SAMPLING VENUS FROM EARTH ORBIT. G. A. Konesky, K–Plasma, Ltd.
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Introduction: On June 5, 2012 the Sun, Venus, and the Earth will align in an inferior conjunction such that the shadow of Venus will be cast along the surface of the Earth (Venus transit). Lacking any significant magnetic field, the outer atmosphere of Venus is being eroded by the solar wind. The resulting comet-like ion tail has been observed, for example, by the SOHO mission [1] near Earth's L1 Lagrangian point, and by both the Pioneer Venus [2] and Venus Express [3] in the vicinity of Venus. During the Venus transit event, the Earth will also pass through this ion tail, although the Earth's magnetosphere would deflect it. It has been proposed [4], perhaps somewhat controversially, that microorganisms may reside in the habitable upper atmosphere of Venus and these too may be carried away by the erosive solar wind.

A mission is proposed in extended Earth orbit to sample any particulate matter, including potential remnant microorganisms that may be contained in Venus' comet-like tail. An aerogel capture mechanism is employed, followed by subsequent basic analysis using ultraviolet fluorescence as an indicator of potential organic compounds. A low cost CubeSat implementation is discussed.

Venus Habitability: While the surface of Venus is extremely inhospitable, a region exists in the upper atmosphere of Venus, between 45 and 65 km, where the temperature and pressure ranges from -25ºC to 75ºC, and 0.1 to 10 bar, respectively.

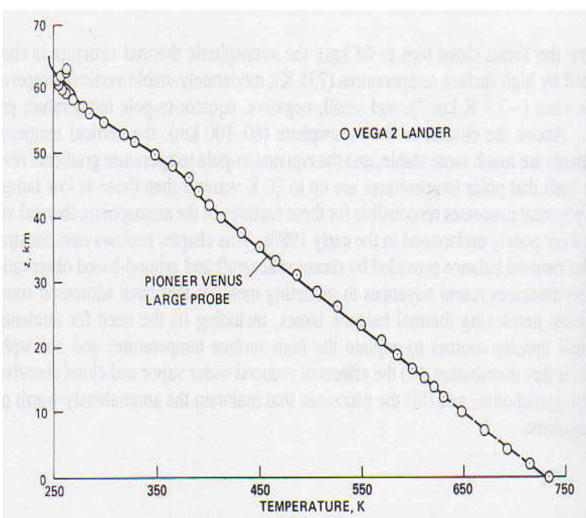

Figure 1. Venus atmospheric temperature profile (NASA/GSFC).

This region of Venus' atmosphere also contains ultraviolet absorbers of an unknown origin whose particle size distribution (primarily from 1 to 4 μm) is compatible with a biological origin [5]. It is difficult to understand the origin of potential cloud-based microorganisms on Venus given its present highly inhospitable surface. However, high a deuterium to hydrogen ratio in Venus' atmosphere [6] suggests that a significant Earth-like ocean once existed and could have been maintained for several billion years by a carbonate-silicate weathering cycle [7].

Figure 2. UV absorbers in Venus' upper atmosphere of an unknown origin (NASA/JPL).

As the Sun gradually brightened, a runaway greenhouse ensued driving the water into the upper atmosphere where solar photodissociation decomposed the water, allowing the lighter hydrogen to escape, and resulted in the present relatively dry conditions [8]. It is interesting to note that during this extended water loss event, the atmosphere of Venus would have been enriched in oxygen from the photodissociating water. In the search for life outside of our solar system, the presence of oxygen in the atmosphere of an exoplanet would generally be considered a positive indication for life. However, the example of Venus provides a potential caution for false-positives [9].

Mission Orbital Design: The transit of Venus would be an ideal time to detect and collect uncharged particles and putative remnant microorganisms from Venus in a Low Earth Orbit (LEO) mission [10]. Unfortunately, there are only two transits of Venus in this century. The first occurred on June 8, 2004 and the next will be on June 5, 2012. They reoccur in 8 year pairs alternately in intervals of 121.5 years and 105.5 years. Given the low frequency of Venus' comet-like tail coming to Earth, we must then consider going to the tail.

The orbits of the Earth and Venus are inclined by approximately 3.39 degrees. At Earth's average distance from the Sun of 149.6x10^6 km, Venus' comet-like tail will have a maximum displacement from Earth's orbital plane of approximately 8.86x10^6 km (5.5x10^6 miles), as shown in figure 3. However, this maximum distance would occur only as infrequently as transits occur, for similar reasons.

On the other hand, an inferior conjunction, where the Sun, Venus and the Earth are only radially aligned, occurs every about 584.006 days (1 year, 7 months, 6 days, and 18 hours), or 2.59904 Venusian years. During any one of these inferior conjunctions, the orbital plane displacement can vary from zero (a transit) to the maximum value.

