EPSC Abstracts
Vol. 6, EPSC-DPS2011-**PREVIEW**, 2011
EPSC-DPS Joint Meeting 2011

Early MESSENGER Results for Less Abundant or Weakly Emitting Species in Mercury's Exosphere

Ronald J. Vervack, Jr. (1), William E. McClintock (2), Rosemary M. Killen (3), Ann L. Sprague (4), Matthew H. Burger (3,5), Aimee W. Merkel (2), and Menelaos Sarantos (6,7)
(1) The Johns Hopkins University Applied Physics Laboratory, Laurel, MD 20723, USA; (2) Laboratory for Atmospheric and Space Physics, University of Colorado, Boulder, CO 80303, USA; (3) Planetary Magnetospheres Laboratory, Solar System Exploration Division, NASA Goddard Space Flight Center, Greenbelt, MD 20771, USA; (4) Lunar and Planetary Laboratory, The University of Arizona, Tucson, AZ 85721, USA; (5) Goddard Earth Sciences Technology and Research, Morgan State University, Baltimore, MD 21251, USA; (6) Heliophysics Science Division, NASA Goddard Space Flight Center, Greenbelt, MD 20771, USA; (7) University of Maryland, Baltimore County, Baltimore, MD 21251, USA. (Ron.Vervack@jhuapl.edu)

Abstract

Now that the MESSENGER spacecraft is in orbit about Mercury, the extended observing time enables searches for exospheric species that are less abundant or weakly emitting compared with those for which emission has previously been detected. Many of these species cannot be observed from the ground because of terrestrial atmospheric absorption. We report here on the status of MESSENGER orbital-phase searches for additional species in Mercury's exosphere.

1. Introduction

Mercury's exosphere is composed of material that originates at the planet's surface, whether that material is native or implanted by the solar wind or micrometeoroids. Many exospheric species have already been detected by remote sensing, including H and He by Mariner 10 [1], Na, K, and Ca by ground-based observations [2-4], and H, Na, Ca, Mg, and Ca^+ by MErcury Surface, Space ENvironment, GEochemistry, and Ranging (MESSENGER) flyby observations [5-7]. However, there are other species that we expect to be present in the exosphere on the basis of MESSENGER surface measurements and models of Mercury's geochemistry, including Fe, Al, Si, O, S, Mn, Cl, Ti, OH, and their ions.

Emission from several of these species falls at wavelengths that cannot be detected from the ground owing to absorption by Earth's atmosphere. Even when observations are possible, whether from Earth or space, these species may be less abundant in the exosphere and/or have small g-factors (i.e., emission probabilities), resulting in weak emission intensities that make them difficult to detect.

This difficulty is highlighted in Figure 1. In this figure, "relative ease" is defined as the combination of g-factor and instrument sensitivity for the strongest emission line within the wavelength range that can be observed by MESSENGER, normalized to Na (note that seasonal variations due to changing levels of solar radiation are not included). Calcium is less abundant than Na and Mg in Mercury's exosphere [5-7], but the larger relative ease has led to routine detection. The similarly large relative ease for Ca^+ was likely a contributor to its detection during the third MESSENGER flyby of Mercury [7], and H has been detected [1,5] despite its small ease owing to its large abundance. Most of the remaining species are less easy to detect, but the advantage of an orbital mission is that a substantial amount of time can be devoted to searches for these species.

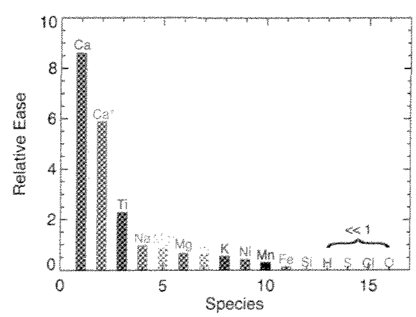

Figure 1: "Relative ease" of detection for species known or expected in Mercury's exosphere.

