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Why Haven't We Found Alien Life Yet? Blame Our Closed Minds

Are we simply looking for life in the wrong places, in the wrong way? Would we even recognize the signs? One astronomer says that out there ideas may point the way to E.T.

By Steve Nadis | November 9, 2020 1:45 PM

Limits don't sit well with Avi Loeb.

Loeb quickly reels some off to me over the phone (hands-free) during a drive home from work: About 25 billion stars, roughly one-quarter of those that reside in the Milky Way, lie in a habitable zone. He rounds that down to an even 10 billion to keep the calculations simple. "And then there are about a trillion galaxies like the Milky Way," he says, "which means there are about 1022 [10 billion trillion] planets in the observable universe that could potentially host life as we know it." In other words, searches for extraterrestrial life have barely scratched the surface. "As in other areas of exploratory science," Loeb says, "we should investigate thoroughly before making sweeping pronouncements."

Most of the searching so far, he adds, has been in the radio range, where scientists have examined a tiny fraction of the possible frequencies in an equally tiny fraction of the possible search space. Surveys in optical wavelengths have been much less extensive. For any new technology we develop, Loeb says, we should consider whether, somewhere, an alien civilization might have developed it, too, possibly leaving behind some detectable traces. "As our technology improves, that can help us imagine things we haven't imagined before and explore things we haven't searched for

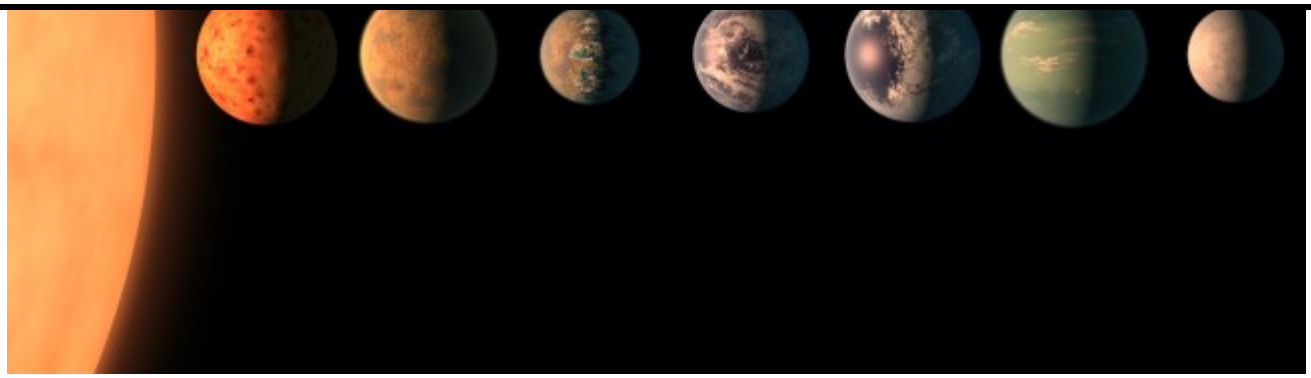
The Vera C. Rubin Observatory is expected to start searching the skies in 2022. (Credit: Rubin Obs/NSF/AURA)

When it comes to imagination, Loeb — cited in *The New York Times* "for his creative and prolific attempts to understand the … universe" — appears to have no shortage. Nor, would it seem, is he lacking in productivity. For over two decades, he has turned out an average of two academic papers each month, in addition to regular essays. He's director of Harvard's Institute of Theory and Computation, a member of the President's Council of Advisors on Science and Technology, founding director of Harvard's Black Hole Initiative and chair of the Breakthrough Starshot Advisory Committee — an endeavor aimed, among other things, at sending miniature spacecraft to other stars.

Florida Tech physicist Manasvi Lingam described his collaboration with Loeb during a postdoctoral fellowship as "exhilarating." From 2017 to 2019, Lingam and Loeb wrote 25 research papers and a forthcoming book, *Extraterrestrial Life: From Biosignatures to Technosignatures*, that provides a wide-ranging discussion of SETI techniques. "With Avi, there's always a fast turnaround time."

Far From the City Lights

Loeb and Princeton University astronomer Edwin Turner are kindred spirits who enjoy batting around speculative ideas. "The conservative impulse that serves science well in some ways doesn't serve us well when it comes to generating hypotheses," says Turner. While touring Abu Dhabi a decade ago, and learning that Dubai is so bright it can be seen from outer space, Loeb and Turner started to wonder whether our telescopes could pick up light from an alien city. After some quick calculations, they determined that the Hubble Space Telescope (HST) would be able to detect light pollution from a city on the outer edges of the solar system, well beyond Pluto, and new, more advanced telescopes could extend that range considerably farther.