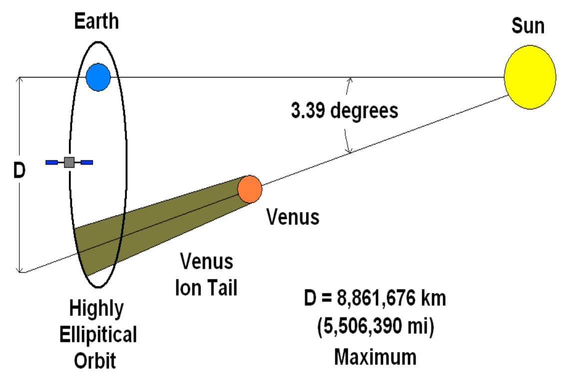

Figure 3. Orbital design for a mission to intercept the ion tail of Venus at maximum plane displacement.

Sample Acquisition and Analysis: The ion component of Venus' comet-like tail is most easily analyzed using a mass spectrometer. The SOHO spacecraft measured an ion flux density [1] of between 2.4x10^3 and 4.4x10^3 $cm^{-2}s^{-1}$ at Earth's L1 Lagrangian point 0.01 AU (about 1.5x10^6 km) sunward of Earth. Wickramasinghe [4] estimates the potential flux of particulates, including putative microorganisms from Venus, to be approximately 1% of the ion flux. He also suggests that the solar wind, moving at about 400 km/s [11] is the primary transport mechanism. However, at a density typically at 10 particles per cm^3, very little thrust would be imparted as compared to the sunlight itself, which is 10^3 to 10^4 times stronger [12].

A mechanism for the collection of particulates coincident with passage through Venus' comet-like tail is suggested by the highly successful use of silica aerogel in the Stardust mission [13]. The very high deceleration forces involved in aerogel capture would necessarily disrupt any structure of putative microorganisms, but identifiable residual organics would survive the impact [14].

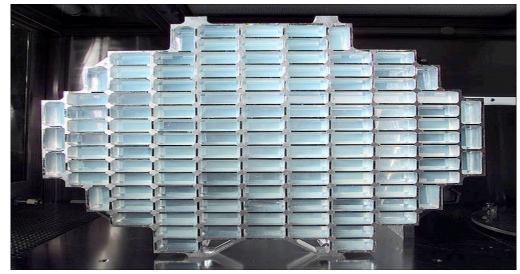

Figure 4. Stardust aerogel collector (NASA/JPL).

Ultraviolet light induced fluorescence is a common method of identifying organic compounds [15] and bioaerosols [16] and is suggested as a mechanism for detecting putative Venusian microorganisms collected by the aerogel.

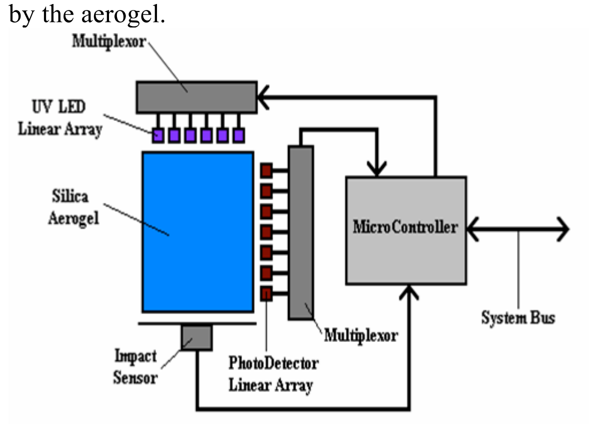

Figure 5. Proposed particle collection and detection.

Possible sources of error include Interplanetary Dust Particles and Carbonaceous Chondrite micrometeorites, and even residual waste water from the International Space Station and other LEO human activities.

References: [1] Grunwaldt H., et al. (1977) *Geophys. Res. Lett., 24,* 1163-1166. [2] Mihalov J. D. and Barnes A. (1982) *JGR, 87,* A11, 9045-9053. [3] Barabash S. et al. (2007) *Nature 450,* 650-653. [4] Wickramasinghe N. and Wickramasinghe J., (2008) *Astrophys. Space Sci., 317,* 133-137. [5] Morowitz H. and Sagan C. (1967) *Nature 215,* 1259-1260. [6] de Bergh C. (1991) *Science 251,* 547-549. [7] Walker J. (1975) *J. Atmos. Sci., 32,* 1248-1255. [8] Kasting J. (1988) *Icarus 74,* 472-494. [9] Konesky G. (2011) *Proc. SPIE 8152,* 815209-1 to -7. [10] Konesky G. (2010) *Proc. SPIE 7819,* 781917-1 to -6. [11] Cravens T. (1997) *Physics of Solar System Plasmas,* Cambridge University Press. [12] Friedman L. (1988) *Star Sailing,* John Wiley and Sons. [13] Bajt S. et al. (2009) *Meteoritics and Planet. Sci., 44,* 471-484. [14] Sandford S. et al. (2006) *Science, 314,* 1720-1725. [15] Bhartia R. et al. (2008) *Appl. Spec., 10,* 1070-1077. [16] Cheng Y. S. (1999) *Aerosol Sci. and Tech. 30,* 186-201.