Uranus's swaying moons could help spacecraft seek out hidden oceans

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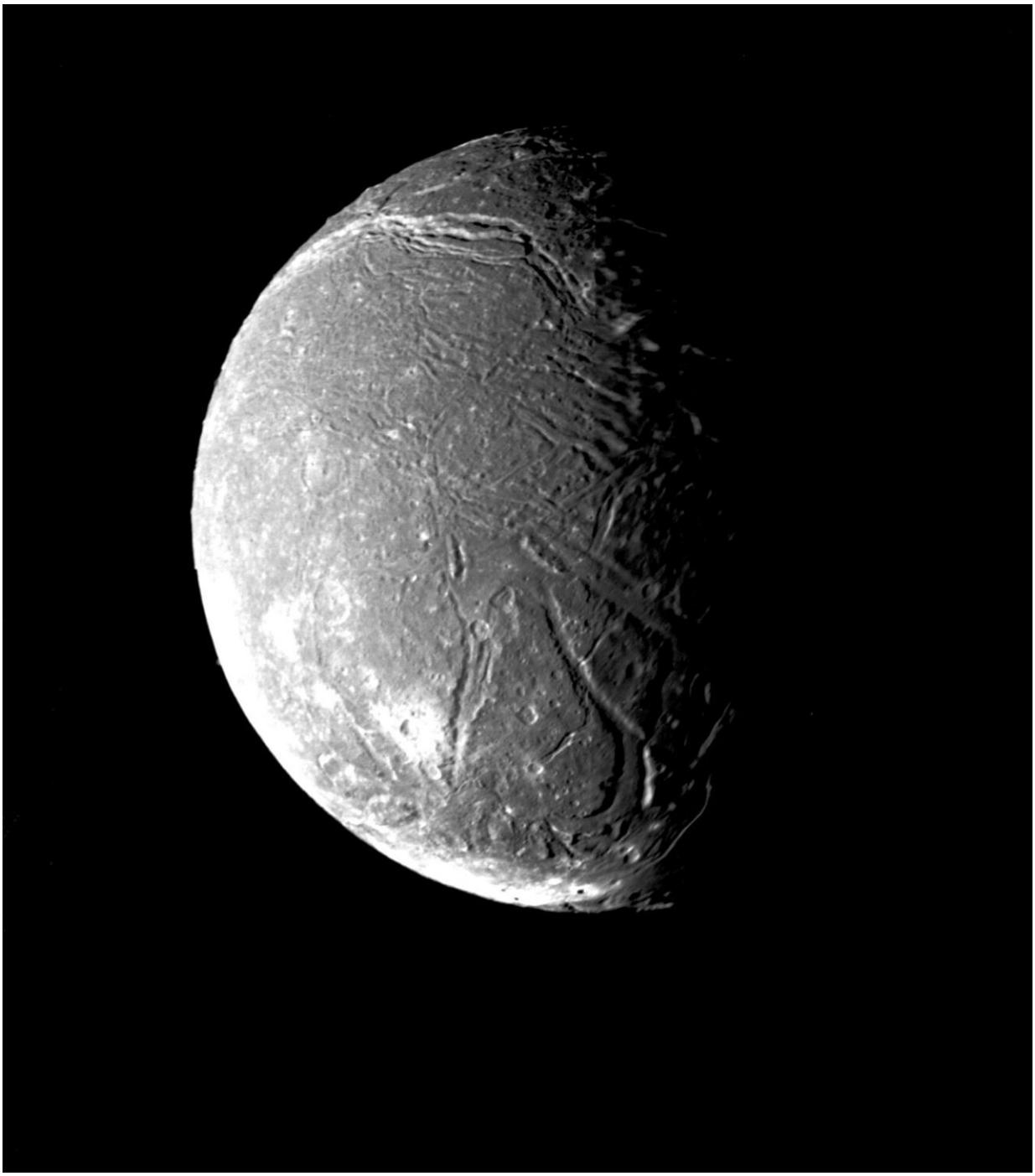