2. Observations

The Ultraviolet and Visible Spectrometer (UVVS) channel of the Mercury Atmospheric and Surface Composition Spectrometer (MASCS) [8] on MESSENGER is the workhorse instrument for observations of exospheric emission, and its wavelength range encompasses lines from all of the species listed above, examples of which are listed in Table 1. The UVVS regularly observes these and other lines during the MESSENGER orbital phase, allowing various regions of the exosphere to be probed for relatively long periods of time. Although K has been previously detected, it is included in the table because the UVVS wavelength range does not include the stronger resonance lines at 766.5 and 769.9 nm that are observed from Earth.

Table 1: Emission lines of potential exospheric species observed by the MESSENGER UVVS

Species	Vacuum Wavelength (nm)
O	130.2, 130.5, 130.6
Cl	133.6
S	180.7, 182.0, 182.6
Si	250.8, 251.5, 251.7, 252.0, 252.5, 252.9
Mn	279.6, 279.9, 280.2, 403.2, 403.4, 403.6
Mg^+	279.6, 280.4
OH	308-310
Fe	252.4, 372.1, 373.8, 374.7, 374.9
Al	394.5, 396.2
Ti	395.0, 395.7, 395.9
K	404.5, 404.8

3. Summary and Conclusions

Although early in the orbital phase of the mission, no obvious signatures of the listed species have been observed in Mercury's exosphere by the UVVS as of this writing. It is possible that detections are elusive because the optimum regions of the exosphere have not been sampled. The Sun-avoidance constraints on MESSENGER place tight limits on the instrument boresight, and some regions are probed less frequently. If there are strong spatial gradients in the distribution of these species, such as has been observed in the dawn-dusk asymmetry in Ca [5-7], a greater sampling of specific regions of the exosphere may be needed in order to observe emission. Summing spectra over time will also aid in the ability to detect weaker emission.

After a full Mercury solar day, substantial time will have been devoted to additional observations, enhancing the probability that some additional species may have been detected. At the very least, strong upper limits on the abundances of these species in the exosphere will be determined as functions of time and space, to the extent that the observations allow for such detail. A failure to detect these species after sufficient time can provide insight into the surface composition and the potential source mechanisms of exospheric material.

Acknowledgements

The MESSENGER project is supported by the NASA Discovery Program under contracts NAS5-97271 to The Johns Hopkins University Applied Physics Laboratory and NASW-00002 to the Carnegie Institution of Washington. RJV, RMK, and ALS are supported by the MESSENGER Participating Scientist Program.

References

[1] Broadfoot, L.A., Kumar, S., Belton, M.J.S., and McElroy, M.B.: Mercury's atmosphere from Mariner 10, Science, 185, 166-169, 1974.

[2] Potter, A.E., and Morgan, T.H.: Discovery of sodium in the atmosphere of Mercury, Science, 229, 651-653, 1985.

[3] Potter, A.E., and Morgan, T.H.: Potassium in the atmosphere of Mercury, Icarus, 67, 336-340, 1986.

[4] Bida T.A., Killen, R.M., and Morgan, T.H.: Discovery of calcium in Mercury's atmosphere, Nature, 404, 159-161, 2000.

[5] McClintock, W.E., et al.: Mercury's exosphere: Observations during MESSENGER's first Mercury flyby, Science, 321, 92-94, 2008.

[6] McClintock, W.E., et al.: MESSENGER observations of Mercury's exosphere: Detection of magnesium and distribution of constituents, Science, 324, 610-613, 2009.

[7] Vervack, R.J., Jr., et al.: Mercury's complex exosphere: Results from MESSENGER's third flyby, Science, 329,. 672-675, 2010.

[8] McClintock, W.E., and Lankton, M.R.: The Mercury Atmospheric and Surface Composition Spectrometer for the MESSENGER mission, Space Sci. Rev., 131, 481-521, 2007.