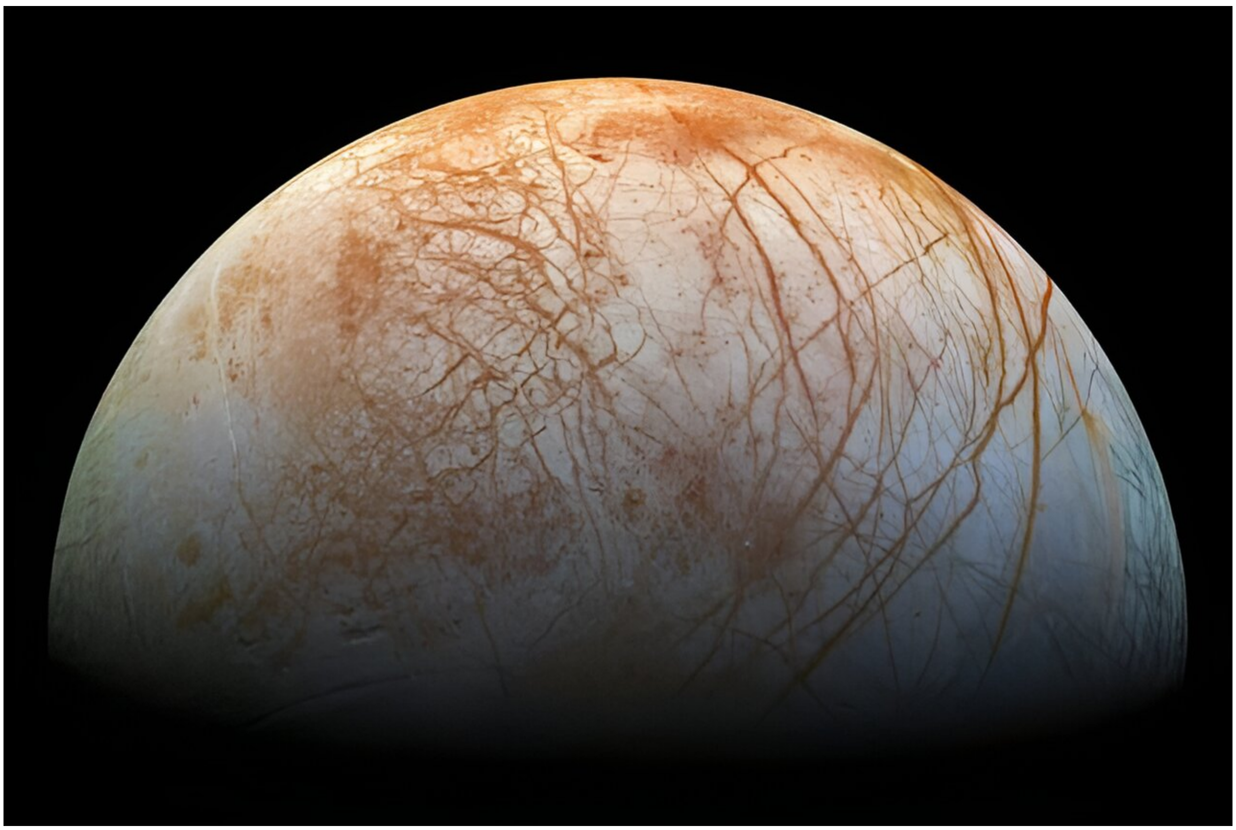
Some intelligent civilizations could be trapped on their worlds

February 28 2024, by Evan Gough



Jupiter's moon, Europa, has a warm ocean under a thick icy shell. Are there other worlds out there like Europa? What would it be like for intelligent creatures that lived in a world like this? They would never see the stars in the sky, their own stars, or any other planets in their solar systems. Credit: NASA/JPL/Galileo spacecraft

Evolution has produced a wondrously diverse variety of lifeforms here on Earth. It just so happens that talking primates with opposable thumbs rose to the top and are building a spacefaring civilization. And we're land-dwellers. But what about other planets? If the dominant species on an ocean world builds a technological civilization of some sort, would they be able to escape their ocean home and explore space?

