THE ROLE OF PHOTON-STIMULATED DESORPTION IN POPULATING THE EXOSPHERE OF MERCURY.

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Introduction: Observations from the MESSENGER spacecraft have established that a chemically complex tenuous exosphere exists [1]. Recent work modeling the ion sputtering, micrometeorite ejection, thermal desorption and photon-stimulated desorption (PSD) contributions to the exosphere at Mercury found generally good agreement when comparing with MESSENGER instrument data [2]. Some models that include PSD contributions for Na and K, show that PSD may dominate by up to three orders of magnitude over ion sputtering and micrometeorite impact vaporization for these species [2]. Other models show a much larger contribution from impact vaporization [3].

It was recently noted that sulfur in particular was underestimated by the modeling efforts [2]. One particularly interesting potential source or S comes from the unique hollows features, typically tens of meters to a few kilometers in size, found in multiple regions across the surface of Mercury, often in impact craters. These are thought to be associated with recent volatile activity [4]. The hollows were identified as broad absorption features in the NIR (0.559 to 0.828 μm) and these features likely contain MgS and possibly CaS [5].

Previous lab measurements using resonance enhanced multiphoton ionization (REMPI) to measure total PSD yields of Ca from calcium sulfide (CaS) showed that PSD could significantly contribute to the calcium exosphere density both globally and in enhanced abundance over the hollows regions [6]. The Ca PSD cross-sections measured and the neutral densities predicted at Mercury [6] were of a similar order of magnitude as previous estimates [2,7], although it was noted that the CaS material used in the experiments was likely only relevant to hollows regions. We report recent work on the PSD of MgS (niningerite) which is also thought to be relevant to the hollows.

Experiment: MgS (niningerite) of >95% purity was synthesized from Mg metal powder and excess S powder in a sealed evacuated silica tube. Neutral sulfur was ejected from the surface of the MgS pellet held in an ultrahigh vacuum chamber using 193 nm photons as the stimulated desorption laser. The neutral S was then detected using 2+1 resonance-enhanced multiphoton ionization followed by time-of-flight mass analysis (REMPI-TOF). The REMPI detection of S consisted of two photon absorption to populate the resonant ^3F excited states, followed by ionization by a third photon. The resonant energy photons at 254.895 nm pulses were generated by passing the 509.79 nm output from Nd:YAG pumped optical parametric oscillator (Spectra-Physics, MOPO-SL) through an angle tuned, frequency doubling BBO crystal (Inrad Optics, Autotracker III).

Results: Velocity distributions were measured by varying the time delay between the PSD laser and REMPI laser. The S is ejected with a bimodal velocity distribution representing both thermal and suprathermal (>1000 K) components.

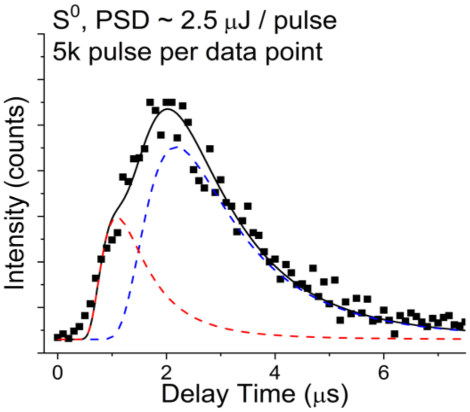

Figure 1. Velocity distribution of S removed by 193 nm PSD of MgS.

The S yield, in terms of neutral sulfur atoms ejected per incident UV photon, was determined by integrating over the S velocity distribution, and the lower limit for the PSD cross was determined to be ~ 5×10^{-22} cm^2. Preliminary Monte Carlo simulations indicate that the density and distribution of S, particularly in the hollows regions, can indeed contain a source term that is related to PSD.

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References: [1] Zurbuchen (2009), *Science* 324, 606-610, [2] Wurz et al., (2019), *JGR Space Phys.*,124,2603-2612, [3] Borin et al., (2010), *A&A*, 517, A89. [4] Blewett et al., (2011), *Science*, 333,1856-1859, [5] Lucchetti et al., (2018), *JGR-Planets*, 123, 2365-2379, [6] Bennet et al., (2016) *JGR-Planets*, 121, 137-146, [7] Killen et al., (2007) *Space Sci. Revs.,* 132, 433- 509.