OBSERVATIONS OF H LYMAN ALPHA BY THE MERCURY ATMOSPHERIC AND SURFACE COMPOSITION SPECTROMETER DURING MESSENGER'S FIRST MERCURY FLYBY AND COMPARISON TO MARINER 10 MEASUREMENTS. Ronald J. Vervack, Jr.[1], William E. McClintock[2], E. Todd Bradley[3], Noam R. Izenberg[1], Rosemary M. Killen[4], Mark C. Kochte[1], Mark R. Lankton[2], Nelly Mouawad[4], and Ann L. Sprague[5], [1]The Johns Hopkins University Applied Physics Laboratory (Ron.Vervack@jhuapl.edu); [2]LASP, University of Colorado; [3]Dept. of Physics, University of Central Florida; [4]Dept. of Astronomy, University of Maryland; [5]LPL, University of Arizona.

Introduction: One of the better measured exospheric species observed by Mariner 10's Ultraviolet Spectrometer (UVS) was hydrogen through observations of the H Lyman α line at 121.6 nm [1-3]. These data revealed interesting features in the exospheric H distribution, but complete explanations for these features have remained elusive [4]. Because of the difficulties of observing H Lyman α at Mercury from Earth orbit, observations of this emission by the UltraViolet and Visible Spectrometer (UVVS) component of the Mercury Atmospheric and Surface Composition Spectrometer (MASCS) instrument [5] onboard the MESSENGER mission [6] represent the first chance in over thirty years to revisit the H exosphere of Mercury and will greatly enhance our understanding of the exospheric H distribution.

Mariner 10 Observations: The Mariner 10 observations of H Lyman α were made by the airglow experiment instrument [1-3]. This was an objective grating spectrometer that used channel electron multipliers at fixed positions in the image plane to measure airglow at preselected wavelengths corresponding to the resonance transitions of ionized and neutral species predicted to be in Mercury's exosphere, including the H Lyman α line at 121.6 nm [7]. Each airglow emission was measured over a 2-nm bandwidth and a field of view of $0.13° \times 3.6°$ [1].

Three observational modes were employed: 1) slow slews across the disk and limb utilizing the spacecraft scan platform; 2) fixed stares to build up signal-to-noise levels; and 3) drifts across the limbs resulting from spacecraft motion [1]. The best observations of H Lyman α from Mariner 10 come from the first and third modes and provide what we know about the H distribution in Mercury's exosphere [1-4,8]. The Mariner 10 observations of H Lyman α are summarized in Figures 1 and 2, which show the H Lyman α emission above the subsolar point determined from Mercury encounters I (29 March 1974) and III (16 March 1975) [2,8].

The two most remarkable features of the H distribution in Mercury's exosphere are seen in Figure 2. The first is the two-component nature of the distribution, and the second is the "bump" near 200 km. While the "bump" feature remains a complete mystery but could possibly be an unexplained artifact [4,8], the two-component nature has been ascribed to a "cold" population of H atoms near the surface (~110 K) and a "warm" population at higher altitudes (~420 K) [4,8]. The "warm" component is likely thermally coupled to the surface near the subsolar point, but because the temperature is roughly 420 K – about 40% less than the

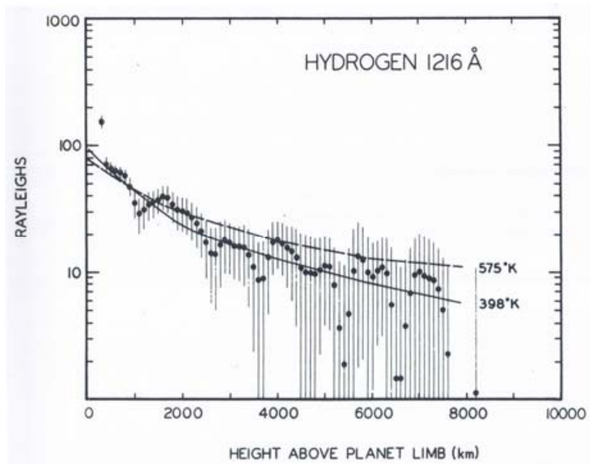

Figure 1. Observations of H Lyman α well above the subsolar point during the first Mercury encounter by Mariner 10. This high-altitude distribution is best fit by a temperature of 420 K. [Figure from 2].

