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On a New Moon Far, Far Away

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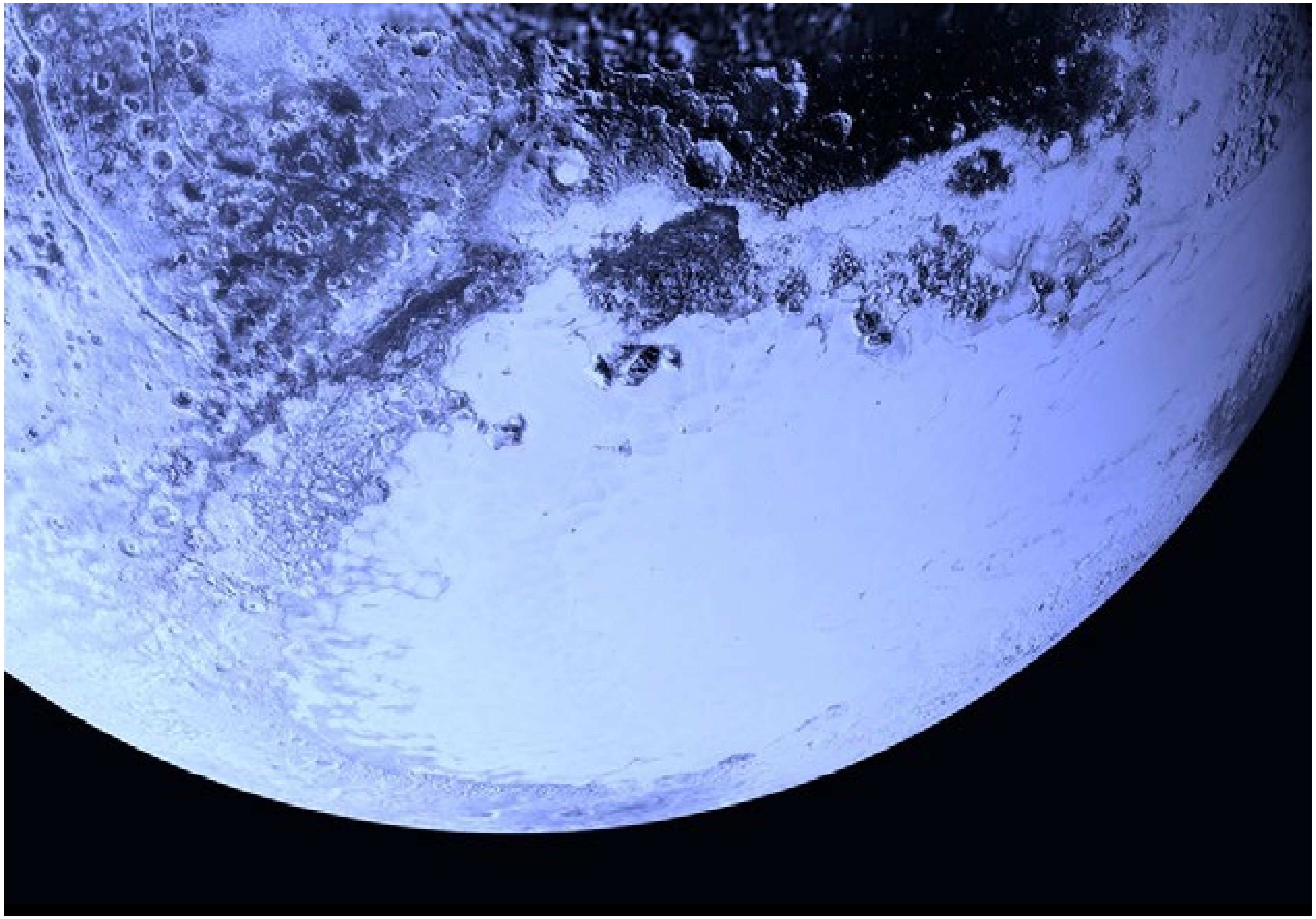
SPACE

Will Pluto Be the Last Habitable World?

