New tool helps interpret future searches for life on exoplanets

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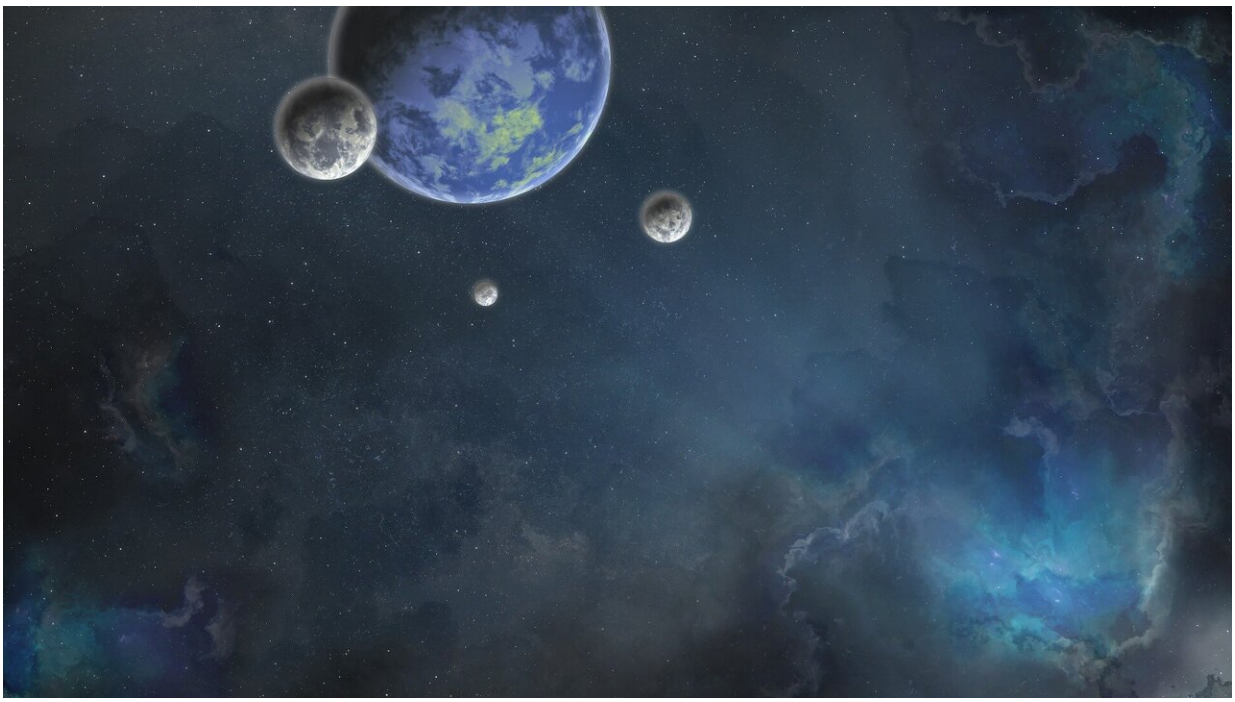

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Is there life on a distant planet? One way astronomers are trying to find out is by analyzing the light that is scattered off a planet's atmosphere. Some of that light, which originates from the stars it orbits, has interacted with its atmosphere, and provides important clues to the gases it contains. If gases like oxygen, methane or ozone are detected, that could indicate the presence of living organisms. Such gases are known as

biosignatures. A team of scientists from EPFL and Tor Vergata University of Rome has developed a statistical model that can help astronomers interpret the results of the search for these "signs of life." Their research has just been published in *Proceedings of the National Academy of Sciences* (*PNAS*).

Since the first exoplanet—a planet that orbits a star other than the sun—was discovered 25 years ago, over 4,300 more have been identified. And the list is still growing: a new one is discovered every two or three days. Around 200 of the exoplanets found so far are telluric, meaning they consist mainly of rocks, like the Earth. While that's not the only requirement for a planet to be able to host life—it also needs to have water and be a certain distance from its sun—it is one criterion that astronomers are using to focus their search.

In the coming years, the use of gas spectroscopy to detect biosignatures in planets' atmospheres will become an increasingly important element of astronomy. Many research programs are already under way in this area, such as for the CHEOPS exoplanet-hunting satellite, which went into orbit in December 2019, and the James-Webb optical telescope, scheduled to be launched in October 2021.

Starting with an unknown

While much progress has been made on detecting exoplanetary biosignatures, several question marks remain. What are the implications of this kind of research? And how should we interpret the results? What if just one biosignature is detected on a planet? Or what if no biosignatures are detected—what should we conclude? Those kinds of questions are what the EPFL-Tor Vergata scientists set out to answer with their new model.

Their work tackles the problem from a new angle. Traditionally,

astronomers have looked for life on another planet based on what we know about life and biological evolution on Earth. But with their new method, the scientists started with an unknown: how many other planets in our galaxy have some form of life. Their model incorporates factors like the estimated number of other stars in the galaxy similar to the sun and how many telluric planets might be orbiting within a habitable distance from those stars. It uses Bayesian statistics—particularly well suited to small sample sizes—to calculate the probability of life in our galaxy based on how many biosignatures are detected: one, several or none at all.

"Intuitively, it makes sense that if we find life on one other planet, there are probably many others in the galaxy with some type of living organism. But how many?" says Amedeo Balbi, a professor of astronomy and astrophysics in Tor Vergata's Physics Department. "Our model turns that intuitive assumption into a statistical calculation, and lets us determine exactly what the numbers mean in terms of quantity and frequency."

"Astronomers already use various assumptions to evaluate how credible life is on a given planet," says Claudio Grimaldi, a scientist at EPFL's Laboratory of Physics of Complex Matter (LPMC) who is also affiliated with the Enrico Fermi Research Center in Rome. "One of our research goals was thus to develop a method for weighing and comparing those assumptions in light of the new data that will be collected over the coming years."

Spreading from one planet to another

Given the small number of planets that will likely be examined in the near future, and assuming that life will emerge independently on any one planet, the EPFL-Tor Vergata study found that if even just one biosignature is detected, we can conclude with a greater than 95%

probability that there are over 100,000 inhabited planets in the galaxy—more than the number of pulsars, which are objects created when a massive star explodes at the end of its life. On the other hand, if no biosignatures are detected, we cannot necessarily conclude that other forms of life do not exist elsewhere in the Milky Way.

The scientists also looked at the theory of panspermia, which states that instead of emerging independently on a given planet, life forms could be carried over from another planet—such as through organic matter or microscopic organisms being carried on comets or spreading between neighboring planets. This implies that the probability of life on a planet also depends on how far it is from other planets and how easily various life forms—whose physical characteristics could be extremely different from those we are familiar with—are able to resist the extreme conditions of space travel and adapt to the new planet. Factoring in panspermia alters the inferred number of inhabited planets elsewhere in the galaxy.

More information: Amedeo Balbi et al. Quantifying the information impact of future searches for exoplanetary biosignatures, *Proceedings of the National Academy of Sciences* (2020). DOI: 10.1073/pnas.2007560117

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