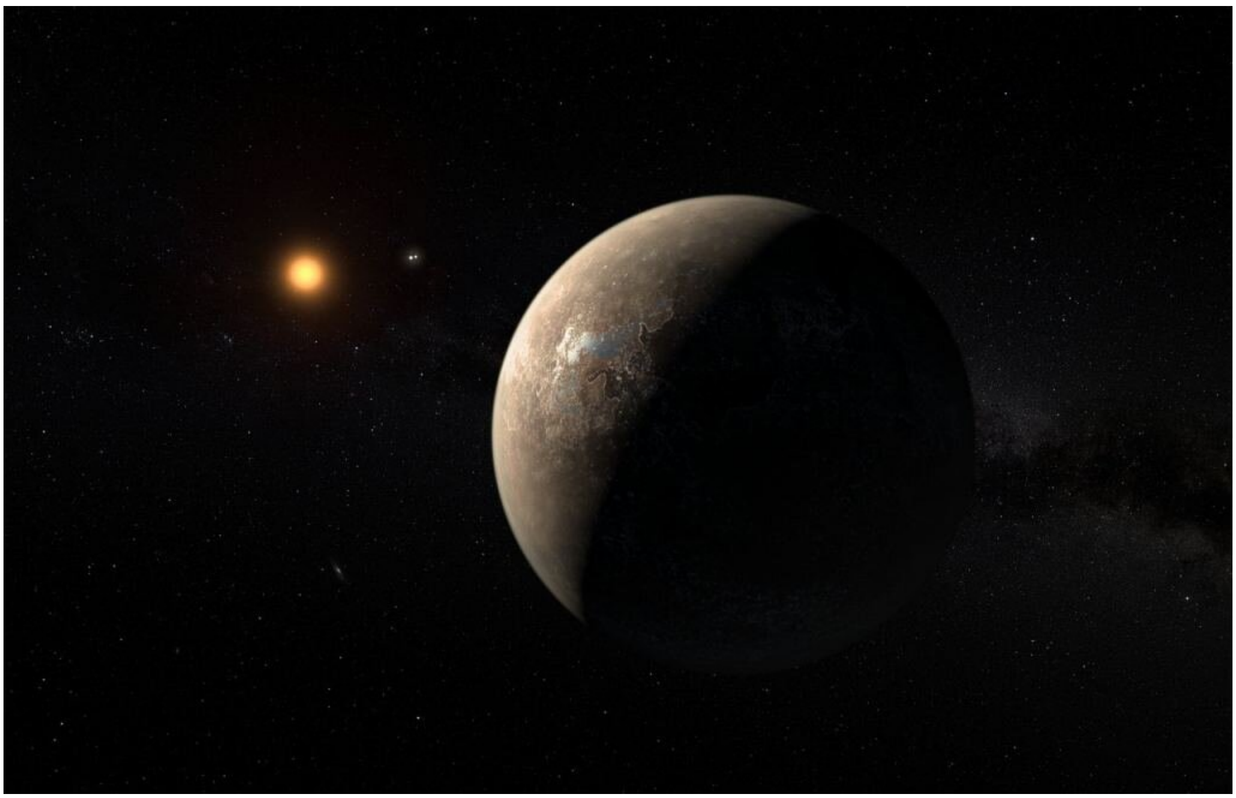
Forget the habitable zone—we need to find the computational zone

April 10 2023, by Paul M. Sutter



This artist's impression shows the planet Proxima b orbiting the red dwarf star Proxima Centauri, the closest star to the Solar System. The double star Alpha Centauri AB also appears in the image between the planet and Proxima itself. Proxima b is a little more massive than the Earth and orbits in the habitable zone around Proxima Centauri, where the temperature is suitable for liquid water to exist on its surface. Credit: ESO/M. Kornmesser

Astronomers are currently searching for signs of life in the "habitable zones" of nearby stars, which is defined as the band around a star where liquid water can potentially exist. But a recent paper argues that we need to take a more nuanced and careful approach, based not on the potential for life, but the potential for computation.

One way to define life itself is as a set of computations that act on information. The information is stored in DNA and the computations are performed by various proteins. The ability to store information and act on its environment allows life to undergo natural selection, which finds ever more complex arrangements.

The traditional searches for life look at how we understand it from an earthly context. Namely, creatures living on the surface of a world just the right distance from a parent star and using liquid water as a solvent for chemical reactions. But it's easy to imagine much more complex and varied forms of life out there in the universe. Life could use other solvents.

Life could be buried underground in icy outer moons. Life may not even require a star. And biological systems could give rise to technological systems that would not meet our current definition for life but might be alive in their own way.

And so a pair of researchers want to rebuild the concept of the habitable zone using a more fundamental concept of computation. They argue that the best chances of finding signs of life are where there is easiest access to computation. The researchers argue that these so-called "computational zones" require three characteristics. One, there must be the capacity for computation, which means that there is a rich set of chemistry available. Two, there must be a raw form of energy, like sunlight or hydrothermal vents. And lastly, computation requires a substrate—something in which the computation can take place.

The traditional view of habitable zones can now be seen as a subset of a much larger concept of computational zones. Where there is life as we currently understand it here on Earth there is computation taking place. But this framework allows us to develop search strategies for concepts of life extending beyond that. For example, if we study individual systems through a lens of computational ability, we might find which systems might be amenable to artificial energy gathering structures like Dyson spheres.

Or we could examine how gas clouds around sub-stellar structures could meet all the conditions necessary for computation, and therefore the conditions necessary for a broadened definition of life.

The search for life in our universe in a scientific way has only just begun. And it's important, as the authors emphasize, to keep an open mind.

The paper is published on the *arXiv* preprint server.

More information: Caleb Scharf et al, Rebuilding the Habitable Zone from the Bottom Up with Computational Zones, *arXiv* (2023). DOI: 10.48550/arxiv.2303.16111

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