Interstellar objects like 'Oumuamua probably crash into the sun every 30 years

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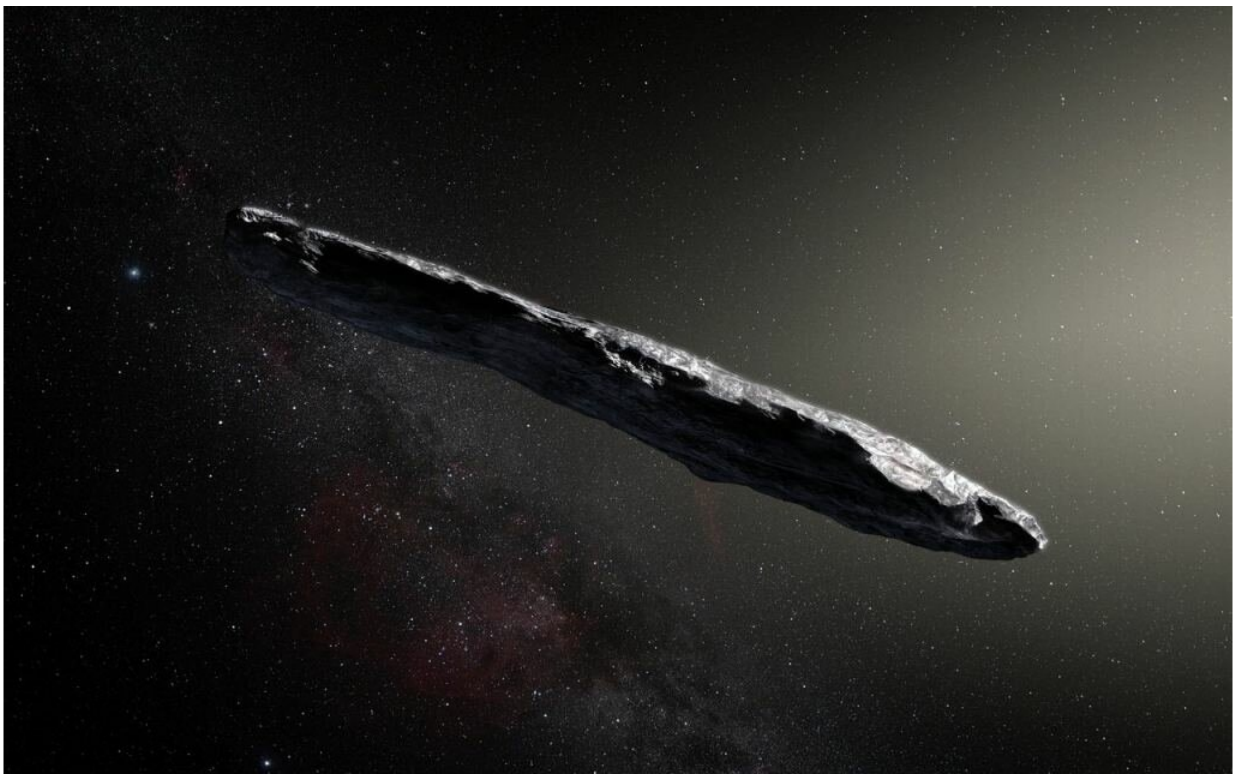

Artist’s impression of the first interstellar asteroid/comet, 'Oumuamua. This unique object was discovered on 19 October 2017 by the Pan-STARRS 1 telescope in Hawaii. Credit: ESO/M. Kornmesser

On October 19th, 2017, the Panoramic Survey Telescope and Rapid Response System-1 (Pan-STARRS-1) in Hawaii announced the firstever detection of an interstellar object, named 1I/2017 U1 (aka. 'Oumuamua). In the months that followed, multiple follow-up observations were conducted to learn more about this visitor, as well as resolve the dispute about whether it was a comet and an asteroid.

Rather than resolving the dispute, additional observations only deepened the mystery, even giving rise to suggestions that it might be an extra-terrestrial solar sail. For this reason, scientists are very interested in finding other examples of 'Oumuamua-like objects. According to a recent study by a team of Harvard astrophysicists, it is possible that interstellar objects enter our system and end up falling into in our sun somewhat regularly.

The study, "Turning up the heat on 'Oumuamua," recently appeared online and was submitted for publication to the *Astrophysical Journal Letters*. The study was conducted by John Forbes – a fellow at the Harvard-Smithsonian Center for Astrophysics' Institute for Theory and Computation (ITC) – and Prof. Abraham Loeb – the director of the ITC, the Frank B. Baird Jr. Prof. of Science and the Chair of the Astronomy Department at Harvard University.

To recap, when 'Oumuamua was first detected, the object was about 0.25 AU from the sun and already on its way out of the solar system. Based on its trajectory, it was concluded that 'Oumuamua was extra-solar in origin, rather than being a long-period object that originated in the Oort Cloud. Astronomers also noted that it appeared to have a high density (indicative of a rocky and metallic composition) and that it was spinning rapidly.