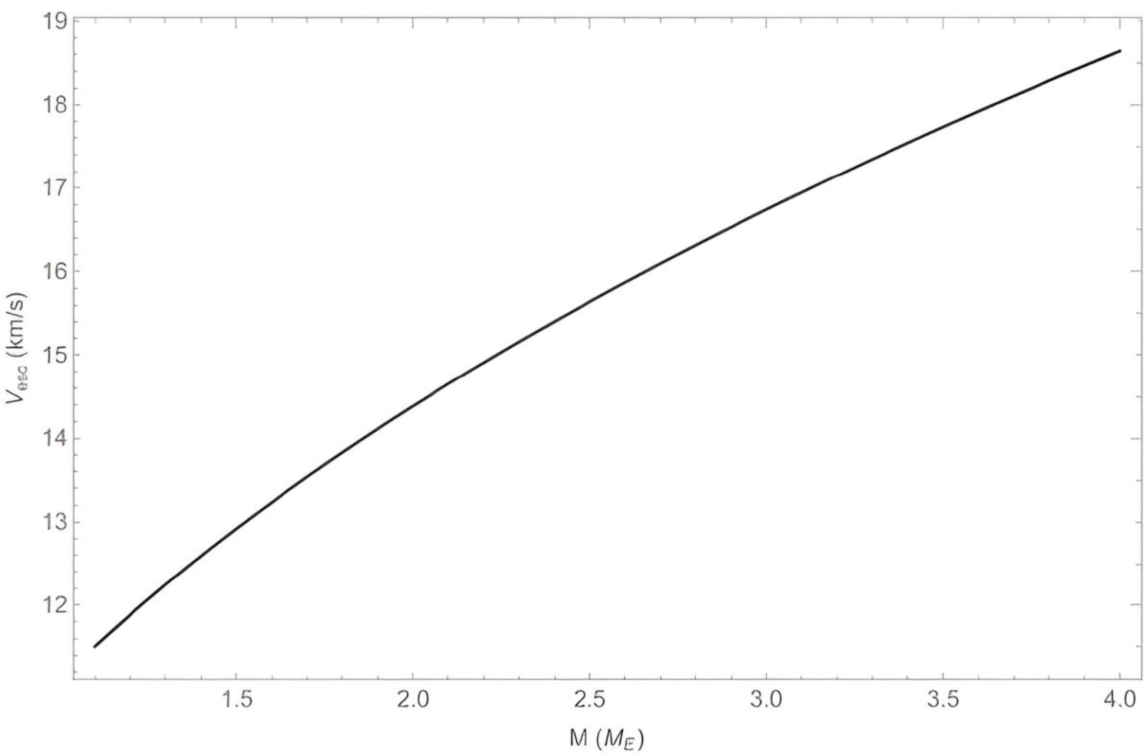
A new article in the *Journal of the British Interplanetary Society* examines the idea of civilizations on other worlds and the factors that govern their ability to explore their solar systems. Its title is "Introducing the Exoplanet Escape Factor and the Fishbowl Worlds (Two conceptual tools for the search of extra-terrestrial civilizations)." The sole author is Elio Quiroga, a professor at the Universidad del Atlántico Medio in Spain.

We have no way of knowing if other extraterrestrial intelligences exist or not. There's at least some possibility that other civilizations exist, and we're certainly in no position to say for sure that they don't. The Drake equation is one of the tools we use to talk about the existence of ETIs. It's a kind of structured thought experiment in the form of an equation that allows us to estimate the existence of other active, communicative ETIs. Some of the variables in the Drake equation are the star formation rate, the number of planets around those stars, and the fraction of planets that could form life and on which life could evolve to become an ETI.

In his new research article, Quiroga comes up with two new concepts that feed into the DE: the exoplanet escape factor and fishbowl worlds.

Planets of different masses have different escape velocities. Earth's escape velocity is 11.2 km/s (kilometers per second), which is more than 40,000 km/h. The escape velocity is for ballistic objects without propulsion, so our rockets don't actually travel 40,000 km/h. But the escape velocity is useful for comparing different planets because it's independent of the vehicle used and its propulsion.

Super-Earths have much greater masses and much higher escape velocities. While there's no exact definition of a super-Earth's mass, many sources use the upper bound of 10 Earth masses to define them. So, an ETI on a super-Earth would be facing a different set of conditions than we do here on Earth when it comes to space travel.



This simple graph from the research article shows how escape velocity rises with planetary mass. The x-axis shows Earth masses, and the y-axis shows the required escape velocity. Credit: Quiroga, 2024

In this work, Quiroga implements the exoplanet escape factor (Fex) and the exoplanet escape velocity (Vex.) By working with them, he arrives at a sample of escape velocities for some known exoplanets. Note that the composition of the planets isn't critical, only their masses.

