The Role of Photon Stimulated Desorption in the Formation of a Sulfur Exosphere at Mercury. Micah J. Schäible,1, * Menelaos Sarantos,2 Brendan A. Anzures,1 Stephen W. Parman,3 and Thomas M. Orlando1 1School of Chemistry and Biochemistry, Georgia Institute of Technology, 2Heliophysics Science Division, Goddard Space Flight Center, 3Department of Earth, Environmental, and Planetary Science, Brown University (*mjschaible@gatech.edu).

Introduction: Sulfur abundances on the surface of Mercury are at least 10 times greater than found in terrestrial and lunar compositions. Due to the volatile nature of sulfur and the direct interaction of ambient ionizing radiation with the surface materials, stimulated desorption processes are expected to eject sulfur into the exosphere where it travels ballistically until it either gravitationally escapes, is photoionized, or returns to the surface. Various desorption mechanisms including ion, electron, and photon and micrometeorite stimulated desorption mechanisms are able to eject sulfur from the surface, although their relative importance is debated.

Observations from the Fast Imaging Plasma Spectrometer (FIPS) taken during the MERCURY Surface, Space Environment, Geochemistry, and Ranging (MESSENGER) spacecraft’s first flyby of Mercury showed a peak measured in the mass over charge range from 32 to 35 amu/e which has been attributed to O2+ and/or S+ and H2S+. While the abundance of other observed ions, e.g. the water group (O+, OH+, etc.), metal group (Na+, Mg+, and Si-group (Al+, Si+) ions, can be accounted for by solar wind sputtering and thermal desorption, the precise species assignment and specific desorption mechanism leading to the signal at m/q = 32-35 amu/e remains unclear.

The goal of this work is to determine the cross-section for photon stimulated desorption (PSD) of S0 and evaluate the role of PSD in forming a sulfur exosphere at Mercury.

Experimental: To help confirm the assignment of the FIPS signal at m/q=32-35 amu/e, and to better constrain the sources of exospheric sulfur at Mercury, PSD of neutral sulfur atoms (S0) from MgS substrates was studied using resonance enhanced multiphoton ionization (REMPI) and time-of-flight (TOF) mass spectrometry. MgS (niningerite) of > 95% purity was synthesized from Mg metal powder and excess S powder, and PSD was initiated by an unfocused 193 nm eximer laser. To detect the photodesorbed S0, a probe laser was focused approximately 1 mm above the center of the MgS surface and tuned to 254.895 nm. The 2+1 REMPI scheme chosen uses two photon absorption of the 3P2 ground state to populate the resonant 3F2 excited state, followed by electron ejection upon absorption of a third photon. The TOF signal at m=32 amu to was only detected when both the PSD and REMPI probe lasers were present, thus confirming resonant ionization of desorbed S0.

Results: Though the PSD process is inherently nonthermal, the measured velocities of ejected S0 were fit using a bi-modal, flux weighted Maxwellian consisting of thermal (Tg = 300 K) and supra-thermal (Tg > 1000 K) components in roughly a 2:1 ratio (see Figure 1).

The desorption yield scales linearly with photon flux below about 1023 photons/cm2/s, indicating single photon desorption mechanisms. Correlating the integrated area of the velocity distribution curve to the number of desorbed S0 per incident PSD pulse allowed a photon desorption cross-section of approximately 4x10-22 cm2 to be determined. Monte Carlo particle tracing simulations of ejected atoms were used to simulate the trajectories of ejected S0 atoms (see figure

Figure 1: Intensity of S0 versus desorption velocity and the flux weighted Maxwellian velocity distributions used to fit the observed signal.

Figure 2: PSD altitude density profile for S0 calculated using a Monte Carlo particle tracking model, and it is shown that PSD is likely the primary source of S0 in Mercury’s exosphere at low (<1000 km) altitudes.

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