Astronomers suggest up to 60% of near-Earth objects could be dark comets

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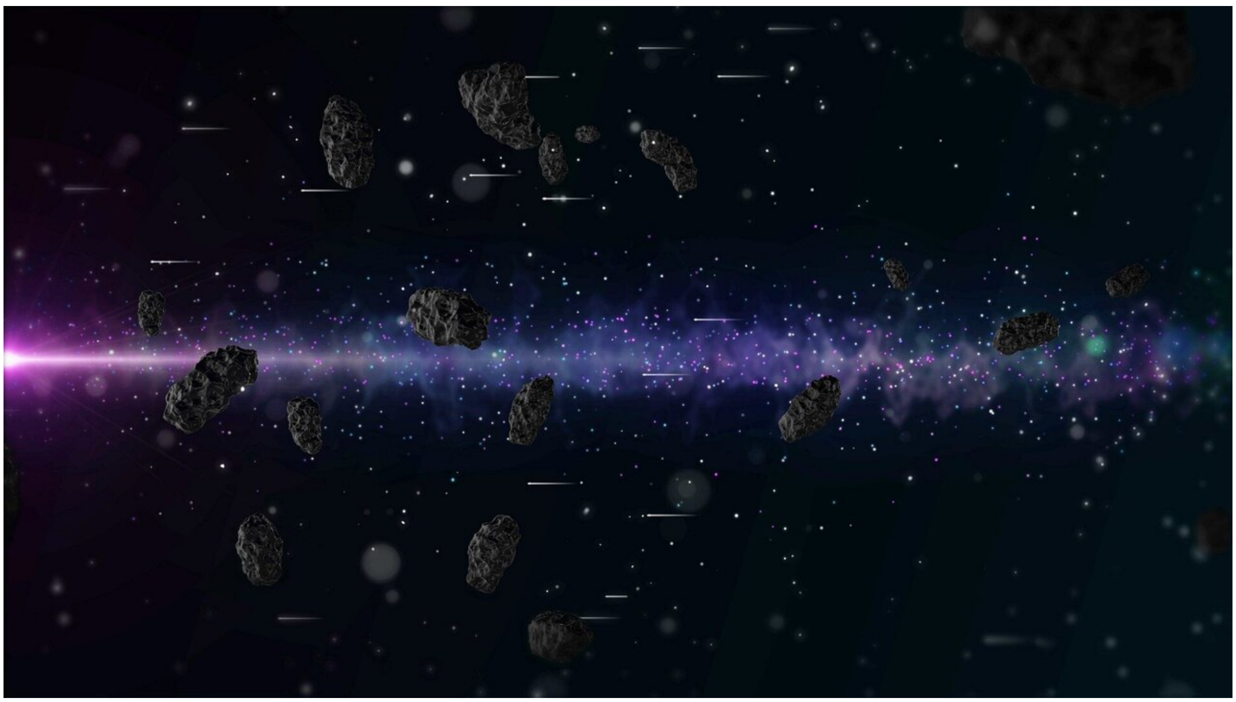

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Up to 60% of near-Earth objects could be dark comets, mysterious asteroids that orbit the sun in our solar system that likely contain or previously contained ice and could have been one route for delivering water to Earth, according to a University of Michigan study.

The findings suggest that asteroids in the asteroid belt, a region of the solar system roughly between Jupiter and Mars that contains much of the system's rocky asteroids, have subsurface ice, something that has been suspected since the 1980s, according to Aster Taylor, a U-M graduate student in astronomy and lead author of the study.

The study also shows a potential pathway for delivering ice into the near-Earth solar system, according to Taylor. How Earth got its water is a longstanding question.

"We don't know if these dark comets delivered water to Earth. We can't say that. But we can say that there is still debate over how exactly the Earth's water got here," Taylor said. "The work we've done has shown that this is another pathway to get ice from somewhere in the rest of the solar system to the Earth's environment."

