ENERGETIC PARTICLE MEASUREMENTS IN MERCURY'S MAGNETOSPHERE: FIRST RESULTS FROM MESSENGER. Ralph L. McNutt, Jr.[1], George C. Ho[1], Stamatios M. Krimigis[1,2], G. Bruce Andrews[1], Daniel N. Baker[3], Robert E. Gold[1], Stefano A. Livi[4], Barry H. Mauk[1], James A. Slavin[5], Sean C. Solomon[6], and the MESSENGER Team. [1]Johns Hopkins University Applied Physics Laboratory, Laurel, MD 20723 (Ralph.McNutt@jhuapl.edu); [2]Academy of Athens, Athens 11527, Greece; [3]University of Colorado, Boulder, CO 80303; [4] Southwest Research Institute, San Antonio, TX 78228; [5]NASA Goddard Space Flight Center, Greenbelt, MD 20771; [6]Department of Terrestrial Magnetism, Carnegie Institution of Washington, Washington, DC 20015.

Introduction: Our present knowledge of Mercury's magnetosphere is derived from two nightside Mariner 10 flybys in 1974 and 1975 [1] that established the presence of an intrinsic magnetic field [2] and of some energetic particles [3] and plasma electrons [4]. Unfortunately, not even the magnetic dipole term was well-resolved, and the fluxes and identity of energetic ions have been a subject of extensive discussion and varying interpretations [5-8]. Figure 1 illustrates the ambiguities in interpreting the results from the Mariner 10 particle measurements [5]. Major issues to be resolved by MESSENGER are the various ambiguities left from the Mariner 10 energetic particle measurements [1].

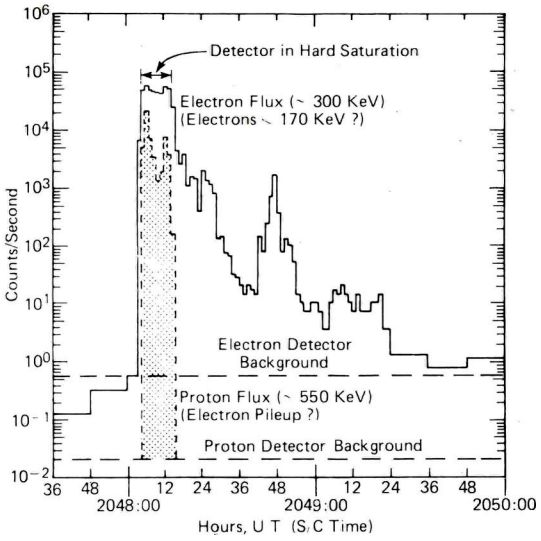

Figure 1. Energetic particle measurement from the first Mariner 10 flyby of Mercury. As shown in the figure, there is still an ongoing debate on what the particle instrument on Mariner detected. The labels "electron flux (~300 keV)" and "proton flux (~500 keV)" are those from Simpson et al. [3]. All other labels have been added by Armstrong et al. [5].

Observations: The MESSENGER mission to the planet Mercury includes a comprehensive set of advanced instruments. Launched on August 3, 2004, MESSENGER will execute the first of three flybys of Mercury on January 14, 2008 [9]. The Energetic Particle Spectrometer (EPS), one of two sensors comprising the Energetic Particle and Plasma Spectrometer (EPPS) instrument [10], is a hockey-puck-size, time-of-flight (TOF) spectrometer that measures ions and electrons over a broad range of energy and pitch angle. Spatial and angular distributions and spectra of energetic particles (if present) will be measured from ~ 15 keV/nucleon to ~ 3 MeV for ions and from ~ 15 keV to ~ 1 MeV for electrons. Time variations will be observed at intervals less than 5 seconds. The sensor resolving time (<1 ns) precludes the possibility of pulse pile-up, a principal issue [5] with the Mariner 10 instrumentation. The sensor is shown in Figure 2.

Figure 2. The EPS sensor and common EPPS electronics just prior to installation of the cover and integration with the MESSENGER spacecraft.

In coordination with the Fast Imaging Plasma Spectrometer (FIPS), another component of EPPS, and MESSENGER's Magnetometer (MAG), EPS will operate in its highest time resolution from six hours before until six hours after flyby closest approach. It is estimated that MESSENGER will transit through Mercury's magnetosphere in approximately 30 minutes. This 12-hour window of high-time-resolution data will be more than sufficient to sample the interplanetary environment and capture the different

regions of Mercury's magnetosphere. The flyby geometry is such that MESSENGER's pass through the nightside magnetosphere is very similar to the first Mariner 10 flyby, during which all of the prior Mercury energetic particle measurements were made. We anticipate that EPS will measure both energetic ions and electrons during the flyby. Figure 3 shows a possible Earth-like substorm particle acceleration mechanism that can also operate in Mercury's magnetotail.

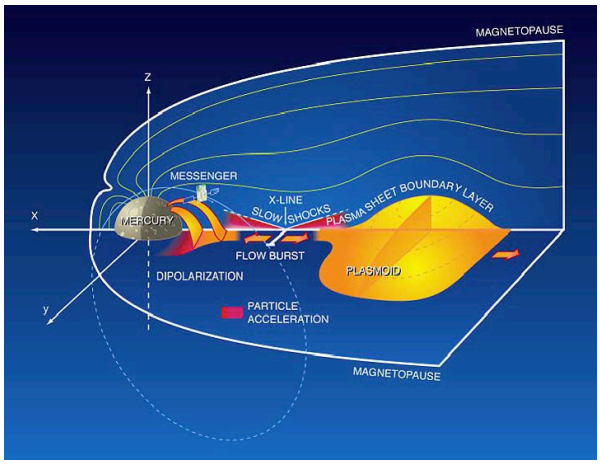

Figure 3. Schematic depiction of a reconnection-driven substorm within Mercury's magetosphere [11]. The MESSENGER orbit during the orbital phase of the mission is also shown in dashed line.

Principal Science Issues: EPS measurements will address a variety of science questions at Mercury [1]: (a) The nature of charged particle acceleration mechanisms; (b) the scale of magnetospheric boundaries describing the envelope of the solar wind flow; (c) the search for evidence on possible signatures of field-aligned currents; (d) the nature of acceleration during magnetospheric substorms; (e) potential diamagnetic effects in the external magnetic field. Answers to these and other questions, together with measurements from MAG and FIPS, will enable determination of the properties and total particle energy content, the potential of Mercury's magnetic field to trap an important part of a heated population for significant periods, and the self-consistent separation of the magnetospheric contribution of the magnetic field from the internal, planet-produced field.

References: [1] Slavin J. A. et al. (2007) *Space Sci. Rev., 131,* 133–160. [2] Ness N. F. et al. (1974) *Science, 185*, 151-160. [3] Simpson J. A. et al. (1974) *Science, 185*, 160-166. [4] Ogilvie K. W. et al. (1974) *Science, 185*, 146-152. [5] Armstrong T. P. et al. (1975) *JGR*, *80*, 4015-4017. [6] Christon S P (1989) *JGR, 94*, 6481- 6505. [7] Baker D. N. et al. (1986) *JGR, 91*, 8742-8748. [8] Eraker J. H. and Simpson J. A. (1986) *JGR, 91*, 9973-9993. [9] Solomon S. C. et al. (2007) *Space Sci. Rev., 131,* 3-39. [10] Andrews G. B. et al. (2007) *Space Sci. Rev., 131*, 523–556. [11] Slavin J. A. (2004) *Space Sci. Rev*., *33*, 1587-1872.

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