News Feature: Hints of life on Venus

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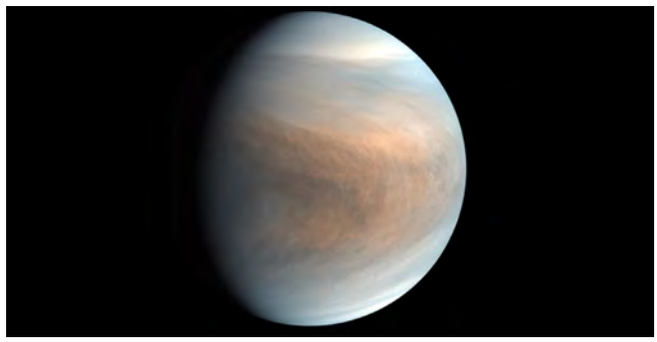
On the 14th of September 2020, the world was briefly distracted from its many present troubles by an announcement from the Royal Astronomical Society, *Hints of life on Venus* (ras.ac.uk/news-and-press/news/hints-life-venus). Subsequent analysis has questioned the discovery of the spectroscopic signature of molecule Phospine, chemical formula PH_3 (en.wikipedia.org/wiki/Phosphine). The problem remains unresolved and in situ examination might be the best way of solving the mystery.

Here John Davies summarises the research and the response by i4is and others.



Synthesized false colour image of Venus, using 283-nm and 365-nm band images taken by the Venus Ultraviolet Imager (UVI). JAXA / ISAS / Akatsuki Project Team

Source: CBS News

See also www.cbsnews.com/video/venus-potential-life-discovered-on-planet

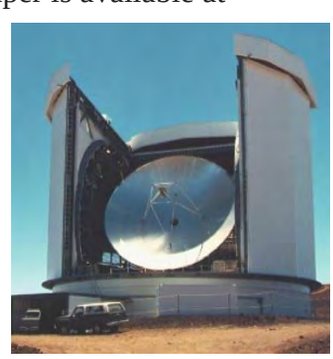
Discovery

Two major classes of chemical process are known to produce phosphine elsewhere in the Solar system. One is the highly energetic convective storms found in the atmospheres of gas giants such as Jupiter and the other is from living processes on Earth. So have we found a biosignature on Venus?

The paper in Nature Astronomy is -

Greaves, JS, Richards, AMS, Bains, W et al. Phosphine gas in the cloud decks of Venus. Nature Astronomy (2020). doi.org/10.1038/s41550-020-1174-4. (Received 07 February 2020). The paper is available at -

www.nature.com/articles/s41550-020-1174-4.pdf.



The James Clerk Maxwell Telescope.

Credit: Cambridge University

The lead author is Jane S Greaves, of the universities of Cardiff and Cambridge, UK. Other authors are from Jodrell Bank, MIT, Cambridge University, Kyoto Sangyo University, Imperial College London, Cardiff University, The UK Open University and East Asian Observatory Hawaii. They used two instruments, the James Clerk Maxwell Telescope (JCMT) in Hawaii and the Atacama Large Millimetre/submillimetre Array (ALMA) in Chile. It's worth quoting from the paper -

> If no known chemical process can explain PH_3 within the upper atmosphere of Venus, then it must be produced by a process not previously considered plausible for Venusian conditions. This could be unknown photochemistry or geochemistry, or possibly life.

- but it also says -

> Information is lacking—as an example, the photochemistry of Venusian cloud droplets is almost completely unknown. Hence a possible droplet-phase photochemical source for PH_3 must be considered (even though PH_3 is oxidized by sulfuric acid).

So the researchers themselves are cautious about the possible biosignature.

ALMA
on the Chajnantor Plateau with Large and Small Magellanic Clouds, Credit: ESO /Malin

Our interstellar colleague, Paul Gilster, was on the ball as usual. His indispensable Centauri Dreams blog published *What Phosphine Means on Venus* (www.centauri-dreams.org/2020/09/15/what-phosphine-means-on-venus/) on 15 September, gathering comments and related work. He also flagged another paper *Phosphine on Venus Cannot be Explained by Conventional Processes* (arxiv.org/abs/2009.06499) dated 15 September, by a team having a clear overlap with paper by Greaves et al.

Support and Doubts

Reactions to the Greaves et al paper have ranged from support to scepticism. A couple of examples -

Mogul (Cal Poly Pomona, USA) et al conclude "...that LMNS data support the presence of phosphine; although, the origins of phosphine remain unknown" [1].

Villanueva et al (Caltech) express doubts: "We here demonstrate that the observed PH3 feature with JCMT can be fully explained employing plausible mesospheric SO2 abundances (~100 ppbv as per the SO2 profile given in their figure 9), while the identification of PH3 in the ALMA data should be considered invalid due to severe baseline calibration issues." thus "We ultimately conclude that this detection of PH3 in the atmosphere of Venus is not supported by our analysis of the data" [2].