Quiroga points out that a planet with a Fex value of 2.2 would make space travel unlikely. "Values of Fex > 2.2 would make space travel unlikely for the exoplanet's inhabitants: they would not be able to leave the planet using any conceivable amount of fuel, nor would a viable rocket structure withstand the pressures involved in the process, at least with the materials we know (as far as we know, the same periodic table of elements and the same combinations of them govern the entire universe)."

"It could, therefore, be the case that an intelligent species on these planets would never be able to travel into space due to sheer physical impossibility," Quiroga writes. In fact, they may never conceive of the idea of any type of space travel at all. Who knows?

Of course, space exploration isn't a one-way street. Astronauts have to return from space, and a planet's mass affects that. Re-entry imposes its own difficulties on a super-Earth ten times more massive than our planet. The atmospheric density also plays a role. A spacecraft needs to control its velocity and frictional heating when re-entering, and that's more difficult on a more massive planet, just as escaping is.

Quiroga also talks about the idea of the "fishbowl worlds." These are the planets above Fex 2.2 from which escape is physically impossible. What could life for an intelligent species be like on a Fishbowl world?

In his research article, Quiroga invites us to be speculative with a nod to science fiction. Imagine an ocean world that's home to an intelligent species. In a fluid environment, unaided communication travels much further than in an atmosphere like Earth's. Unaided signals could travel for hundreds of kilometers.

In an environment like that, "… communication between individuals could be feasible without the need for communication devices," Quiroga explains. So, the impetus to develop communication technologies might not be there. In that case, Quiroga says, the technology may not have developed and the civilization might not be considered "communicative" at all, one of the keys to the definition of an ETI.

Mass (T)	Radius (T)	Vex (Kms/s)	Fex	Semaphor
0,85	2,2	6,95	,62	Kepler-100c
1,17	0,94	9,45	,85	Proxima Centauri b
1	1	11,19	1,00	Earth
2,35	2	20,90	1,87	Kepler-10c
6,45	2.65	16,67	1,49	GJ-1214b
14,11	3,37	22,89	2,05	Kepler-103b
16.13	2.41	26,33	2,35	Kepler-131b
7,34	1,32	26,38	2,36	Kepler-100b
10,5	1,71	27,72	2,48	KOI-94b
8,25	0,84	35,06	3,13	Kepler-131c

This figure from the research shows how easy or difficult it would be to reach space from some known exoplanets. Green indicates that escape is possible, orange indicates likely problems, and red indicates the practical impossibility of space travel. Credit: Quiroga 2024

"Telecommunications technology might never emerge on such a world, even though it could be home to a fully developed civilization," Quiroga writes. "Such a civilization would not be "communicative" and would not be contemplated in the Drake equation."

Other circumstances could effectively trap civilizations on their home worlds. On a planet with continuous, unbroken cloud cover, the starry sky would never be visible. How would that affect a civilization? Can you wonder about the stars if you can't see them and don't know they're there? Of course not. A similar thing is true in a binary star system with no nighttime. Stars would never be visible and would never be objects and sources of wonder.

Ocean worlds present a similar conundrum. On ocean worlds or moons with warm oceans and frozen ice shells kilometers thick, any inhabitants would have extremely limited views of the universe they inhabit. It's difficult to imagine a technological civilization arising in an ocean under several kilometers of ice. But we're in no position to judge whether that's possible or not.

Quiroga's exoplanet escape factor (Fex) can help us imagine what kinds of worlds could host ETIs. It can help us anticipate the factors that prevent or at least inhibit space travel, and it brings more complexity into the Drake equation. It leads us to the idea of Fishbowl worlds, inescapable planets that could keep a civilization planet-bound forever.

Without the ability to ever escape their planet and explore their solar systems, and without the ability to communicate beyond their worlds, could entire civilizations rise and fall without ever knowing the universe they were a part of? Could it happen right under our noses, so to speak, and we'd never know?

More information: Elio Rodríguez, Introducing the Exoplanet Escape Factor and the Fishbowl Worlds (two conceptual tools for the search for extra terrestrial civilizations), *Journal of the British Interplanetary Society* (2024). DOI: 10.59332/jbis-076-10-0365

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