Silence reveals insights in search for extraterrestrial life

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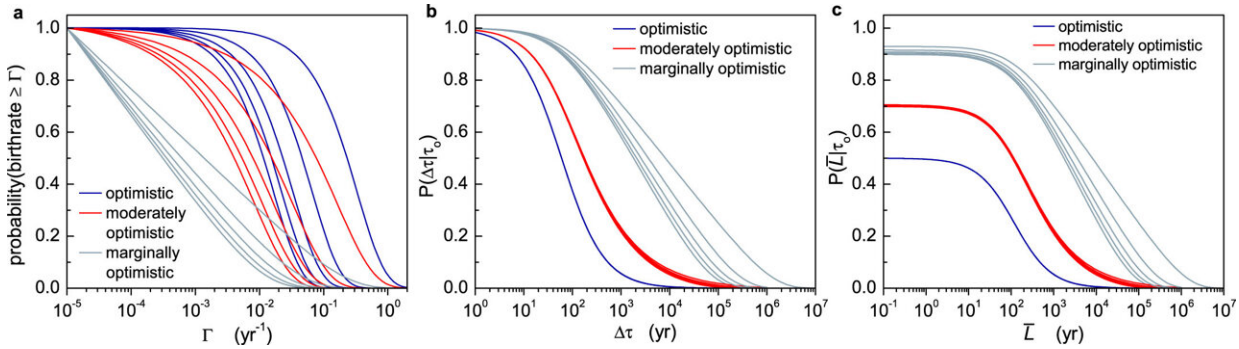

Effects of technoemission anisotropy on the posterior probabilities. a, Posterior probability of the emission rate being greater than Γ for different fractions q of anisotropic technoemissions modeled by randomly oriented narrow beams with aperture of 2 arcmin ($\alpha \simeq 6 \times 10^{-4}$ rad). For each prior considered q = 0, 0.25, 0.5, 0.75, and 0.95 (from left to right). b, Corresponding posterior probability of the next crossing event occurring not sooner than $\Delta\tau$. c, Posterior probability of the average emission longevity *L*. Credit: *The Astronomical Journal* (2023). DOI: 10.3847/1538-3881/acc327

The search for radio signals from extraterrestrial civilizations has yet to yield evidence of alien technological activity. Research carried out at EPFL suggests we continue searching while optimizing the use of available resources.

For over sixty years, amateur and professional astronomers have been

monitoring the sky in the search for extraterrestrial intelligence (SETI). So far, to no avail. But how should we read the absence of alien radio signals? Is it time we stop looking? Or should we double down and look harder, peering ever deeper into our galaxy? A recent statistical analysis of the sixty-year silence suggests a simple, optimistic explanation and urges the SETI community to continue searching, but to stay patient, as the chances for detecting signals in the coming sixty years are slim.

The prevailing explanations for the absence of electromagnetic signals from extraterrestrial societies fall into two extreme categories, says Claudio Grimaldi from EPFL's Laboratory of Statistical Biophysics. The "optimistic" camp holds that we've been using detectors that are not sensitive enough or missed incoming signals because we've been pointing our radio telescopes in the wrong direction. The "pessimistic" camp, on the other hand, interprets the silence as indicating the absence of alien life in our galaxy.

According to Grimaldi's study, published in *The Astronomical Journal*, there's a third explanation. "We've only been looking for 60 years. Earth could simply be in a bubble that just happens to be devoid of radio waves emitted by extraterrestrial life," he says.

Modeling the Milky Way as a sponge

Grimaldi's study builds on a statistical model initially developed to model porous materials such as sponges, which he sees as a fitting analogy for the question at hand: "You can imagine the sponge's solid matter to represent electromagnetic signals radiating spherically from a planet harboring extraterrestrial life into space." In this analogy, the sponge's holes—its pores—would represent regions where signals are absent.

By repurposing mathematical tools to study porous materials and using

Bayesian statistics, Grimaldi was able to draw quantitative conclusions from the sixty years of observed silence. His findings are conditional on the assumptions that there is at least one electromagnetic signal of technological origin in the galaxy at any given time and that Earth has been in a silent bubble, or a "pore," for at least 60 years.

"If it is true that we've been in a void region for sixty years, our model suggests that there are less than one to five electromagnetic emissions per century anywhere in our galaxy. This would make them about as rare as supernovas in the Milky Way," says Grimaldi. In the most optimistic scenario, we would have to wait more than 60 years for one of these signals to reach our planet. In the least optimistic scenario, that number would go up to around 2,000 years. Whether we detect the signals when they cross our path is another question. In either case, our radio telescopes would have to be pointed in the right direction to see them.

Defining best practices to continue searching

The search for extraterrestrial intelligence currently has the wind in its sails, buoyed by the discovery, around 20 years ago, of the first planets beyond our solar system. Today, researchers assume there could be as many as 10 billion Earth-like planets—rocky, the right size, and located at the right distance from the sun to harbor life. Their sheer number increases the likelihood that technological life may have developed on one of them.

This has led to new initiatives across the SETI community. The privately funded "Breakthrough Listen" project, the largest of its kind, has put close to 100 million dollars towards dedicating radio telescope time to search for techno-signals from extraterrestrial civilizations. With the initiative ending in two years, Grimaldi says that it's a good time to think about how to pursue the search for extraterrestrial intelligence in the future.

"The dream of the SETI community is to look for signals all the time, across the entire sky. Even today's largest telescopes can only see a small fraction of the sky. Today, there are telescope arrays, such as the Allen Telescope Array (ATA) in California, that point in different directions and can be directed at specific regions to get more detailed information when necessary. The same is true for optical telescopes."

"But," says Grimaldi, "the truth is, we don't know where to search, at which frequencies and wavelengths. We are currently looking at other phenomena using our telescopes, so the best strategy might be to adopt the SETI community's past approach of using data from other astrophysical studies—detecting radio emissions from other stars or galaxies—to see if they contain any techno-signals, and make that the standard practice."

Ineffective or just unlucky?

Asked whether he considers his conclusions encouraging or discouraging, Grimaldi laughed and said, "This is something we need to think about. We may have been unlucky in that we discovered how to use radio telescopes just as we were crossing a portion of space in which electromagnetic signals from other civilizations were absent. To me, this hypothesis seems less extreme than assuming that we are constantly bombarded by signals from all sides but are, for some reason, unable to detect them."

More information: Claudio Grimaldi, Inferring the Rate of Technosignatures from 60 yr of Nondetection, *The Astronomical Journal* (2023). DOI: 10.3847/1538-3881/acc327

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