Missions

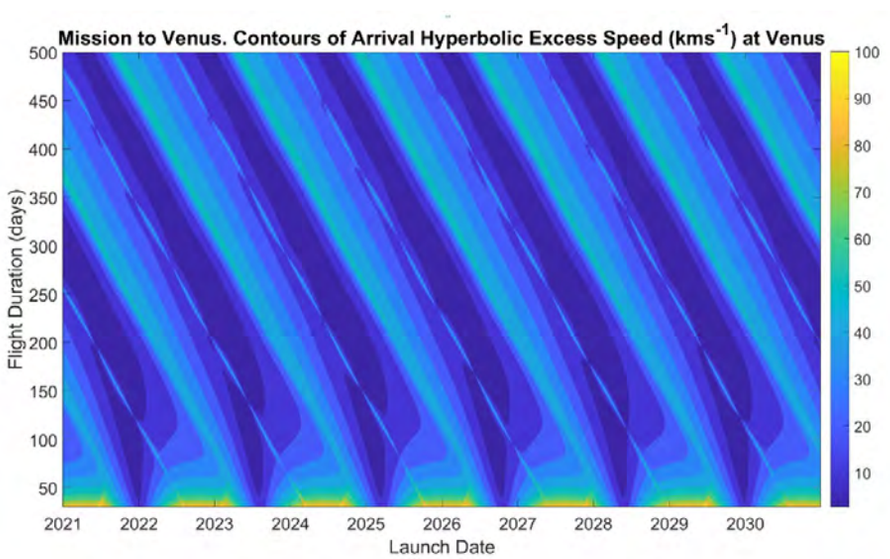
The original Greaves et al paper suggests "Ultimately, a solution could come from revisiting Venus for in situ measurements or aerosol return."

The i4is technical team have a worldwide reputation for timely mission studies, starting with the three-day Andromeda study delivered to Breakthrough Starshot in March 2016 [3]. And the first Project Lyra study in November 2017, only a month after the discovery of the first interstellar object (ISO), subsequently named 1I/'Oumuamua.

When Professor Greaves and her colleagues announced what might turn out to be the first life beyond our planet the i4is technical team responded quickly. The result is Hein et al, *A Precursor Balloon Mission for Venusian Astrobiology* which was published as a preprint on 24 September (arxiv.org/abs/2009.11826), ten days after the Greaves et al paper was published. The i4is team propose a precursor astrobiological mission to search for life forms in situ with instrument balloons floating in the Venusian cloud deck. This could be delivered to Venus via launch opportunities in 2022-2023. The mission would collect aerosol and dust samples by means of small balloons and would -

- directly scrutinize whether they include any apparent biological materials and, if so, their shapes, sizes, and motility.
- Use a miniature mass spectrometer to permit the detection of complex organic molecules.
- Contextual cameras to search for macroscopic signatures of life in the Venusian atmospheric habitable zone.

Formal publication was on 9 November 2020 in The Astrophysical Journal Letters [4].



Porkchop plots (en.wikipedia.org/wiki/Porkchop_plot) for encounter velocities at Venus from Earth in km/sec. An ideal mission would have both a short transfer time and low entry velocity. As the plot shows, such missions are possible every synodic period (~584 days) with the next such launch opportunity arising at the end of 2021.

Credit: Hein, Hibberd et al, Figure 2.

The plot was generated via Hibberd's Optimum Interplanetary TrajectorySoftware (OITS) (github.com/AdamHibberd/OptimumInterplanetaryTrajectory). More details in the paper.

[1] *Is Phosphine in the Mass Spectra from Venus' Clouds?*, Rakesh Mogul, Sanjay S Limaye, MJ Way, Jamie A Cordova Jr, arxiv.org/abs/2009.12758, LMNS is Large Probe Neutral Mass Spectrometer.

[2] *No phosphine in the atmosphere of Venus*, Geronimo Villanueva and 26 others, authors.library.caltech.edu/106365/s.

[3] i4is.org/what-we-do/technical/andromeda-probe/ and arxiv.org/ftp/arxiv/papers/1708/1708.03556.pdfs.

[4] *A Precursor Balloon Mission for Venusian Astrobiology*, Andreas M Hein, Manasvi Lingam, T Marshall Eubanks, Adam Hibberd, Dan Fries and William Paul Blase, Published 2020 November 9. The Astrophysical Journal Letters, Volume 903, Number 2, The American Astronomical Society, The Institute of Physics.

Amongst others, Forbes magazine noticed our proposal: *Proposed Venus Balloon Mission Could Detect Life By 2022* (www.forbes.com/sites/brucedorminey/2020/09/28/low-cost-privately-funded-balloon-mission-could-scope-out-venus-life-by-2022) interviewing both i4is Technical Director Dr Andreas Hein and Prof Manasvi Lingam (Florida Tech and Harvard).

Also in the wake of the Greaves et al paper the Venus flybys of BepiColombo enroute to Mercury last month and next year (sci.esa.int/web/bepicolombo/-/bepicolombo-flies-by-venus-en-route-to-mercury) may yield some clues.

Other new missions to Venus are under consideration including Breakthrough Initiatives funding a study led by Professor Sara Seager of MIT, who was one of the authors of the Greaves et al paper (breakthroughinitiatives.org/news/31).

Venus has recently been of wider astronautical interest with earlier proposals such as ESAs EnVision radar mapping orbiter (www.esa.int/ESA_Multimedia/Images/2019/03/EnVision_mission_concept) and NASA's Seismic and Atmospheric Exploration of Venus (SAEVe) lander (ntrs.nasa.gov/citations/20190001916).

Conclusion

Why does i4is take an interest in Venus? In our quest for interstellar exploration and ultimately, settlement, i4is is interested in many related fields. The search for extraterrestrial life in the solar system, if successful, supports the possibility of life beyond the solar system. The i4is Project Lyra studies were first prompted by the discovery of the first interstellar objects (ISOs) in the solar system and happily brought together a team capable of rapid mission planning. The paper *A Precursor Balloon Mission for Venusian Astrobiology* is the result of the convergence of these two.

Onward and upward!

Visualisation of balloons with payload near the Venusian cloud decks.

Credit: Adrian Mann.