FIRST ION PLASMA MEASUREMENTS IN THE MERCURY MAGNETOSPHERE. T. H. Zurbuchen[1], J. M. Raines[1], G. Gloeckler[1], K. Kabin[2], S. M. Krimigis[3], G. B. Andrews[3], J. A. Slavin[4], P. L. Koehn[1,5], and the MESSENGER Team, [1]Department of Atmospheric, Oceanic and Space Sciences, University of Michigan, 2455 Hayward St., Ann Arbor, MI 48109-2143, USA, thomasz@umich.edu, jraines@umich.edu, gglo@umich.edu; [2]Department of Physics, University of Alberta, 3-57G Civil Electrical Bldg., Edmonton, AB T6G 2G7 Canada, kabin@ualberta.ca; [3]Johns Hopkins University Applied Physics Laboratory, 11100 Johns Hopkins Rd., Laurel, MD 20723, USA, tom.krimigis@jhuapl.edu, Bruce.Andrews@jhuapl.edu; [4]Code 670 NASA Goddard Space Flight Center, Greenbelt, MD 20771 USA, James.A.Slavin@nasa.gov; [5]Department of Physics and Astronomy, Eastern Michigan University, 303 Strong Hall, Ypsilanti, MI 48197 USA, pkoehn@emich.edu

Introduction: The MESSENGER mission to Mercury offers the first opportunity for direct measurements of low-energy ions in Mercury's magnetosphere. We present observations of the Fast Imaging Plasma Spectrometer (FIPS), which is part of the Energetic Particle and Plasma Spectrometer (EPPS) instrument [1,2]. These first observations will characterize Mercury's heliospheric environment, its magnetosphere, and, potentially, pick-up ion components originating from surface sputtering and atmospheric processes [3]. We put these observations in the context of predictions of Mercury's exosphere based on magneto-hydrodynamic (MHD) and other models [4,5].

The Observations: Planet Mercury, with the smallest magnetosphere in the solar system, was visited three times in 1974-75 by Mariner 10. Surprisingly, the observations yielded irrefutable evidence for an internal magnetic field and for magnetospheric activity that was discovered using magnetic field and high-energy particle measurements [6]. Despite the richness of the Mariner results no ion plasma measurements were then available. Thus, the FIPS measurements are expected to provide novel and unprecedented contributions to many of the scientific discussions that have been ongoing for over 30 years. FIPS measures ions from <50 eV/e to 14 keV/e with a time resolution of up to 8 s. During a measurement interval, FIPS detects individual ions within a mass range of 1-40 amu that enter its unique, 1.4-π-sr field of view. These observations occur during the entire Mercury encounter, starting within Mercury's heliospheric environment at 52 Mercury radii (R_M), crossing Mercury's magnetosphere down to an altitude of 200 km, and back out to 52 R_M. Such measurements in these locations relative to Mercury have never been made before.

The Questions: Due to the small size of Mercury's magnetosphere, and due to Mercury's inner heliosphere location, there are numerous fundamental questions related to the nature of Mercury's magnetosphere and the major differences in the nature of solar wind interactions at Mercury compared with those at Earth. What are the basic properties of Mercury's plasma environment, and how are they distributed within the magnetosphere? What does the ion composition indicate about the rate of entry of solar wind into the magnetosphere and the composition of Mercury's exosphere and regolith? How does such a small magnetosphere accommodate heavy planetary ions with large gyroradii and incorporate them into its thermal plasma populations? What is the total rate of mass exchange between the planet and the magnetosphere? Are fast bulk flows (i.e., "Alfvenic jets") of hot plasma ever present in the plasma sheet as observed at Earth during substorms? Are they accompanied with reconnection signatures in the magnetic field measurements and energetic particle acceleration events?

One of the most important questions addresses the time-variability of Mercury's magnetosphere in the absence of an ionosphere. Figure 1 [adapted from 7] depicts density contours of a N-S cut through Mercury's magnetosphere during solar wind conditions measured within one day by Helios 2 at Mercury's distance.

