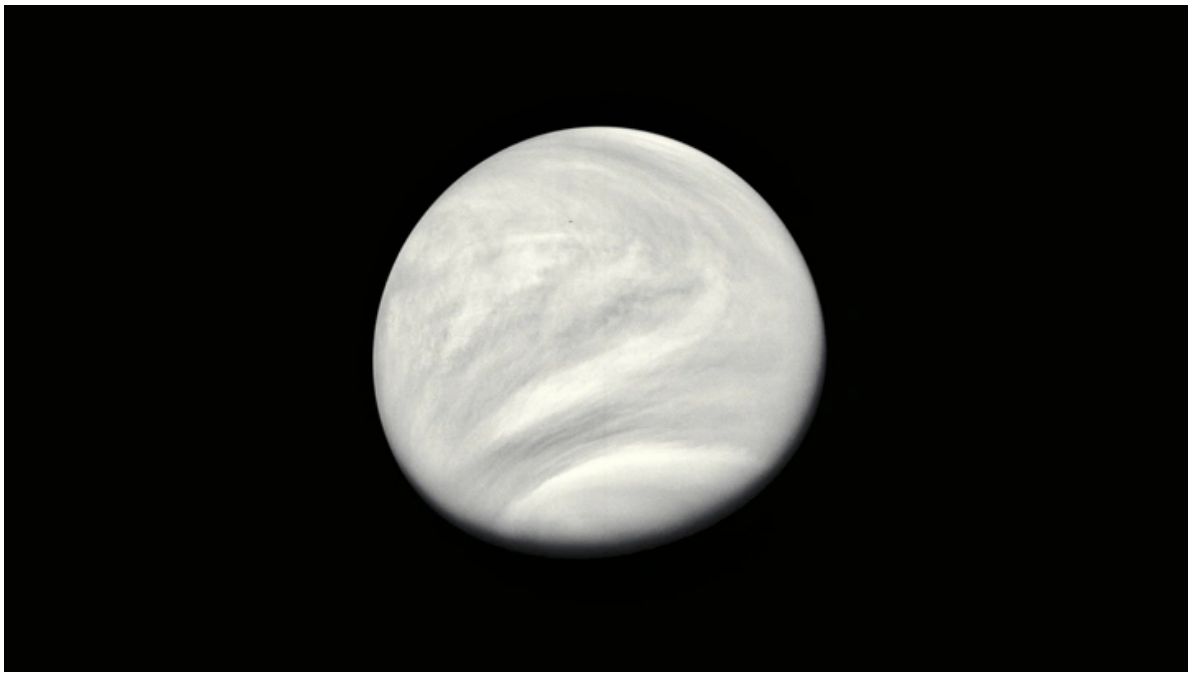
SCIENCE

Astronomers Are Now Obsessed With a Particular Gas on Venus

If phosphine is lurking in the planet's atmosphere, the source could, just maybe, be alien life.

MARINA KOREN DECEMBER 15, 2020



NASA

A few days ago, at the fall meeting of the American Geophysical Union, one of the most important conferences in science, a certain session began with a

viewpoints," said Sushil Atreya, a climate and space sciences professor at the University of Michigan and one of the conference's organizers. "All viewpoints are important, and we should treat our colleagues with respect."

Gathered on little screens in the Zoom room—this is still 2020, after all—were scientists on opposing sides of the most intriguing mystery in astronomy to emerge this year: What's going on inside the clouds of Venus?

Back in September, one team of scientists reported that it had discovered evidence of a toxic gas called phosphine in the planet's atmosphere. On Earth, the gas is produced by microorganisms. Phosphine can't survive for very long in Venus's atmosphere, so if the gas were there, *something* would have to be replenishing the supply. The researchers offered a couple of potential explanations for the source. It could be a chemical process that no one had ever seen before, or—maybe, possibly, probably not, but it just can't be ruled out—some form of Venusian life.

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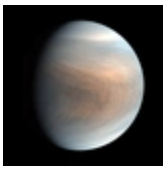

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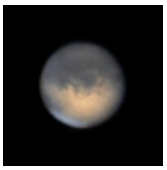

The Before Times of a Solar System

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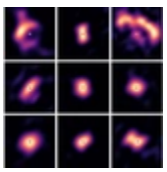

beyond Earth, and in those first moments, other scientists in the field were unusually excited about the research and its implications.

But in the months since the big announcement, the enthusiasm has dissipated. Other scientists have raised doubts about the research. The original team has revised its findings. The science community is divided—enough that one rebuttal paper had the authors "invite" the researchers who originally identified the phosphine to consider retracting their study altogether. In scientific literature, that counts as quite a salty attack, enough to make other researchers wince. (The researchers later removed that wording and apologized.)

[Read: Why Venus is the best planet]

The controversial part of this discovery was supposed to be the suggestion that life could exist in Venus's clouds. Aliens, though, are not the subject of the current debate. Scientists are sparring over something more basic: the detection of the gas itself.

Is there phosphine in Venus's atmosphere, or isn't there? To a nonscientific observer, the question might seem straightforward enough. Why would determining this simple fact be complicated?

The shortest answer is that astronomy is hard. The work requires scientists to draw big conclusions about faraway places based on tiny signals imprinted on the light that reaches Earth. Telescope observations don't produce handy readouts that say *Yes phosphine* or *No phosphine*. The scientists behind the discovery had to apply mathematical equations to extract those little signals from noisy data and then try to interpret them based on their current knowledge of another planet, which itself isn't very robust. The momentous detection showed up in a simple plot of squiggly lines—or it didn't, depending on whom you ask. Astronomy is full of disagreements like this one, but these squiggles provide the basis for nearly everything we know

Venus was the first planet human beings ever explored with spacecraft. Starting in the 1960s, a series of Soviet missions revealed a furnace of a world, with a thick, cloudy atmosphere that keeps the surface so hot that lead would melt on it like ice on Earth. In the same era, astronomers Carl Sagan and Harold Morowitz suggested that, although Venusian ground was inhospitable to life, its atmosphere might not be. Perhaps the inhabitants of an early Venus, once as habitable and balmy as Earth, had escaped into the skies when the planet became unbearably sweltering.

