Abstract for 11th Low Cost Planetary Missions Conference
June 9-11, 2015, Berlin, Germany

Low cost mission to measure noble gases and their isotopic ratios in Venus atmosphere

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Getting reliable measurements of noble gases in Venus' atmosphere with a CubeSat-derived mission concept is very challenging. But if feasible it could change how we make this fundamental geochemical measurement in planetary atmospheres and other gaseous environments (e.g., plumes emanating from icy moons or dwarf planets) across the solar system. Venus poses the most urgent and nearby target for such measurements, to fill in a key piece of the puzzle of Venus' origin, evolution, and divergence from Earth's geophysical history. Noble gases are tracers of the evolution of planets. They trace processes such as the original supply of volatiles from the solar nebula, delivery of volatiles by asteroids and comets, escape rate of planetary atmospheres, degassing of the interior, and its timing in the planet's history. However, a major observational missing link in our understanding of Venus' evolution is the elementary and isotopic pattern of noble gases and stable isotopes in its atmosphere, which remain poorly known (Chassefiere et al., 2012). The concentrations of heavy noble gases (Kr, Xe) and their isotopes are mostly unknown, and our knowledge of light noble gases and stable isotopes is incomplete and imprecise.

A small satellite derived from the cubesat technology would be equipped with a quadrupole ion trap mass spectrometer (QITMS) that would analyze a sample of the Venus atmosphere obtained below the homopause and then return data to a mother spacecraft that would download the data to Earth. The miniaturized QITMS is discussed in session 4 (Darrach et al., 2015). During a nominal measurement, the spacecraft will collect a ram-enhanced atmosphere sample in a small accommodation chamber where the major constituent species (CO2 and N2) will be removed by an ion/getter pump. The resultant sample, having enriched noble-gas partial pressures, will be admitted into the QITMS, ionized by an electron beam, and the resultant ions trapped and mass analyzed by an rf potential field. The investigation will return noble gas abundances and isotopic ratios to better than 5%. The platform itself leverages JPL's prior planetary CubeSat developments.

Because noble gases provide strong constraints on the evolution processes, these measurements were rated number 1 investigation of objective A (How did the atmosphere of Venus form and evolve?) of goal I (Understand atmospheric formation, evolution, and climate history on Venus) of the VEXAG "Goals-Objectives-Investigation for Venus Exploration" published in 2014. Such measurements are also be responsive to several of the 10 priority questions defined in the 2013 Decadal Survey for Planetary Exploration. Finally, these measurements and their interpretation address two of the five science goals of the Planetary Science Division as described in the 2014 NASA Science plan.

This work has been performed at the Jet Propulsion Laboratory, California Institute of Technology, under contract to NASA.