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THE HINDU EXPLAINS

Relevant for: Geography | Topic: The Earth and the Solar System

This artistic illustration depicts the Venusian surface and atmosphere, as well as phosphine molecules. Photo: ESO via Reuters

The story so far: An international team of astronomers led by Jane S. Greaves of Cardiff University and University of Cambridge, U.K., has announced the discovery of traces of a molecule known as phosphine on Venus. This has caused great excitement because, given the chemical and geological composition of Venus, this can imply the existence of life forms that release this substance through bio-chemical pathways.

The researchers say in the paper, "[Phosphine] could originate from unknown photochemistry or geochemistry, or, by analogy with biological production of [phosphine] on Earth, from the presence of life." The paper, published on September 14 in *Nature Astronomy*, is a careful exposition of the work done over many years. Professor Greaves first observed phosphine on Venus using the James Clerk Maxwell Telescope in the Mauna Kea observatory in Hawaii in 2017. Pursuing the search further with the 45-telescope array ALMA (Atacama Large Millimeter/submillimeter Array) in Chile led to a confirmation of their observations by this extremely sensitive instrument in 2019.

Editorial | Venus in focus

The detected presence of phosphine on Venus does convey the possibility of life there. After detecting the phosphine and estimating the amount in Venus's atmosphere — 20 parts per billion — researchers have calculated whether this amount of phosphine can be produced by natural chemical processes, such as sunlight, volcanoes erupting and lightning. The other mechanisms could at most produce only ten-thousandth of the amount of phosphine they have detected. However, they do not rule out the possibility that there could be unknown natural processes (photochemistry or geochemistry) that can produce this amount of the biomarker. Therefore, more work is needed to prove that it is indeed because of bacteria, or some sort of life, that there is so much phosphine on Venus.

A molecule of phosphine gas consists of a phosphorus atom surrounded by three hydrogen atoms, just like ammonia consists of a nitrogen atom surrounded by three hydrogen atoms. On Earth, this molecule is produced by industrial processes. It is also produced by some anaerobic bacteria, which live in oxygen-sparse environments such as sewers, landfills, or even animal guts. If you can rule out the production of the gas through chemistry, it is the biochemical processes that form a source of the gas — the anaerobic bacteria — hence it is considered a biomarker in astronomy.

Yes, it has been seen on Jupiter and Saturn. As early as the 1970s, when the first exoplanets were not even discovered experimentally, phosphine was seen on Jupiter. But there it is said to form deep in the interiors of the gas giant and rise to the top, in a purely chemical process. But now, on Venus there is a doubt.

The surface temperature of Venus, at about 470 degrees Celsius, is too hot to harbour life as we know it. It is hot enough to melt lead. It is hotter than Mercury which is closest to the sun. According to a senior astronomer who is a member of the Astronomical Society of India, this is because Venus has experienced a runaway greenhouse effect which traps all heat that falls on it. But high up in its atmosphere, there are clouds which can provide a cooler home for microbial

life. Even there, the atmosphere is teeming with sulphuric acid vapour which makes it extremely hostile, thereby reducing the chance of finding life forms. According to the expert, the phosphine signature could be the sign of some extraordinary chemistry, as it could be of life forms. The next logical step is to actually do *in situ* measurements from Venus's atmosphere by sending space probes there.

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There have been several space missions to study Venus, and some of the recent dedicated missions are the European Space Agency's Venus Express and JAXA's Akatsuki. Many space missions have flown by Venus: for example, NASA's Parker Solar Probe used the gravity of Venus to achieve gravity-assisted boosts to its velocity on its journey to the Sun. NASA is planning a mission to Venus to be launched next year. The Indian Venus mission is being developed. Though formally unnamed, it is referred to as Shukrayaan-1.

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