Alien comet carries record-heavy water, and its birthplace looks nothing like our cosmic neighborhood

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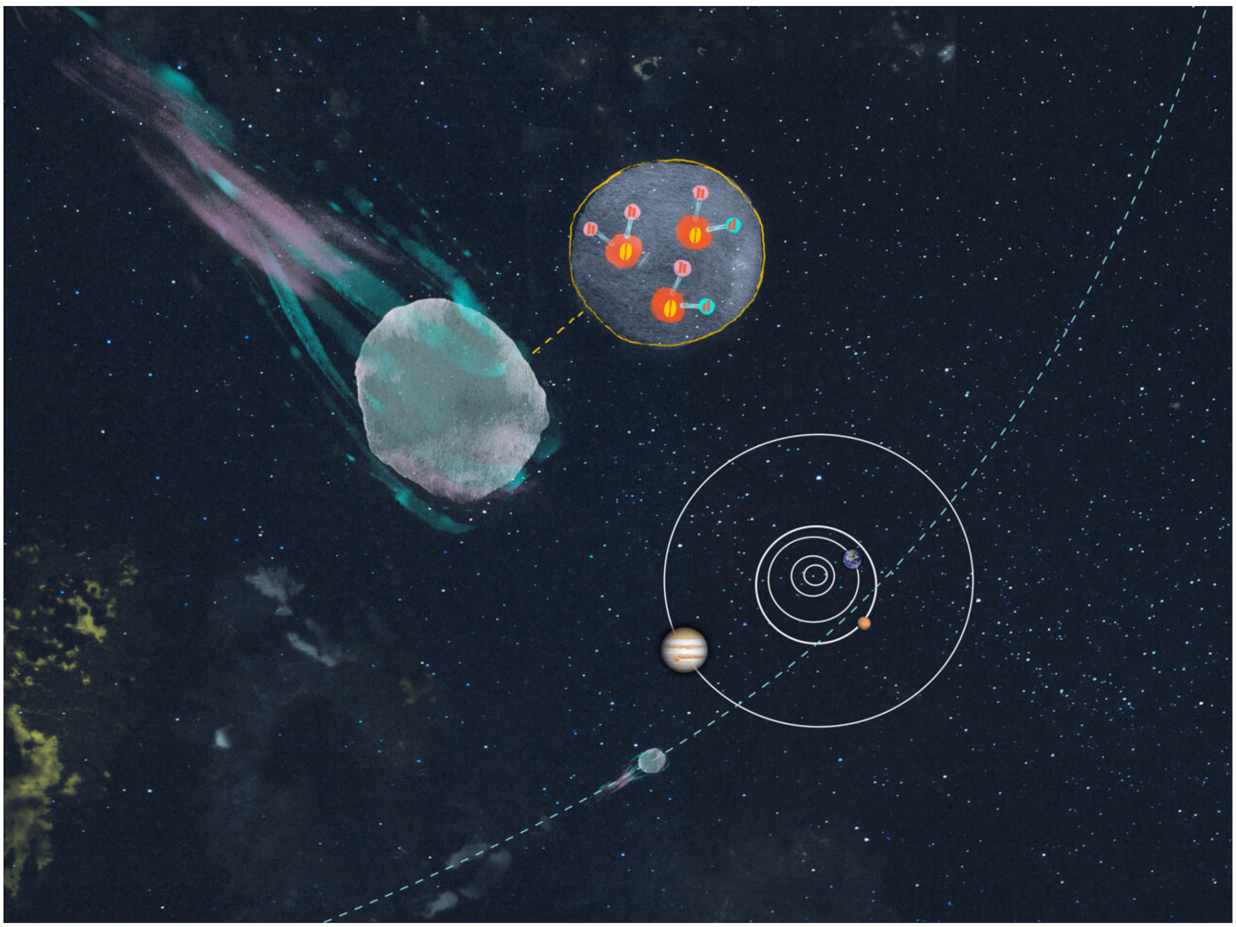

A new study of the interstellar comet 3I/ATLAS led by the University of Michigan shows that its water has a remarkably high content of deuterium. This form of hydrogen is comparatively less abundant in our solar system, enabling researchers to glean new insights about other planetary processes at work in our galaxy. Credit: U-M News/Hans Anderson

Less than a year ago, astronomers discovered a comet soaring through our sky that was not from our solar system. Although we still don't know where this interstellar object called 3I/ATLAS came from, research led by the University of Michigan has revealed new insights about its birthplace. Wherever that was, it was much colder than the environment that created our solar system.