Ariel, Uranus's fourth largest moon, is thought to be made of equal parts rock and ice. A new computer model developed at the University of Texas Institute for Geophysics could be used to detect liquid water oceans beneath Ariel's icy surface. Credit: NASA/JPL

When NASA's Voyager 2 flew by Uranus in 1986, it captured grainy photographs of large ice-covered moons. Now nearly 40 years later, NASA plans to send another spacecraft to Uranus, this time equipped to see if those icy moons are hiding liquid water oceans.

The mission is still in an early planning stage. But researchers at the University of Texas Institute for Geophysics (UTIG) are preparing for it by building a new computer model that could be used to detect oceans beneath the ice using just the spacecraft's cameras.

The research is important because scientists don't know which ocean detection method will work best on Uranus. Scientists want to know if there's liquid water there because it's a key ingredient for life.

The new computer model works by analyzing small oscillations—or wobbles—in the way a moon spins as it orbits its parent planet. From there, it can calculate how much water, ice and rock there is inside. Less wobble means a moon is mostly solid, while a large wobble means the icy surface is floating on a liquid water ocean. When combined with gravity data, the model computes the ocean's depth as well as the thickness of the overlying ice.

Uranus, along with Neptune, is in a class of planets called ice giants. Astronomers have detected more ice giant-sized bodies outside of our solar system than any other kind of exoplanet. If Uranus's moons are found to have interior oceans, that could mean there are vast numbers of potentially life-harboring worlds throughout the galaxy, said UTIG planetary scientist Doug Hemingway, who developed the model.

"Discovering liquid water oceans inside the moons of Uranus would transform our thinking about the range of possibilities for where life could exist," he said.

The UTIG research, which was published in the journal *Geophysical Research Letters*, will help mission scientists and engineers improve their chances of detecting oceans. UTIG is a research unit of the Jackson School of Geosciences at The University of Texas at Austin.

All large moons in the solar system, including Uranus's, are tidally locked. This means that gravity has matched their spin so that the same side always faces their parent planet while they orbit. This doesn't mean their spin is completely fixed, however, and all tidally locked moons oscillate back and forth as they orbit. Determining the extent of the wobbles will be key to knowing if Uranus's moons contain oceans, and if so, how large they might be.

Moons with a liquid water ocean sloshing about on the inside will wobble more than those that are solid all the way through. However, even the largest oceans will generate only a slight wobble: A moon's rotation might deviate only a few hundred feet as it travels through its orbit.

That's still enough for passing spacecraft to detect. In fact, the technique was previously used to confirm that Saturn's moon Enceladus has an interior global ocean.

To find out if the same technique would work on Uranus, Hemingway made theoretical calculations for five of its moons and came up with a range of plausible scenarios. For example, if Uranus's moon Ariel wobbles 300 feet, then it's likely to have an ocean 100 miles deep surrounded by a 20-mile-thick ice shell.

Detecting smaller oceans will mean a spacecraft will have to get closer or pack extra powerful cameras. But the model gives mission designers a slide rule to know what will work, said UTIG Research Associate Professor Krista Soderlund.

"It could be the difference between discovering an ocean or finding we don't have that capability when we arrive," said Soderlund, who was not involved in the current research.

Soderlund has worked with NASA on Uranus mission concepts. She is also part of the science team for NASA's Europa Clipper mission, which recently launched and carries an ice penetrating radar imager developed by UTIG.

The next step, Hemingway said, is to extend the model to include measurements by other instruments to see how they improve the picture of the moons' interiors.

The journal article was coauthored by Francis Nimmo at the University of California, Santa Cruz.

More information: D. J. Hemingway et al, Looking for Subsurface Oceans Within the Moons of Uranus Using Librations and Gravity, *Geophysical Research Letters* (2024). DOI: 10.1029/2024GL110409

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