An artist's concept shows the TRAPPIST-1 planetary system, with its seven Earth-sized, temperate exoplanets orbiting an ultra-cool dwarf star. It's unusual to have so many planets in the habitable zone. (Credit: NASA/JPL/Caltech)

Although there aren't any known planets lying in the solar system's periphery, Loeb and Turner have come up with a method for determining whether a newly discovered light source is natural or artificial. Their technique is based on the principle that light drops off in intensity according to the square of the distance traveled.

Suppose we measure the brightness of a radiant object and repeat that measurement after the object has moved twice as far away from us, heading away from the sun. If the object was natural, such as a previously unknown planet or asteroid, and merely reflecting light from the sun, its brightness would decrease by a factor of 16: Its brightness (as measured from Earth) would have dropped off fourfold during the light's journey from the sun to the object (since two squared equals four) and another fourfold during its journey back to us. If, on the other hand, the object was a luminous spacecraft, its brightness would drop off only by a factor of four since it produces its own light rather than reflecting it from the sun.

If our measurements of a distant light source indicate a fourfold drop in intensity, we should not immediately start worrying about an alien invasion, says Turner. "But we will want to point other telescopes there and … try to figure out what's going on."

Pollution As the Solution to Dilution

The James Webb telescope could spot the presence of these molecules in an exoplanet's atmosphere, the researchers concluded, if concentrations were 10 times current terrestrial levels. Observing high levels of these long-lived pollutants and no signs of life-sustaining molecules like oxygen, Loeb and his coauthors said, "might serve as an additional warning to the 'intelligent' life here on Earth about the risks of industrial pollution."

The Edge Effect

A 2005 paper in the journal *Astrobiology* by MIT astronomer Sara Seager and three other researchers identified a distinct feature of an Earthlike planet covered with large stretches of vegetation. Plants appear green because they reflect light in the green part of the spectrum, but at higher wavelengths, between the red and infrared range, reflectance shoots up dramatically. A graph of reflectance versus wavelength shows a steep rise at a wavelength of 700 nanometers that creates a pronounced "red edge" — a feature, though not evident to the human eye, that's readily observable by telescopes with spectral sensitivity.

