The Gamma-Ray Spectrometer (GRS)

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 GRS sensor is a coaxial germanium crystal 50 mm in diameter and 50 mm in length, chosen for its superior energy resolution and the ability to anneal the detector to remove accumulated radiation damage. The detector is rigidly clamped in a hermetically sealed Al capsule pressurized with clean, dry nitrogen. The capsule is cooled to an operating temperature in the 80-95 K range by a mechanical cryocooler. A plastic scintillator anti-coincidence shield surrounds the germanium detector on its sides and back, for rejection of cosmic-ray background. Galactic cosmic rays continuously bombard the surface of Mercury, and through interactions with the surface, gamma rays of discrete energies that are characteristic of specific elements are created. A fraction of these gamma rays, as well as those from the decay of radiogenic elements, escape from the surface, where they can be detected by the orbiting GRS. Gamma-ray fluxes are measurable at altitudes up to 1000 km and for gamma rays up to about 10 MeV that emanate from depths of up to tens of centimeter beneath the surface. Detected fluxes are generally low and require numerous orbital passes over a specific region to obtain a statistically well-defined energy spectrum. The measurements of elements such as Fe, Si, Mg, Na, Al, Ca, Ti, K and Th by GRS provide insight into distinguishing between different formation models for Mercury as well as other planetary evolution issues.

The NS detector is described in the document file NS_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.