The sun's future is going to change the status quo



NASA, JOHNS HOPKINS UNIVERSITY APPLIED PHYSICS LABORATORY AND SOUTHWEST RESEARCH INSTITUTE

Astronomers often talk about our sun's future and how it will likely bring about the end of the Earth. Specifically: like all hydrogen-fusing stars, the sun gets gradually brighter with time as it converts more and more hydrogen in its core into helium (changing its own composition and therefore central temperature). But it will also eventually get to a point where the central hydrogen runs out, the core contracts, and the rest of the star responds. In what's termed the Red-Giant-Branch (RGB) stage, the outer envelope of the sun will begin to inflate—growing more than100 times in radius over less than100 million years if it doesn't lose too much material.

At this point it's bye-bye to Mercury and Venus (even if their orbits expand due to stellar mass loss, as I talk about below). But eventually the sun will shrink again. This happens when its core of helium starts fusing, once more altering the balance and flow of energy in the star. Later, just as the core hydrogen ran out, the helium in the core will also run out—resulting in a new inflation of the outer envelope. This time the Sun gets even bigger. As an Asymptotic-Giant-Branch (AGB) object, its radius might crank up to nearly 1,000 times the present solar dimensions. Now it's a distinct possibility that Earth and Mars get engulfed.

Except some other stuff is also happening throughout these phases. Energy is still being generated by fusion in shell regions around the core and the sun is in fact going to lose quite a lot of its mass—literally blowing material away in a strengthened solar wind. This may mute the physical diameter it reaches as an RGB and then AGB star, but not by a great deal. It could be enough to save Earth and Mars, though. Because as the sun loses mass, the orbits of the planets will actually expand in order to conserve angular momentum.

Another critical factor for our planetary system is that the larger the surface area of a star the larger its luminosity—the total power it can push out as electromagnetic radiation. By the time the sun gets into its RGB and AGB phases, its luminosity can grow to 1,000 or even several thousand times its present value.

We can work out what this might do to the nominal temperature of other bodies in the system. The bottom line is that their temperature should increase roughly like the fourth root of solar luminosity. That means that they'll get hotter by anywhere from a factor of 2 to perhaps a factor of 7 or 8 depending on the stellar output. The first round of this heating will come during the RGB stellar phase. It'll then get cold again until the AGB phase kicks in, after which it'll reach its second and utterly final peak.

For fun we can take a look at the implications for icy, chemically rich objects like Europa, Titan, and good old Pluto. The question to ask is—who's last? Which is the final potentially habitable body within the most familiar orbital terrain of our solar system?

Of course, as a frozen object gets heated it will lose a lot of sublimated material to the vacuum of space. Water, carbon monoxide and so on will just stream away.

Today the icy moon Europa has an equatorial surface temperature of around 110 Kelvin (-163 Celsius). That means that it could get as hot as over 770 Kelvin (497 Celsius) by the time the sun has reached the end of its AGB phase, and perhaps even during the earlier RGB phase. Naturally there will be intermediate periods where things might be more temperate, but as the stellar clock ticks Europa will get seriously hot.

Further away is Titan, a place with lots of frozen water and a hydrocarbon-rich surface environment—if there was ever a place that might get really interesting with a heat spell it would be Titan. If Titan's surface is about 94 Kelvin (-179 Celsius) today, it might certainly warm up to a temperate state. But like Europa, as the Sun gets to its maximum luminosity we'd expect Titan to hit as high as about 680 Kelvin (407 Celsius). That's not so comfy.

Pluto is a slightly different story. In the present-day solar system Pluto is coated in frozen everything: Solid water, solid carbon monoxide, solid nitrogen, solid methane, all at a chilly 43 Kelvin (-230 Celsius). But by the time the sun reaches peak luminosity (during its RGB and then AGB stages), Pluto may warm up to an acceptably habitable 300 Kelvin (27 Celsius). On the way to that peak it might spend millions of years between the freezing and boiling point of water (assuming a thick atmosphere).

Of course, as a frozen object gets heated it will lose a lot of sublimated material to the vacuum of space. Water, carbon monoxide and so on will just stream away. However, even a low gravitational surface acceleration like Pluto's (about 1/12th of Earth's) will cause some buildup of atmosphere. And atmosphere is good at encouraging more atmosphere, by making it harder for molecules to make it from the surface to space. In other words, Pluto could develop a thicker envelope, and conceivably much more clement conditions.

All of this new found status would be fleeting, though. Pluto would have at best a few hundred thousand, or possibly a million or two years to bask in the glory of being the last habitable world of the solar system. After that it too would return to the eternal cold of the cosmos.