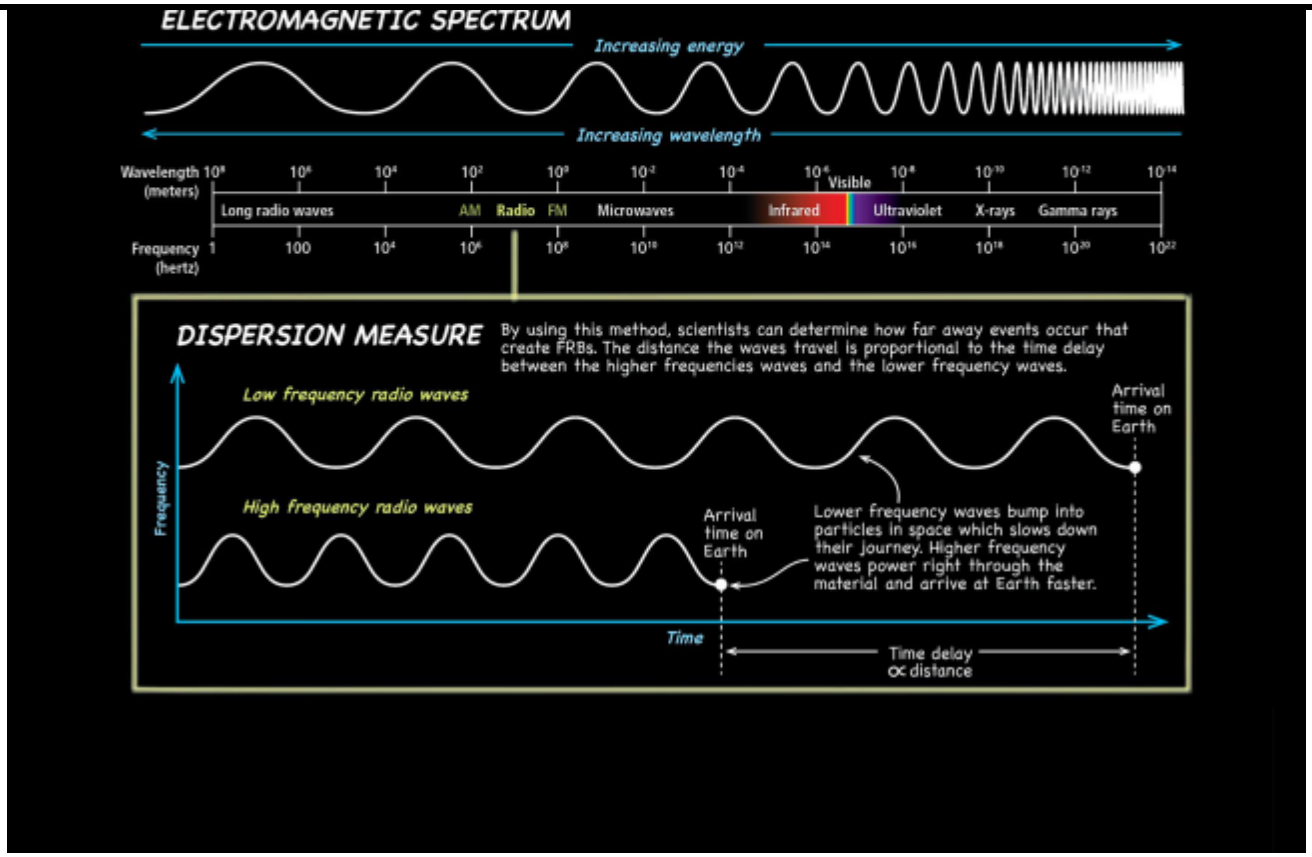
In 2017, Lingam and Loeb got to wondering: What if an exoplanet was covered by vast tracts of photovoltaic arrays instead of boundless greenery? Massive structures like this, Lingam and Loeb reasoned, would produce an artificial spectral edge analogous to the red edge caused by vegetation, though occurring at different wavelengths (depending, of course, on the materials making up the arrays). They calculated where the spectral edge would lie for silicon-based solar cells — a reasonable choice given silicon's abundance in the universe — and those composed of other widely used photovoltaic ingredients, including gallium arsenide and perovskite. Future telescopes, such as WFIRST, set to launch in the mid-2020s, would be capable of detecting a "silicon edge," should it exist.

Lingam and Loeb believe that such an analysis would be particularly powerful when applied to exoplanets that are "tidally locked," meaning they keep the same orientation with respect to the parent star and therefore have permanently light and dark sides. An inhabited planet equipped with large-scale solar-electric generation could illuminate the dark side, and other installations might release significant amounts of waste heat on the cooler, darker side — developments that could be

Although these photovoltaic arrays would undergo wear and tear, Lingam and Loeb wrote in the *Monthly Notices of the Royal Astronomical Society*, "they can remain functional for a duration of time that is not insignificant by astrophysical standards and would thus represent genuine extraterrestrial artifacts." If artifacts are someday spotted, they write, it could be an early, if not the first, example of a new field: "interstellar archaeology."

The Mystery of FRBs

The first fast radio burst (FRB), an intense blast of radio waves emanating from outside our galaxy and lasting just a few milliseconds, was spotted in 2007. Astronomers have since seen more than 100 others. "The popular view is that these bursts come from young neutron stars with very strong magnetic fields," says Loeb. But that supposition has not been confirmed. And there may not be a single source, he adds, because there are at least two types of bursts — a small minority that repeat and most that do not.



(Credit: Roen Kelly/Discover)

Lingam and Loeb offered a provocative solution to the puzzle: Maybe some of the FRBs are artificial. If that were the case, what would be the purpose of such incredibly powerful bursts? In a 2017 paper in *Astrophysical Journal Letters*, Lingam and Loeb raise two possibilities: It could be a beacon to broadcast the presence of an alien civilization, which they deem "rather implausible." Or, it could power large spaceships tugged by even larger (in area, not in mass) light sails. "The optimal frequency for powering the light sail is shown to be similar to the detected FRB frequencies," they write — a fact that, when combined with other technical arguments, could "lend some credence to the possibility that FRBs might be artificial in origin."

Naysayers might dismiss this, insisting that "extraordinary claims require extraordinary evidence,"

Something like this, if sufficiently large, could be spotted by NASA's Transiting Exoplanet Survey Satellite (TESS), which looks for dips in the brightness of a star caused by a planet passing in front of it. TESS could also detect dips caused by the passage of giant artificial mega-structures. Officials announced in October 2019 that TESS would collaborate with Breakthrough Listen — a $100 million SETI initiative, the largest and most generously funded in the field's history.

