MERCURY'S EXOSPHERE: CURRENT UNDERSTANDING AND CONUNDRUMS. R. M. Killen[1] and R. J. Vervack, Jr.[2], [1]NASA Goddard Space Flight Center, 8800 Greenbelt Road, Greenbelt MD 20771 USA (rosemary.killen@nasa.gov), [2]Johns Hopkins Univ. Applied Physics Lab., 11100 Johns Hopkins Rd., Laurel MD 20723 (ron.vervack@jhuapl.edu).

Introduction: Mercury's exosphere has been studied for the past 45 years following the ground-breaking Mariner 10 mission that discovered H and He [1]. Decades of ground-based spectroscopic studies and the more recent MESSENGER mission have revealed the additional presence of Na, K, Mg, Ca, Al, Fe, and Mn in Mercury's exosphere. Extensive temporal and spatial studies of the species Na, K, and Ca have been performed using ground-based telescopes [2]. During its four years in orbit, the MESSENGER Ultraviolet and Visible Spectrometer (UVVS) regularly observed Na, Mg, Ca, and H, primarily but not exclusively with line-of-sight radial sweeps tangent to the near-equatorial surface and back-and-forth sweeps perpendicular to the Sun-Mercury line in the nightside tail region [3]. During the last few Mercury orbits of MESSENGER, Al, Mn, and Ca^+ were observed by UVVS [4]. Finally, Al and Fe have been observed using the Keck telescope on Mauna Kea [5].

Although MESSENGER provided an unprecedented view Mercury's exosphere, there is much that is not understood, particularly in terms of the physical processes that generate and maintain the exosphere. Furthermore, there are apparent discrepancies between the ground-based observations and those by UVVS that need to be explained. We present several examples of the conundrums that exist with respect to Mercury's exosphere.

Example 1. The Ca exosphere was initially reported to be of high temperature, roughly 20,000 K, from ground-based data [6]. UVVS observations confirmed this high temperature, with values up to 70,000 K reported [7]. These temperatures are not only very large compared with the temperatures found for the other species but their origin, while speculated [8], is not fully understood.

Example 2. A puzzling discrepancy may exist in the spatial distribution between ground-based observations of Ca and UVVS observations. Burger et al. [7] determined a dawn-centered source for Ca. Although this may be consistent with ground-based observations, it is not certain whether they are in fact consistent. The ground-based data imply extensive Ca in high northern and southern latitudes and anti-sunward of the planet [9]. The UVVS tail region observations were sampled primarily north-south whereas the ground-based data were obtained east-west. It remains to show that the antisunward data from both sets of observations are consistent.

Example 3. Another difference between the ground-based and space-based observations is seen in the Na data. Ground-based data often show high-latitude peaks, either in the north or in the south or both [10]. These high-latitude peaks were not seen in the UVVS data. Although UVVS obtained some observations tangent to the south pole, it rarely made observations near the north pole due to the high northern latitude of periherm and geometry restrictions. These differences could be due to observational geometry or to the limitations inherent in both the ground and space-based techniques.

Example 4. A final conundrum concerns the apparently sporadic nature of the Al, Fe, Mn, and Ca^+, which were searched for on many occasions both from the ground and with UVVS. With the exception of one unusual Ca^+ detection by UVVS during the third flyby of Mercury, these species were only observed during the last few Mercury years of the MESSENGER mission [4] and only on a few observing runs at the Keck [5]. The reasons for the sporadic nature of these observations is unknown.

Future Work: The spatial and temporal variations in Mercury's exosphere and their sources require more investigation. In particular, high-latitude variability and its possible correlation with the magnetic cusps needs to be investigated. The reasons for sporadic variability in weakly emitting and/or less abundant species like Al should be studied. Finally the interaction of the plasma environment with the surface and exosphere, and the roles of dust, meteor streams and cometary streams in the production of exospheric species should be elucidated to provide a more complete understanding of the source processes for the exosphere.

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