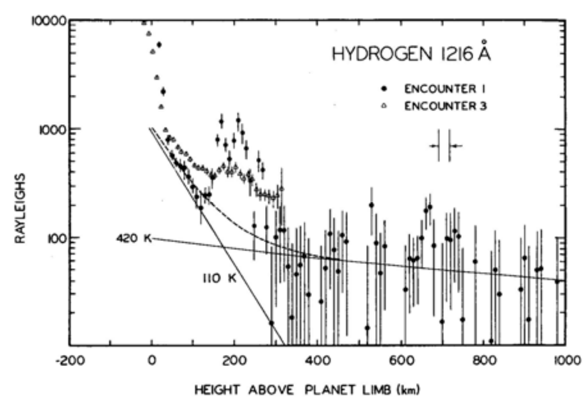

Figure 2. Observations of H Lyman α above the subsolar point during the first and third Mariner 10 Mercury encounters. The "cold" and "warm" two-component nature of the distribution is evident as is the mysterious "bump" near 200 km. [Figure from 4].

local surface temperature – it may be representative of a dayside average rather than the local temperature [4]. The "cold" temperature component, on the other hand, is characteristic of the nightside temperature and suggests that this population originates there. However, if so, the atoms would have to survive a large number of collisions with an increasingly warmer surface to get from the nightside to the dayside without gaining energy. Attempts to demonstrate a potential have considered selective thermal escape of faster atoms [4] and possibly a low accommodation coefficient [8], but a nightside source for the "cold" population of atoms has never been viably demonstrated, primarily owing to a lack of data [4]. Given that the "cold" population has a density roughly an order of magnitude larger than the "warm" population (230 versus 23 cm^{-3}), the true origin of the two-component nature of the H distribution is one of the biggest open questions in understanding Mercury's exosphere.

MESSENGER Observations: The workhorse on MESSENGER for measuring the distribution of species in Mercury's exosphere is the UVVS component of the MASCS instrument. 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). The UVVS has a long-slit entrance aperture that subtends 0.04° × 1° for atmospheric observations and possesses a mechanism to reduce the aperture to 0.04° × 0.05° for surface observations. The resolution varies with the wavelength but is approximately 0.2 nm at H Lyman α [5]. The smaller field of view and higher resolution of UVVS compared with the Mariner 10 UVS will yield excellent observations of the H Lyman α emission at Mercury on both spatial and spectral scales.

The trajectory of MESSENGER during the first Mercury flyby and the observations by MASCS/UVVS are shown in Figure 3. Of particular note are the observations in the time period MSCM4, which represents the dayside exosphere observations on the outbound leg. The geometry of the UVVS observations during this time closely parallels that of the Mariner 10 UVS observations, allowing a fairly direct comparison of the two sets of observations.

The UVVS observations of H Lyman α enable an investigation into the important, outstanding questions that remain post-Mariner 10: "What is the detailed nature of the two-component distribution of H in the exosphere?" and "Does the 'bump' near 200 km exist, and if so, what is its origin?" The UVVS data are compared and contrasted with the Mariner 10 data to address these questions while at the same time revealing the changes that have occurred over the intervening thirty-three years. Of particular importance in this investigation will be inclusion of UVVS observations of H Lyman α in the tail region [9] as well as placing the H Lyman α observations in the context of other exospheric species such as Na observed by UVVS [10,11]. These additional data provide a distinct advantage over the Mariner 10 measurements, which had to be analyzed without the benefit of supporting observations.

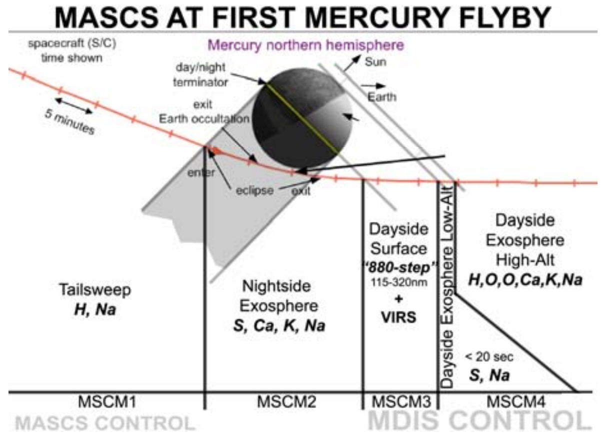

Figure 3. Illustration of the MASCS/UVVS observations during MESSENGER's first Mercury flyby.

The UVVS data are the first of their kind in over thirty years and, while they will shed much light on the H distribution, they represent only our first glimpse at this aspect of the complicated Mercury exospheric system. A full understanding of the exosphere, and of the H Lyman α emission in particular, requires many observations spanning a variety of observing conditions such as will be provided by UVVS during MESSENGER's second and third Mercury flybys and, most importantly, the orbital phase of the mission.

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