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MESSENGER Observations of Mercurys Exosphere from the First Two Flybys

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During the first two MESSENGER flybys of Mercury, the UltraViolet and Visible Spectrometer (UVVS) channel of the Mercury Atmospheric and Surface Composition Spectrometer (MASCS) conducted simultaneous, high-spatial-resolution measurements of several species, including the first detection of Mg in Mercury's exosphere. These observations have provided an unprecedented glimpse into the structure of the exosphere and the processes behind it. Of particular note are the first detections of neutral magnesium, a species long predicted to be a significant component of the surface.

The UVVS is a scanning grating monochromator with three spectral channels — far-ultraviolet (FUV: 115-190 nm), mid-ultraviolet (MUV: 160-320 nm), and visible (VIS: 250-600 nm) — that provide a spectral resolution varying from 0.2 nm at UV wavelengths to 0.5 nm at visible wavelengths and with a two-position aperture that sub-tends either $0.04^\circ \times 1^\circ$ or $0.04^\circ \times 0.05^\circ$. The UVVS observations occurred in four more or less distinct regions: (1) extended tail, (2) nightside (the "fantail"), (3) near dawn terminator, and (4) dayside. During the extended tail observations on the inbound part of the trajectory, the UVVS line of sight was rocked back and forth about the Sun-Mercury line, sweeping out a region of space approximately three planetary diameters tall. During both flybys, successful observations in the extended tail were obtained of the sodium (Na) doublet emission at 589.0/589.6 nm, whereas additional observations of emission by magnesium (Mg) at 285.2 nm and by calcium (Ca) at 422.7 nm were obtained during the second flyby.

The high-latitude enhancements seen in the Na tail during both encounters are likely associated with variations in the solar-wind-sputtering source component of Na atoms. This result is consistent with MESSENGER magneto-sphere observations, which suggest that the plasma flow during the first flyby was more focused in the north but more uniformly distributed during the second flyby.

Observations of Ca and Mg obtained simultaneously with the Na observations in the tail region during the second flyby show that the spatial distributions differ for each of the three species. In contrast to Na, Ca emission in the tail region is strong emission near equatorial latitudes and weaker at higher latitudes, whereas Mg appears to be more uniformly distributed, but may weakly trend with Ca.

Once the spacecraft entered Mercury's shadow, it executed a 180° roll in order to observe the daylit surface dur-ing the outbound trajectory. During this roll, the UVVS line of sight was initially pointed in the direction of the dawn hemisphere, rotated north, and finished viewing the dusk hemisphere near the equator. This roll, referred to as the fantail, provided observations of Ca emission during the first flyby and of Na, Ca, and Mg emission during the second flyby.

At the end of the fantail observations, the UVVS line of sight intersected the dark, nightside surface of the planet. As the spacecraft passed through closest approach and began its outbound leg, it emerged from Mercury's shadow. Although the line of sight still intersected the nightside surface, at least some part of the column between the spacecraft and surface was illuminated and resulted in measurable emission from Ca during the first flyby and from Na, Ca, and Mg during the second flyby. These observations continued until the line of sight crossed the dawn terminator, at which point sunlight reflected from the bright dayside disk precluded exospheric observations. As with the tail observations, both the fantail and near-terminator observations show differing spatial distributions of Na, Ca, and Mg, including unexpected dawn-dusk asymmetries in Na and Ca that are not correlated. These

distributions provide important insights into the processes that generate and maintain the exosphere. We will compare these distributions with Monte Carlo models based on ejection from the three expected source processes: photon-stimulated desorption, impact vaporization and ion sputtering.