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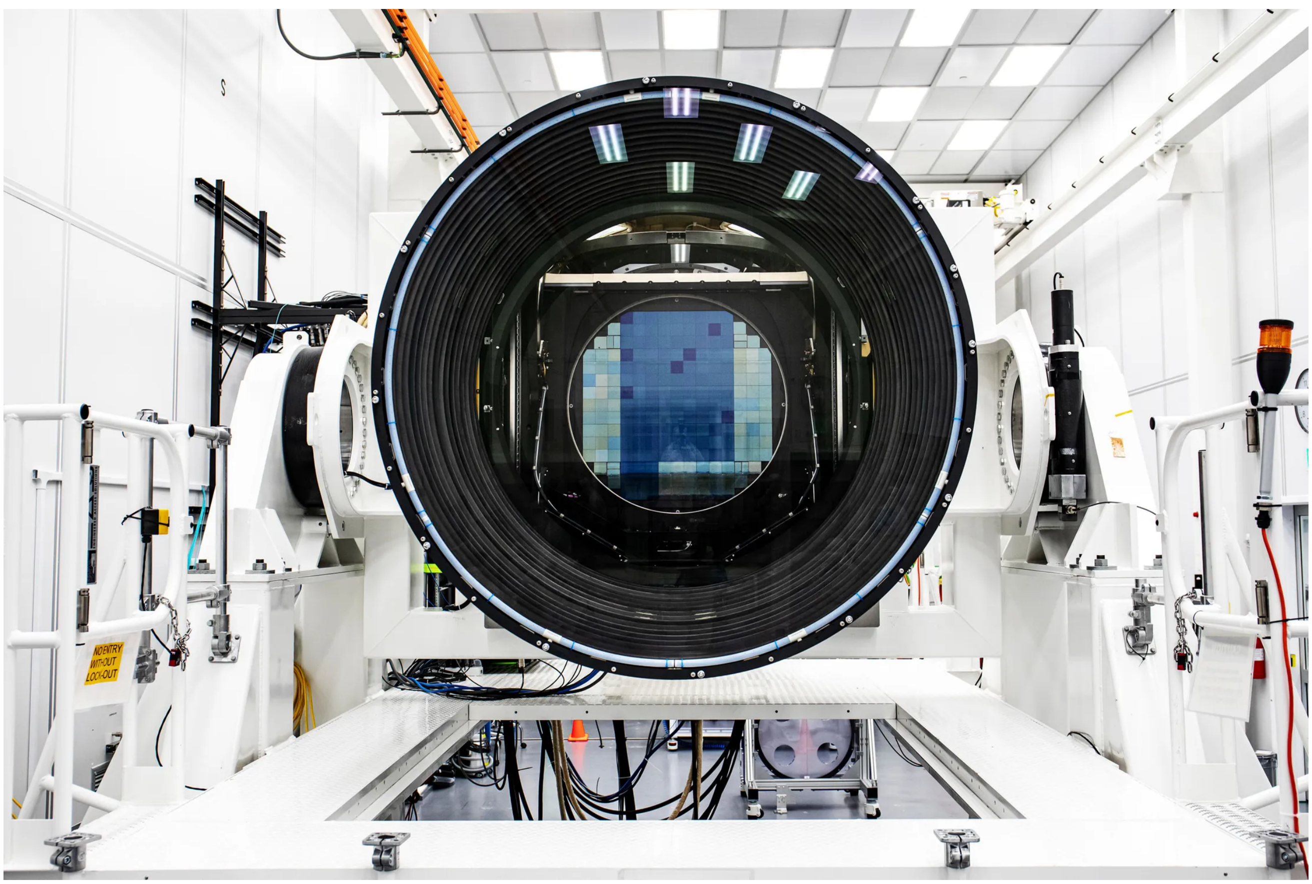
Scientists Say You’re Looking for Alien Civilizations All Wrong

A new report lays out a modern way to search for E.T., calling for better use of big data and machine learning techniques.



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AN INFLUENTIAL GROUP of researchers is making the case for new ways to search the skies for signs of alien societies. They argue that current methods could be biased by human-centered thinking, and that it's time to take advantage of data-driven, machine learning techniques.

The team of 22 scientists released a new report on August 30, contending that the field needs to make better use of new and underutilized tools, namely gigantic catalogs from telescope surveys and computer algorithms that can mine those catalogs to spot astrophysical oddities that might have gone unnoticed. Maybe an anomaly will point to an object or phenomenon that is artificial—that is, alien—in origin. For example, chlorofluorocarbons and nitrogen oxide in a world's atmosphere could be signs of industrial pollution, like smog. Or perhaps scientists could one day detect a sign of waste heat emitted by a Dyson sphere—a hypothetical massive shell that an alien civilization might build around a star to harness its solar power.

"We now have vast data sets from sky surveys at all wavelengths, covering the sky again and again and again," says George Djorgovski, a Caltech astronomer and one of the report's lead authors. "We've never had so much information about the sky in the past, and we have tools to explore it. In particular, machine learning gives us opportunities to look for sources that may be inconspicuous but, in some way—with different colors or behavior in time—they stand out." For example, that could include objects that flicker or are surprisingly bright at some wavelength, or ones that move unusually fast or orbit in an unexplainable path.

Of course, most of the time, data outliers turn out to have mundane explanations, like an instrumental error. Sometimes they do reveal novelties, but of a more astrophysical nature, like a type of variable star, quasar, or supernova explosion no one has seen before. That's a crucial advantage of this approach, the scientists argue: No matter what happens, they always learn something. The report quotes astrophysicist Freeman Dyson: "Every search for alien civilizations should be planned to give interesting results even when no aliens are discovered."

