Sulfur at Mercury

- Sulfur is an expected component of Mercury’s exosphere, but observed sulfur ion abundances [Zurbuchen et al., 2008] are underestimated by current exosphere formation models.
- Here, the velocity distribution and cross-section for photon stimulated desorption (PSD) of neutral sulfur ($S^0$) was measured from MgS target materials using Resonance enhanced multi-photon ionization - time-of-flight mass spectrometry (REMPI-TOF).
- Estimates of the $S^0$ desorption rate produced by solar photons suggest that PSD should be included as a source of exospheric sulfur at Mercury.

**Experimental Details**

- Pellets of 0.3 cm diameter MgS (niningerite) -> produced with a porosity of approximately 20%.
- Lightly scraped with a clean razor blade, and loaded into an ultrahigh vacuum (UHV) chamber.
- PSD initiated using pulsed, unfocused UV eximer laser at 193 nm (6.42 eV).
- 60° incidence, 20 Hz, 10 ns pulse, 10-250 μJ cm$^{-2}$ per pulse.
- REMPI of $S^0$ using pulsed 254.895 nm light focused in the desorption plume.
- Two photon absorption of the 3P2 ground state to populate the resonant 3F4 excited state, followed by electron ejection upon absorption of a third photon (2+1).
- ~1.5 mJ per 10 ns pulse.
- TOF signal integrated over >1000 laser pulses.
- TOF signal at m=32 amu detected only when both the PSD and REMPI lasers, confirming resonant ionization of photodesorbed $S^0$.
- Velocity distributions were measured by stepping the time delay between PSD and REMPI laser at 50 ns intervals.

**Velocity and Cross-sections**

The flux density of the photodesorbed $S^0$ was measured as a function of time after the initial PSD pulse, and velocity distributions were determined by using the Jacobian transform, $P_v(t) = t_v d^2S(t_0)$ where $S(t_0)$ is the measured signal intensity of desorbed $S^0$ at probe laser delay time $t_0$.

The distributions were best fit using a bi-modal Maxwellian distribution consisting of a low temperature thermal component which matches the substrate temperature and a high temperature ‘supra-thermal’ component.

$$P_v(v,T_{trans}) = \frac{1}{2} \left( \frac{m}{\langle E_{trans} \rangle} \right)^2 v^3 \exp \left( \frac{-mv^2}{\langle E_{trans} \rangle} \right)$$

where $\langle E_{trans} \rangle = 2k_B T_{trans}$

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<tr>
<td>28</td>
<td>300 (0)</td>
<td>1075 (61)</td>
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<td>4x10$^{-22}$</td>
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<td>17</td>
<td>300 (0)</td>
<td>1152 (191)</td>
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<td>8x10$^{-23}$</td>
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**PSD at of Sulfur at Mercury**

- Recent exosphere formation models for Mercury have concluded that PSD contributes minimally to the release of Na and K in comparison with thermal and sputtered desorption [Wurz et al., 2019].
- PSD has not been considered for other species such as $S^0$. The photodesorbed surface flux of $S^0$, $\Phi(S^0)$, can be determined using:

$$\Phi(S^0) = \Phi_{\lambda>3.5 \text{ eV}} \times \cos(SZA) \times [S]_{surf} \times \sigma(S^0)$$

- $S^0$ vapor densities due to PSD could reach 3500 cm$^3$ at the surface and about 0.1 cm$^3$ at 1000 km.
- PSD should be considered as a source term for $S^0$ when modeling the formation of Mercury’s exosphere.

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