A comet rich in heavy water

The new finding is based on the observation that 3I/ATLAS is remarkably rich in a specific type of water that contains deuterium. The team's study is published in the journal *Nature Astronomy*.

"Our new observations show that the conditions that led to the formation of our solar system are much different from how planetary systems evolved in different parts of our galaxy," said Luis Salazar Manzano, lead author of the new study and a doctoral student in the U-M Department of Astronomy.

Water is made of two hydrogen atoms and one oxygen atom, hence its H_2O formula. In typical water molecules, though, those hydrogen atoms have just one proton at their core. In the comet's water, a high ratio of its water molecules contain deuterium, a form of hydrogen with the standard issue proton plus a neutron. These heavier forms of water also exist on Earth, but in much lower quantities than were observed in 3I/ATLAS.

"The amount of deuterium with respect to ordinary hydrogen in water is higher than anything we've seen before in other planetary systems and planetary comets," Salazar Manzano said.

In fact, the ratio was 30 times that of any comet in our solar system, Salazar Manzano said, and 40 times the value found in the water in our oceans.

These ratios tell researchers about the conditions that were present where these celestial objects formed, allowing them to compare the birthplace of 3I/ATLAS with our solar system when planets and comets were forming. In particular, this result means 3I/ATLAS came from somewhere colder and with lower levels of radiation, said Teresa Paneque-Carreño, a co-leader of the new study and U-M assistant professor of astronomy.

"This is proof that whatever the conditions were that led to the creation of our solar system are not ubiquitous throughout space," Paneque-Carreño said. "That may sound obvious, but it's one of those things that you need to prove."

How astronomers studied 3I/ATLAS

Accomplishing an unprecedented study like this required a lot of things going right, the team said. It started with astronomers discovering 3I/ATLAS early enough to enable follow-up studies, Paneque-Carreño said.

With the comet's timely discovery, Salazar Manzano and other collaborators could secure time at the MDM Observatory in Arizona, where they saw some of the earliest evidence of gas emission from the comet (MDM stands for Michigan, Dartmouth and the Massachusetts Institute of Technology, the observatory's original partners).

That's when Salazar Manzano contacted Paneque-Carreño to collaborate, who brought expertise with the Atacama Large Millimeter/submillimeter Array, or ALMA, in Chile to further observe and characterize the comet's chemical properties.

ALMA is sensitive enough to detect the subtle difference between deuterated and conventional water that the team could characterize the ratio between the two. This study represents the first time scientists have been able to perform this type of analysis on an interstellar object.

"Being at the University of Michigan and having access to these facilities was the key to making this work possible," Salazar Manzano said. "We were part of a team that was very talented and very experienced in multiple areas, all of us complemented each other and that's what allowed us to analyze and interpret these data sets."

What this means for future searches

This work also shows that it will be possible to characterize future interstellar objects in this way to learn more about what goes on in planetary systems beyond our solar system. Although 3I/ATLAS is only the third interstellar object that astronomers have discovered to date, that count is likely to increase as new observatories join the search, Paneque-Carreño said—as long as we don't make it too hard on ourselves.

"We need to be taking care of our night skies and keeping them clear and dark so we can detect these tiny and faint objects," she said.

More information: Luis E. Salazar Manzano et al, Water D/H in 3I/ATLAS as a probe of formation conditions in another planetary system, *Nature Astronomy* (2026). DOI: 10.1038/s41550-026-02850-5

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