Listen's ground-based telescopes would focus on potentially habitable planets identified by TESS. Loeb cites the example of Tabby's Star: Discovered in 2016, two years before the TESS launch, it exhibited a peculiar dimming pattern, prompting some to speculate that it was surrounded by some kind of alien structure. It turns out that our view was blocked by an oddly shaped disk of dust, Loeb says, but that's the kind of irregularity TESS scientists would be looking for.

Searching for Interstellar Visitors

On Oct. 19, 2017, an astronomer using Hawaii's Pan-STARRS telescope discovered an object moving past the sun at 196,000 miles per hour, so fast that it almost surely originated from outside the solar system. The object, dubbed 'Oumuamua — Hawaiian for "first scout from a distant place" — was initially classified as an asteroid and then a comet and more recently as a chunk of hydrogen ice.

Interstellar visitor 'Oumuamua has defied easy classification — Loeb has suggested it's an artificial lightsail — but a team of astronomers concluded in 2019 that it's a natural object. (Credit: Auntspray/Shutterstock)

But Loeb has analyzed all of these ideas and finds that they still leave some questions unanswered. He doesn't see a plausible way that a "large hydrogen iceberg" could form. And even if it did, he says, an object like that could not survive its interstellar journey to the solar system because hydrogen evaporates so readily. Furthermore, 'Oumuamua has unusual features that don't match those of asteroids or comets: For one thing, it's extremely elongated, about 10 times longer than it is wide. The object's acceleration is also unexplained, as there's no sign of outgassing, propulsion caused by the release of gas that's normally seen in comets. Loeb and Shmuel Bialy of Harvard suggested that 'Oumuamua was being pushed and sped up by solar radiation, in which case it must be shaped more like a thin pancake than a cigar as was commonly assumed. That raised the possibility that 'Oumuamua "might be a lightsail of artificial origin" — a case they made in a November 2018 paper in *Astrophysical Journal Letters*.

In a July 2019 article in *Nature Astronomy*, an international team of 14 astronomers reached a

In the meantime, a second interstellar visitor, Comet Borisov, was discovered in 2019, whipping around the sun at 110,000 mph. This object is "clearly not artificial," Loeb says, "because it looks like any other comet we've seen before." But there soon should be many more interlopers to look at. The Pan-STARRS observatory has given us the capacity to survey the entire sky, and the Vera C. Rubin Observatory, expected to begin an even broader survey in 2022, "will be much more sensitive," Loeb says, "a bigger and better telescope that could potentially detect an 'Oumuamua-type object every month."

When it comes to SETI, evidence ultimately carries the day, Loeb insists. "We should collect evidence without prejudice, without assuming we know the truth in advance, and see what we learn." On the other hand, he says, we should be open-minded and allow for some risk-taking in our pursuit of that evidence. As the physicists Giuseppe Cocconi and Philip Morrison wrote in 1959, one year before SETI began: "The probability of success is difficult to estimate, but if we never search, the chance of success is zero."

Steve Nadis is a contributing editor to *Discover*.