The research further suggests that one large object may come from the Jupiter-family comets, comets whose orbits take them close to the planet Jupiter. The team's results are published in the journal *Icarus*.

Dark comets are a bit of a mystery because they combine characteristics of both asteroids and comets. Asteroids are rocky bodies with no ice that orbit closer to the sun, typically within what's called the ice line. This means they are close enough to the sun for any ice the asteroid may have been carrying to sublimate, or change from solid ice directly into gas.

Comets are icy bodies that show a fuzzy coma, a cloud that often surrounds a comet. Sublimating ice carries dust along with it, creating the cloud. Additionally, comets typically have slight accelerations propelled not by gravity, but by the sublimation of ice, called nongravitational accelerations.

The study examined seven dark comets and estimates that between 0.5 and 60% of all near-Earth objects could be dark comets, which do not have comae but do have nongravitational accelerations. The researchers also suggest that these dark comets likely come from the asteroid belt, and because these dark comets have nongravitational accelerations, the study findings suggest asteroids in the asteroid belt contain ice.

"We think these objects came from the inner and/or outer main asteroid belt, and the implication of that is that this is another mechanism for getting some ice into the inner solar system," Taylor said. "There may be more ice in the inner main belt than we thought. There may be more objects like this out there. This could be a significant fraction of the nearest population. We don't really know, but we have many more questions because of these findings."

In previous work, a team of researchers including Taylor identified nongravitational accelerations on a set of near-Earth objects, naming them "dark comets." They determined that the dark comets' nongravitational accelerations are likely the result of small amounts of sublimating ice.

In the current work, Taylor and their colleagues wanted to discover where the dark comets came from.

"Near-Earth objects don't stay on their current orbits very long because the near-Earth environment is messy," they said. "They only stay in the near-Earth environment for around 10 million years. Because the solar system is much older than that, that means near-Earth objects are coming from somewhere—that we're constantly being fed near-Earth objects from another, much larger source."

To determine the origin of this dark comet population, Taylor and their co-authors created dynamical models that assigned nongravitational accelerations to objects from different populations. Then, they modeled a path these objects would follow given the assigned nongravitational accelerations over a period of 100,000 years.

The researchers observed that many of these objects ended up where dark comets are today, and found that out of all potential sources, the main asteroid belt is the most likely place of origin.

One of the dark comets called 2003 RM, which passes in an elliptical orbit close to Earth, then out to Jupiter and back past Earth, follows the same path that would be expected from a Jupiter family comet, Taylor says—that is, its position is consistent with a comet that was knocked inward from its orbit.

Meanwhile, the study finds that the rest of the dark comets likely came from the inner band of the asteroid belt. Since the dark comets likely have ice, this shows that ice are present in the inner main belt.

Then, the researchers applied a previously suggested theory to their population of dark comets to determine why the objects are so small and quickly rotating. Comets are rocky structures bound together by ice—picture a dirty ice cube, Taylor says. Once they get bumped within the solar system's ice line, that ice starts to off gas. This causes the object's acceleration, but it can also cause the object to spin quite fast—fast enough for the object to break apart.

"These pieces will also have ice on them, so they will also spin out faster and faster until they break into more pieces," Taylor said. "You can just keep doing this as you get smaller and smaller and smaller. What we suggest is that the way you get these small, fast rotating objects is you take a few bigger objects and break them into pieces."

As this happens, the objects continue to lose their ice, get even smaller, and rotate even more rapidly.

The researchers believe that while the larger dark comet, 2003 RM, was likely a larger object that got kicked out of the outer main belt of the asteroid belt, the six other objects they were examining likely came from the inner main belt and were made by an object that had gotten knocked inward and then broke apart.

More information: Aster G. Taylor et al, The dynamical origins of the dark comets and a proposed evolutionary track, *Icarus* (2024). DOI: 10.1016/j.icarus.2024.116207 , On Arxiv: doi.org/10.48550/arXiv.2407.01839

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