This gave rise to the theory that rather than being an interstellar comet, 'Oumuamua was actually an interstellar asteroid. This was consistent with the fact that it did not experience any outgassing or form a tail when it made its closest approach to the sun. However, as 'Oumuamua began to make its way out of the solar system, another research team noted that it experienced an increase in velocity.

This strange behavior once again led scientists to hypothesize that 'Oumuamua might be a comet, since outgassing as a result of solar heating would explain its sudden change in speed. Unfortunately, between the fact the object had not experienced any outgassing nearer to the sun, or experienced a rapid evolution in its spin (which accompanies the sudden release of material), scientists were once again at a loss.

As noted, this gave rise to the idea that 'Oumuamua could in fact be a light sail, which was originally proposed in another study by Prof. Loeb and Shmuel Bialy (a postdoc research with the ITC). Basically, a light sail is form of spacecraft that relies on radiation pressure to generate propulsion, which would explain why the object sped up when moving away from the sun.

Regardless of its true nature, the fact that 'Oumuamua has defied classification has made it the subject of great interest. As Prof. Loeb told universe Today:

"The discovery of 'Oumuamua allows us to calibrate the abundance of interstellar objects of its size, based on the survey time and sensitivity of the Pan STARRS telescopes. There should be roughly a quadrillion (10^{15}) such objects per star in the Milky Way. A small fraction of these objects pass near Jupiter and kick it enough to get trapped in the System System."

In a previous study, Prof. Loeb and Manasvi Lingam (a postdoc researcher with the ITC) calculated that the solar system hosts an estimated 6,000 trapped interstellar objects. In a follow-up study, Loeb and Amir Siraj identified four candidates for possible study and indicated that many more will likely be found with the Large Synoptic

Survey Telescope (LSST) – which could even be studied by a robotic mission in the near future.

"This is one way to learn about the structure and composition of 'Oumuamua-like interstellar objects," said Loeb. "In our new paper we proposed instead studying the vapor produced when such objects pass close to the sun and get evaporated by the intense solar heat. We calculated the likelihood of that happening, keeping in mind that 'Oumuamua did not show any signs of a cometary tail or carbon-based gas since it did not pass close enough to the sun."

This proposal would build upon the well-established tradition of examining the spectra of comets as they pass close to the sun to learn more about their origins. By determining the production rates of water, diatomic carbon (C_2), cyanide (CN), and amino radicals ($NH_{2)}$ – as well as the comet's dynamical properties – scientists are able to determine which part of the protoplanetary disk the comet is likely to have formed in.

Applying this to bodies in the solar system, Forbes and Loeb sought to constrain how often interstellar visitors pass close to our sun. This consisted of using the known orbit of 'Oumumua and the Monte Carlo method (where random sampling is used to obtain numerical values) to determine the expected distribution of the orbits of interstellar objects in the vicinity of the sun.

From this, they were able to obtain estimates on how often objects collide with our sun, and how many of these are likely to be interstellar in origin. As Loeb said:

"We have found that such objects collide with the sun once every 30 years, while about 2 pass within the orbit of Mercury each year. We identified preferred orientations for the orbits of interstellar objects and concluded that at least one of the known solar system objects is extrasolar in origin."

Forbes and Loeb also identified the likely orbital orientations that extrasolar objects would have in our solar system, using data from the International Celestial Reference System (ICRS). As with the previous study conducted by Loeb and Lingam, they even identified some known objects in the solar system that have these orientations.

These were drawn from NASA's JPL Small-Body Database, the majority of which belong to the Kreutz group – a family of sungrazing comets that have orbits which bring them extremely close to the sun at perihelion. Of these, Forbes and Loeb identify a few that could be interstellar in origin based on the inclination of their orbits.

"In the future, many more interstellar objects are likely to be discovered by LSST," said Loeb. "Another telescope with the potential to discover sun-grazing comets is the forthcoming Daniel K. Inoue Solar Telescope (DKIST), which is located just next to the Pan STARRS observatory on Mount Haleakala in Hawaii. DKIST will observe the sun at high spatial and temporal resolution, and is equipped with multiple spectro-polarimeters. DKIST's capabilities of studying sun-grazing comets may be limited by its lack of a coronograph to block the sun-light, but its unprecedented sensitivity and resolution may yield interesting discoveries."

This latest study could help inform future studies of interstellar objects, which could reveal what kinds of conditions are present in extrasolar systems without having to send robotic missions to study them directly. Assuming that some of these objects are artificial in nature, they could also resolve the Fermi Paradox.

Since the discovery of 'Oumuamua (and because of our inability to resolve the question of its true nature), scientists have been eager to find another interstellar object in our solar system for study. Knowing that there are already some out there, and which could be studied very soon, is an exciting prospect. Either way, we stand to learn a great deal about this universe we inhabit.

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