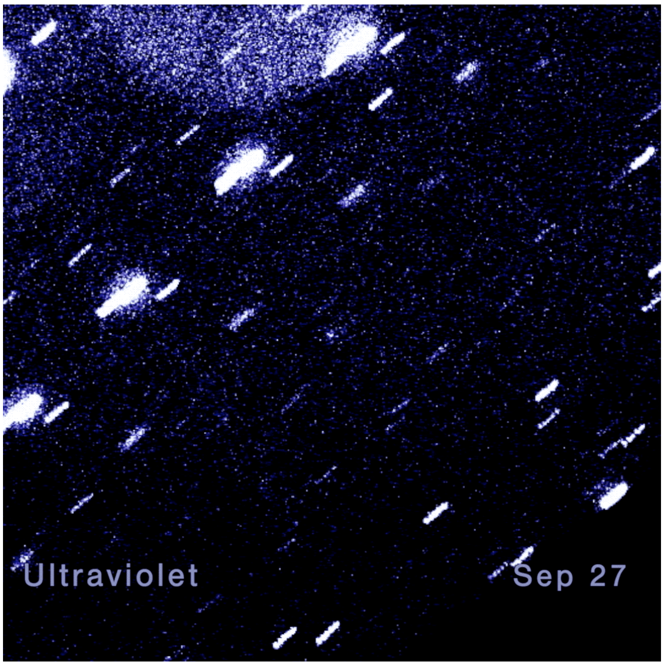

Credit: NASA

For the first time, NASA's Neil Gehrels Swift Observatory tracked water loss from an interstellar comet as it approached and rounded the Sun. The object, 2I/Borisov, traveled through the solar system in late 2019.

"Borisov doesn't fit neatly into any class of solar system comets, but it also doesn't stand out exceptionally from them," said Zexi Xing, a graduate student at the University of Hong Kong and Auburn University in Alabama who led the research. "There are known comets that share at least one of its properties."

Comets are frozen clumps of gases mixed with dust, often called "dirty snowballs." Scientists estimate hundreds of billions of them may orbit the Sun. Based on Borisov's speed and computed path, however, it must have come from outside the solar system. The comet is only the second known interstellar visitor, discovered two years after the first object, named 'Oumuamua, zipped through the solar system.

Amateur astronomer Gennady Borisov discovered the comet on August 30, four months before it made its closest approach to the Sun. The early identification gave multiple space- and ground-based observatories time for detailed follow-up observations. In October, scientists using the Apache Point Observatory in Sunspot, New Mexico, detected the first hint of water from the comet. In the following months, NASA's Hubble Space Telescope snapped images of Borisov as the comet sped along at around 100,000 miles (161,000 kilometers) per hour.

As a comet approaches the Sun, frozen material on its surface—such as carbon dioxide—warms and begins converting to gas. When it gets within 230 million miles (370 million kilometers) of the Sun, water vaporizes. Xing and her colleagues confirmed the presence of water from Borisov and measured its fluctuations using ultraviolet light.

When sunlight breaks apart water molecules, one of the fragments is hydroxyl, a molecule composed of one oxygen and one hydrogen atom. Swift detects the fingerprint of UV light emitted by hydroxyl using its Ultraviolet/Optical Telescope (UVOT). Between September and February, Xing's team made six observations of Borisov with Swift. They saw a 50% increase in the amount of hydroxyl—and therefore water—Borisov produced between Nov. 1 and Dec. 1, which was just seven days from the comet's closest brush with the Sun.

At peak activity, Borisov shed eight gallons (30 liters) of water per second, enough to fill a bathtub in about 10 seconds. During its trip through the solar system, the comet lost nearly 61 million gallons (230 million liters) of water—enough to fill over 92 Olympic-size swimming pools. As it moved away from the Sun, Borisov's water loss dropped off—and did so more rapidly than any previously observed comet. Xing said this could have been caused by a variety of factors, including surface erosion, rotational change and even fragmentation. In fact, data from Hubble and other observatories show that chunks of the comet broke off in late March.

"We're really happy that Swift's rapid response time and UV capabilities captured these water production rates," said co-author Dennis Bodewits, an associate professor of physics at Auburn. "For comets, we express the amount of other detected molecules as a ratio to the amount of water. It provides a very important context for other observations."

Swift's water production measurements also helped the team calculate that Borisov's minimum size is just under half a mile (0.74 kilometer) across. The team estimates at least 55% of Borisov's surface—an area roughly equivalent to half of Central Park—was actively shedding material when it was closest to the Sun. That's at least 10 times the active area on most observed solar system comets. Borisov also differs from solar system comets in other aspects. For example, astronomers working with Hubble and the Atacama Large Millimeter/submillimeter Array, a radio telescope in Chile, discovered Borisov produced the highest levels of carbon monoxide ever seen from a comet at that distance from the Sun.

Borisov does have some traits in common with solar system comets, though. Its rise in water production as it approached the Sun was similar to previously observed objects. Xing and her team also found that other molecules in Borisov's chemical inventory—and their abundances—are similar to home-grown comets. For example, with respect to hydroxyl and cyanogen—a compound composed of carbon and nitrogen—Borisov produced a small amount of diatomic carbon, a molecule made of two carbon atoms, and amidogen, a molecule derived from ammonia. About 25% to 30% of all solar system comets share that trait.

But Borisov's combined characteristics defy placement in any single known comet family. Scientists are still pondering what this means for comet development in other planetary systems.

The team's results were published in the April 27, 2020, issue of The *Astrophysical Journal Letters* and are available online.

Swift was developed to study gamma-ray bursts, the most luminous explosions in the universe. But for the last decade, Bodewits has used it to learn more about comets as they traverse the solar system. Most UV light is absorbed by Earth's atmosphere, so scientists must look for hydroxyl's signature from space. And because Swift has a flexible observing strategy and rapid reaction time, it can perform long-term monitoring of interesting new targets. The first five observations of Borisov were composed of UVOT snapshots taken over 12 hours, and the last was a series of images captured over 24 hours.

"The team did not envision that the mission would contribute so much to our understanding of planetary science when it was being built," said Swift Principal Investigator S. Bradley Cenko at NASA's Goddard Space Flight Center in Greenbelt, Maryland. "But it's a nice example of people coming up with creative and powerful ways to use the capabilities that are out there to do unexpected and exciting science."

More information: Water Production Rates and Activity of Interstellar Comet 2I/Borisov, iopscience.iop.org/article/10. … 847/2041-8213/ab86be

Provided by NASA

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