The Neutron Spectrometer (NS)

1. Instrument Overview

The Mercury Surface, Space ENvironment, GEochemistry, and Ranging (MESSENGER) mission was designed to orbit Mercury following one Earth flyby, two of Venus, and three of Mercury. It launched in August 2004 and achieved orbit insertion around Mercury on 18 March 2011. Initial data collection began during the three flybys of Mercury and consisted primarily of global mapping and measurements of the surface, atmosphere, and magnetosphere composition. The nominal one-Earth-year long mission ended on 17 March 2012. This was immediately followed by the start of a one-year-long extended mission. A second and final two-year-long second extended mission ended on 30 April, 2015, when the MESSENGER spacecraft impacted the surface as expected. MESSENGER orbital observations provide data to answer questions about the nature and composition of Mercury's crust, tectonic history, structure of the atmosphere/magnetosphere, and the nature of the polar caps.

The Gamma-Ray and Neutron Spectrometer (GRNS) instrument forms part of the geochemistry investigation of the MESSENGER mission. The GRNS package is composed of two independent sensors: the Gamma-Ray Spectrometer (GRS) and the Neutron Spectrometer (NS). GRS detects gamma-ray emissions in the 0.1 - 10 MeV range, allowing the identification of certain elements and their abundances to be determined. NS measures the flux of ejected neutrons in three energy ranges and is particularly sensitive to the H content of a body. Taken together, the gamma-ray and neutron measurements are used to infer the composition of Mercury's surface over localized regions using established techniques, such as used recently on the Lunar Prospector and Mars Odyssey missions.

The NS sensor consists of three scintillators, each wrapped separately and coupled to separate photo-multiplier tubes. The three scintillators are sensitive to neutrons of different energies: thermal neutrons (0.025 - 1 eV), epithermal neutrons (1 eV - 500 keV), and fast neutrons (500 keV - 7 MeV). The first and third scintillators are lithium (6Li)-glass scintillators (LG1 and LG2) which respond to a combination of thermal and epithermal neutrons. The middle scintillator is a borated plastic (BP) scintillator that responds only to epithermal and fast neutrons due to its electronics setup. The interaction of galactic cosmic rays (GCR) with the surface of Mercury produces neutrons, some of which escape the surface and produce a neutron signal that can be measured by the orbiting NS sensor. The measured neutron energy spectrum reflects the transport properties of the surface composition and is sensitive to depths down to about 1 m. Thermal neutrons are sensitive to a variety of elements, including Fe, Ti, Gd, Sm, Cl, and C. Epithermal neutrons are mostly sensitive to H abundance. Fast neutrons can provide a good measure of average atomic mass. For the MESSENGER mission, the NS sensor establishes and maps the abundance of H over most of the northern hemisphere of Mercury, providing significant new information regarding the potential presence of water ice within and near permanently shaded craters near the north pole.

The GRS detector is described in the document file GRS_INST.PDF. Both instruments are described in full detail in Goldsten et al., 2007.

2. References Cited

Goldsten, J.O., E.A. Rhodes,, W.V. Boynton, W.C. Feldman, D.J. Lawrence, J.I. Trombka, D.M. Smith, L.G. Evans, J. White, N.W. Madden, P.C. Berg, G.A. Murphy, R.S. Gurnee, K. Strohbehn, B.D. Williams, E.D. Schaefer, C.A. Monaco, C.P. Cork, J.D. Eckels, W.O. Miller, M.T. Burks, L.B. Hagler, S.J. Deteresa, and M.C. Witte, The MESSENGER Gamma-Ray and Neutron Spectrometer, Space Science Reviews, 131, 339-391, 2007.