The project grew out of a major 2019 workshop at Caltech's Keck Institute for Space Studies in Pasadena, California, and includes a team of astronomers and planetary scientists primarily at Caltech and NASA's Jet Propulsion Laboratory—plus a handful of others, like Jason Wright from Penn State's Center for Exoplanets and Habitable Worlds, and Denise Herzing, an expert on dolphin communication, who was included because of her expertise on nonhuman languages.

The hunt for alien technosignatures is related to, but differs from, astrobiology, which often refers to the broader search for habitable—not necessarily *inhabited*—planets. Astrobiologists look for signs of the elements necessary for life as we know it, such as liquid surface water and atmospheres with the chemical signatures of oxygen, carbon dioxide, methane, or ozone. Their search typically includes seeking evidence of very simple life forms, such as bacteria, algae, or tardigrades. The James Webb Space Telescope has helped astronomers make headway there, by enabling spectroscopy of planetary atmospheres and illuminating promising worlds like K2-18 b, which has methane and carbon dioxide, and GJ 486 b, which appears to have water vapor. Technosignature searches also differ from searching for radio signals that could have been sent by sophisticated alien civilizations, either by accident or deliberately seeking contact. This search for extraterrestrial intelligence, also known as SETI, typically involves using dedicated radio telescopes like the Allen Telescope Array and the Green Bank Observatory to scan parts of the sky at a range of frequencies.

But Djorgovski and some of his colleagues are concerned that these kinds of searches are plagued by biases, like preconceived notions about what aliens might be like, what technologies they may have developed, how they'd colonize planets, and the kinds of signals their civilizations emit. They point out that other beings might not have a carbon-and-water-based chemistry, and might use technologies we're not familiar with. "In the past, searches for extraterrestrial intelligence focused on radio. I'm personally skeptical about this because it basically makes an assumption that an advanced civilization wants to send signals and would use the technology of mid-20th century planet Earth to do it, and in a way that we can understand," he says. As an example, he mentions how in the early 20th century, around when *War of the Worlds* and other fictional works fueled speculation about Martians, the inventors Nikola Tesla, Thomas Edison, and Guglielmo Marconi all thought they detected signals from Mars—but they turned out to be radio noise at low frequencies that can't penetrate Earth's atmosphere.

Others are more sanguine about radio SETI. Such research should be thought of as complementary with newer data-driven approaches, rather than as a competitor, says Sofia Sheikh, a coauthor on the report and an astronomer at the SETI Institute in Mountain View, California. "I think there's still a very important place for that in the field because the sky is big. Any way that we can better our chances by guessing what might be more likely places to look, that's worthwhile," she says.

Sheikh characterizes the report as a useful resource to help researchers work toward common goals, so they won't need to reinvent the wheel when figuring out how to dive into an unfamiliar data set or code their own anomaly-detection algorithms. Over the past decade, she and other astronomers have made use of catalogs with optical and infrared data from NASA's Kepler and TESS space telescopes, the European Space Agency's Gaia, and the National Science Foundation-funded Zwicky Transient Facility. They're also looking forward to the Vera Rubin Observatory, being built in northern Chile, which will amass data on some 10 billion Milky Way stars and millions of solar system objects.

Previous celestial surveys focused on trying to map the sky while including the faintest possible objects. But many of these more recent efforts are part of a move toward what's called a "time-domain survey," in which astronomers map the same patch of sky multiple times in order to see changes as a function of time. "If you come back again with your telescope, you'll see the sky is not stationary, it's not static. Things pulsate and wiggle and oscillate," says James Davenport, a University of Washington astronomer not involved in the report. That's why taking repeated measurements can yield critical data, he says. "A lot of things change minute to minute, hour to hour, and year to year."

Davenport agrees with the report's authors that data-driven techniques, including data drawn from surveying the sky repeatedly, would be helpful when trying to locate a needle in a cosmic haystack—another world colonized by intelligent beings. These techniques could include studying the light curves of distant objects to see if they behave differently than expected, or studying the orbital parameters of objects flying in our own solar system, since some may not have originated here. The machine-learning tools include "unsupervised learning," where a computer algorithm analyzes parameters like the brightnesses of stars or quasars at particular wavelengths—and can identify statistical outliers.

It's hard to know which anomalies will turn out to be interesting—or even reveal a sign of alien technology. For example, in 2017, a cigar-shaped object dubbed Oumuamua, which looked like either an asteroid or a comet, hurtled through our solar system. Controversy erupted when Harvard astrophysicist Avi Loeb argued that its weirdly accelerating orbit could be explained by it being an alien spaceship. New research this March proved the interstellar interloper is a comet after all, albeit a strange one, lacking a tail and accelerating thanks to expelled hydrogen. Oumuamua was indeed an outlier that led to interesting science—and data-driven research might turn up more objects like it.

The new technosignature report doesn't so much signal a shift in the field, but rather shows how it's growing and including scientists with different perspectives and expertise, says Anamaria Berea, a computational social scientist at George Mason University who was not involved in the project. She says it's worth using new tools to explore data sets that were previously collected for other purposes, in the hopes of finding those interesting outliers. "Ten, twenty years ago, we didn't have this explosion of artificial intelligence and computation technologies," she says. "Now they can be used also for archived data."

Technosignatures are popular topics of study, but they still add up to a small field that lacks steady funding. Berea hopes that ancillary science from data-driven approaches—learning from anomalies that *aren't* actually aliens—will boost the field and give it more legitimacy. In the meantime, the team behind the new paper will continue exploring one of humanity's most profound questions: whether or not we are alone in the universe.

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