Mercury's magnetospheric conditions are calcu-

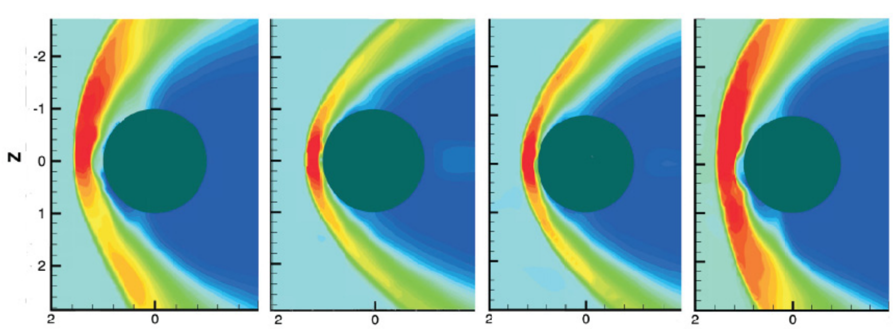

Figure 1. Temporal variability of Mercury's magnetosphere caused by solar wind changes as measured by Helios.

lated using the code described by Kabin et al. [4]. The simulations make simplifying assumptions about the interactions of the magnetosphere and the near-planetary environment. It is not clear, for example, whether the structural changes of the magnetosphere are associated with substorm activity. Even though there is an expectation that the solar wind is the source of most magnetospheric plasma, no data exist to convincingly confirm this assumption [6]. It is expected that Mercury's surface sputtering and atmospheric escape are contributors to Mercury's space environment [5]. These Mercury-derived ions can be distinguished from the solar wind source on the basis of their ionic composition, especially of the heavy ion component. From their measured incidence direction and energy, and using magnetic field measurements, the point of origin of these ions can be further constrained.

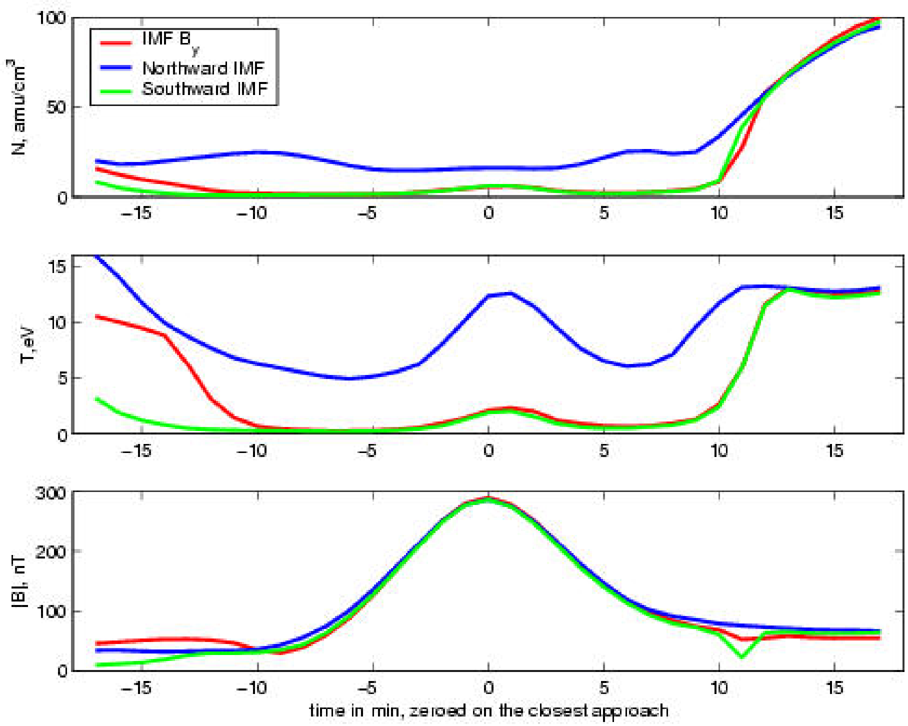

Figure 2. Model predictions for the MESSENGER's first Mercury flyby for northward, southward, and B_y IMF conditions.

Summary: Figure 2 presents the plasma density and temperature and the magnetic field strength calculated using an MHD model during stationary magnetospheric conditions for northward, southward, and pure B_y interplanetary magnetic field (IMF). The model predicts large differences in the densities and temperatures of the background cold plasma between the northward and southward (or B_y) IMF conditions. These differences can help identify the actual conditions that will occur during the flyby on January 14. The density increase seen in the model for all three IMF conditions about 10 minutes after the closest approach is associated with the spacecraft entering the magnetosheath. Note that our model does not include energetic ions and electrons, which are expected to produce additional sharp peaks along the MESSENGER trajectory. The location and intensity of these peaks depend on the magnetic field topology in the vicinity of Mercury, as well as on the nature of the energization mechanism. Thus, together with the magnetic field observations, EPPS measurements will provide important clues about the internal magnetic field of Mercury, as well as physical processes in the plasma environment of the planet.

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