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The Chemical Composition of Mercury's Exosphere

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Mercury does not have a dense atmosphere whose altitude dependence is described by a single scale height. The Ultraviolet Spectrometer (UVS) instrument on Mariner 10 discovered a tenuous exosphere with gaseous species H, He, and O. Since the Mariner 10 flybys, ground-based telescopes have been used to observe the exosphere of Mercury in the Na and K spectroscopic D lines. Calcium has been observed primarily in the polar and anti-sunward exosphere. Radar-bright regions have been discovered at the poles, attributed to volatile deposits (water or sulfur) in permanently shadowed craters. Recently, Mg was discovered during MESSENGER's second flyby of Mercury. Many more species are predicted to exist in Mercury's exosphere, and they are a diagnostic of the surface composition. In many cases, orders-of magnitude differences exist in the predictions of abundances from different models because of our current lack of understanding of Mercury's surface composition and source processes. The small amount of O at the base of the exosphere (n[O] < 4 $\times$ 10^4 particles/cm-3) relative to the surface abundance ($\sim$50%) is surprising. This may indicate that the exospheric O is bound in molecules, is inefficiently desorbed, or efficiently escapes. Elements such as Na, Ca, Ar, Ne and S are expected to yield critical information about Mercury's surface. To fully characterize the temporal and spatial variability of Mercury's exosphere, correlated in situ and ground-based observations are essential. Measurements of Na will enable these correlations. Calcium is a refractory element and may be considered a tracer of ion sputtering processes. Both 36Ar and Ne are not expected to be endogenic to Mercury, but implanted by the solar wind. The S content in Mercury's crust and interior is highly diagnostic of the planet's origin.