space exploration spacecraft

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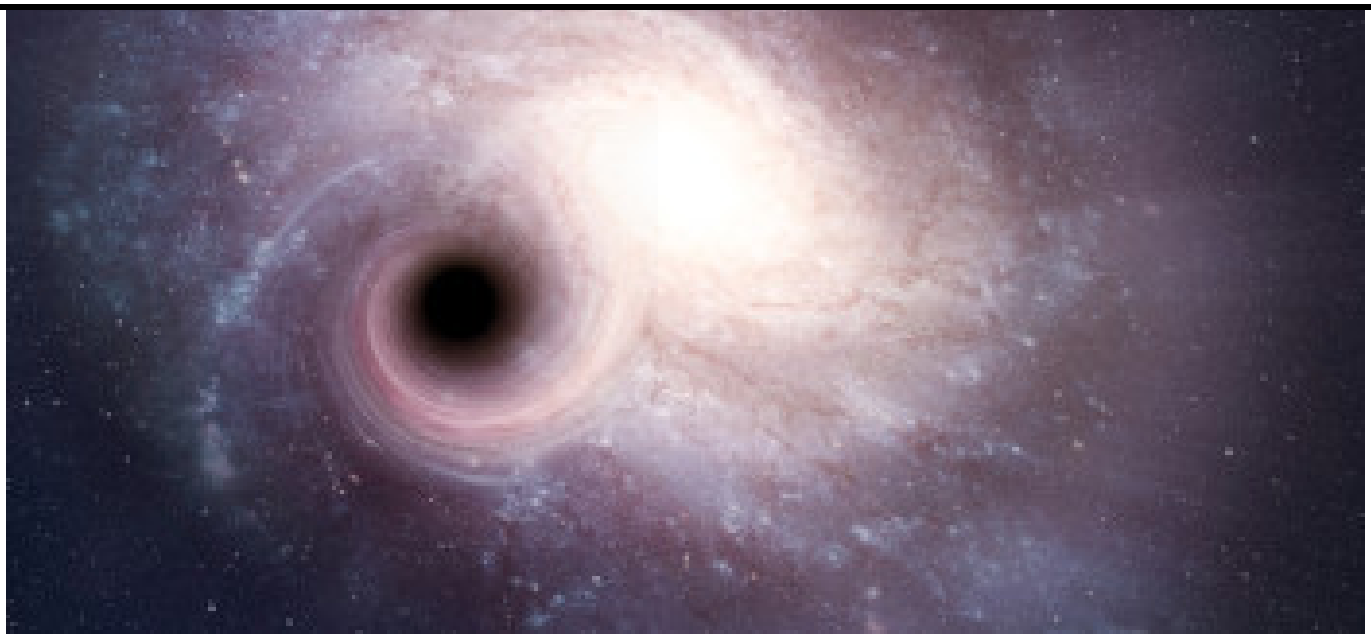
Where Is the Edge of the Universe?



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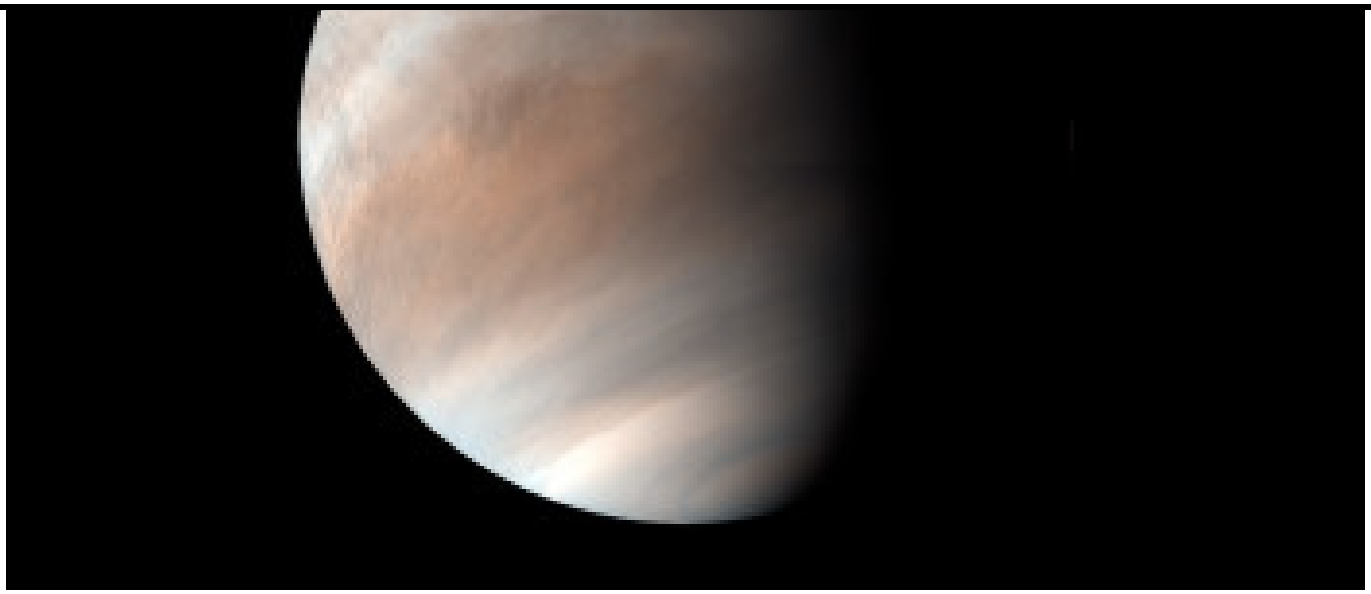

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