Decades later, Jane Greaves, an astronomer at Cardiff University, directed a telescope at our next-door neighbor. Greaves had come across research that suggested astronomers looking for extraterrestrial life should consider checking for phosphine on exoplanets, since any alien astronomers looking back at us could likely spot signs of the same gas on Earth. She decided to test the idea on Venus. "I wasn't really expecting that we'd detect anything," Greaves told me in September.

When Greaves and her colleagues examined their sets of squiggly lines, they saw a distinct dip, a sign of a molecule absorbing a particular wavelength of light. They determined that this chemical signature belonged to phosphine.

[Read: Why is NASA neglecting Venus?]

After the news came out, other scientists around the world dug into the research, and a flurry of papers started appearing online.

One group revisited telescope observations of Venus's atmosphere from several years ago and determined that they showed no evidence of the phosphine that Greaves and her team said they'd found in the cloud tops. Several researchers replicated the team's data analysis and came up empty, suggesting that the specific formula Greaves and her colleagues had used to make sense of their observations might have produced a fake signal. One

found a potential signal for phosphine, buried in data from a NASA mission that started studying Venus in 1978.

"Even the publications that [say] no phosphine have their own different ways of saying no phosphine," Clara Sousa-Silva, an astrochemist who studies phosphine at Harvard, and one of Greaves's co-authors, told me recently. "We disagree on how much signal there is in different places, and then we disagree on who is making that signal as strong as it is, and how. It seems like these are huge disagreements, but they come down to teeny, tiny decisions and data-processing mechanisms."

Sousa-Silva and her colleagues expected the scrutiny, of course, and even welcomed it. Science, especially science at the edge of current knowledge, is supposed to be an intellectual scuffle, and this one is still in motion. Most of the papers haven't undergone peer review, the careful process by which ideas are tested and honed for publication in scientific journals. "What we're seeing is the volatile and messy process by which science plays out," David Grinspoon, an astrobiologist at the Planetary Science Institute, told me. Grinspoon has written about the possibility of life on Venus since the 1990s, but was not involved in the latest research. "And if one were to try to sum up who's right, who's wrong—right now, it would be a maddening exercise."

[Read: A hint of water in the atmosphere of a faraway planet]

To make matters more complicated, it turned out that there was a problem with the raw data from one of the two telescopes involved in the research, and they would need to be reprocessed. Scientists don't usually work with raw data, relying instead on telescope staff to provide them with carefully refined information. Greaves's team had relied on the erroneous data to confirm the presence of phosphine, and several of the response papers had used them too.

might be produced by some kind of life. “Even if there’s less phosphine than we originally stated on Venus, our interpretation that it’s very hard to produce with any known chemistry still stands,” Sara Seager, an astrophysicist at MIT, told me.

Those who have detected evidence of phosphine in Venus’s clouds say that although the case for it might be weaker, it’s not dead yet; those who don’t see evidence of it say that the phosphine researchers are seeing only what they want to see. The pro-phosphine side thinks the other is overly resistant to the possibility that a long-lived dream—uncovering a potential sign of life on another planet—might be real; the anti-phosphine side thinks the other is enamored by that same dream.

Only fresh observations can help turn a collection of maybes into a consensus, one way or another. Scientists on both sides of the debate have analyzed and reanalyzed the data they have, but they need new observations of Venus. Unfortunately for them, Venus is oblivious to the kvetching unfolding a planet away and has since moved along. The planet is currently too close to the sun for telescopes to study it without frying themselves, particularly the kinds of instruments that scientists want to use to investigate the mystery further. They’ll have to wait until the spring and summer, when Venus moves into a more convenient spot, for the next round of observations.

[Read: The methane mystery on Mars]

Even then, there will be plenty of time for more deliberation. Mars scientists spent 15 years debating whether there’s truly methane gas—which can be produced by both chemical processes and living organisms—on the red planet, and only recently reached some agreement. (They still disagree about whether methane on Mars is a sign of life.) And that debate unfolded with plenty of spacecraft on and around Mars, with instruments capable of sifting

from Earth.

No ruling body of the solar system, no Supreme Court of astronomy, will someday pass down the definitive determination about phosphine on Venus. If the case becomes weaker, the search might end in a quieter way, with telescope facilities rejecting proposals for observations, says Ignas Snellen, an astronomer at Leiden University and one of the researchers who believes that the tantalizing signal is really sulfur dioxide. "Strictly speaking, from a scientific point of view, you can never prove that there is no phosphine," Snellen told me, but "at some point, you have to stop looking."

An absence of phosphine wouldn't mean that Venus must be uninhabited. "Nobody ever came out and said, 'If there is life on Venus, then there should be phosphine,'" Grinspoon said. "It's not true that if there's no phosphine on Venus, there shouldn't be life."

And even if no phosphine exists on Venus—even if Venus isn't the place where we first detect life outside of Earth—some other molecule, someday, could galvanize the scientific community like this molecule did, and spark another debate that could bring us closer to answering some of our most existential questions.

"I know the public just expected us to one day point and say, 'Hey, aliens!'" Sousa-Silva said. "We're going to point our telescopes at a planet, and we're going to detect a cool molecule that could be a biosignature—water, oxygen, methane, phosphine—and when we do, we're going to argue like this again. This is the discussion we'll be having every time, and hopefully, every time a little better."

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