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MESSENGER observations of ULF waves in Mercury's inner magnetosphere

Scott A. Boardsen (1,2), Brian J. Anderson (3), James A. Slavin (1), Haje Korth (3), David Schriver (4), and Sean C. Solomon (5)

(1) Heliophysics Science Division, NASA Goddard Space Flight Center, Greenbelt, MD 20771, USA (scott.a.boardsen@nasa.gov/ Fax: 301-286-5348); (2) Goddard Planetary Heliophyiscs Institute, University of Maryland, Baltimore County, Baltimore, MD 21228, USA; (3) Johns Hopkins University Applied Physics Laboratory, Laurel, MD 20723, USA; (4) IGPP, UCLA, 3871 Slichter Hall, Los Angeles, CA 90095-1567, USA; (5) Carnegie Institution of Washington, Washington, DC 20015, USA.

1. Introduction

Highly coherent waves with frequencies around ~1 Hz were observed during the first [1] and second [2] nearly equatorial flybys of Mercury by the MErcury Surface, Space ENvironment, GEochemistry, and Ranging (MESSENGER) spacecraft. They were also briefly observed near the equatorial crossing during the Mariner 10 flyby in 1974 [3]. These waves are poorly understood, in part due to the limited spatial and temporal coverage of the flybys.

The polar orbit of the MESSENGER spacecraft allows mapping of these waves versus magnetic latitude and magnetic local time, and permits us to further characterize their spectral content, amplitudes, and polarization properties. This information, combined with theory, will aid in the physical interpretation of these waves, and thus in determining the role these waves play in Mercury's magnetosphere. In this paper we present examples, statistics, and our interpretation of these waves from observations during MESSENGER's first six months in orbit.

2. Wave Observations

An example of these waves recorded by the MESSENGER Magnetometer [4] is shown in Figure 1. The top and middle panels are dynamic spectra of the magnetic field parallel and perpendicular to the local magnetic field direction, respectively, and the bottom panel is the field magnitude. In the frequency-time panels, the top, middle, and bottom white lines are the local proton (f_{cH+}), He^{++}(f_{cHe++}), and He^{+} (f_{cHe+}) gyrofreqnencies, respectively. The spacecraft location in magnetic coordinates is given at the bottom. The transverse emissions are first seen at a magnetic latitude of 30º, and as the spacecraft approaches the magnetic equator the emission intensity shifts to the compressional direction as the frequency shifts toward f_{cH+}. The fundamental mode and its second harmonic are clearly visible.

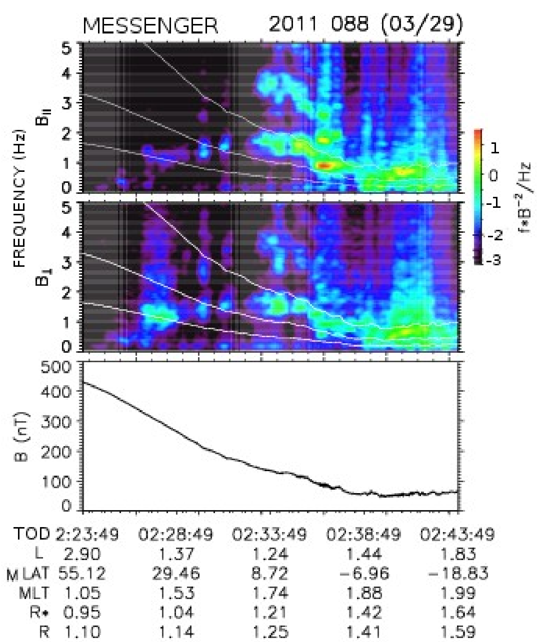

Figure 1. (Top to bottom) Dynamic spectra of the parallel and perpendicular magnetic field, along with field magnitude.

Similar, highly coherent magnetic waves at frequencies near 1 Hz are almost always observed inside Mercury's inner magnetosphere, and generally waves exhibit harmonic banded structure in dynamic spectra. The fundamental frequency lies between f_{cHe+} and f_{cH+}, and its frequency variation in time is typically smooth, often starting at f_{cHe+} at higher latitudes and rising to f_{cH+} as the spacecraft moves equatorward.

The statistical distribution of these waves with magnetic local time (MLT) through May 2, 2011, is shown in Figure 2. The black shaded region is the coverage, and the red dots indicate observations of these waves. They have been detected at all MLT values sampled so far, up to magnetic latitude 50°. The cause of the apparent north/south asymmetry is under investigation.

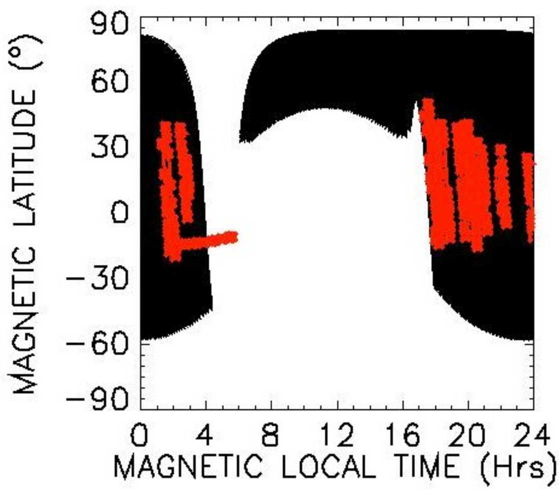

Figure 2. Distribution of events (red) laid over coverage (black), inside Mercury's magnetosphere, from April 24 to May 2, 2011. The coverage will be more complete after the first 6 months of observations.

The wave polarizations are consistent among the events observed. These waves are almost always strongly linearly polarized, with very few examples of circular polarization. Their wave amplitude tends to maximize near the magnetic equator, where they tend to be strongly compressional. At their largest observed extent in magnetic latitude, the polarization tends to be linear and transverse to the background magnetic field.

3. Implications

In the region of closed magnetic field at Mercury, the loss cone is large (> 30°), leading to notable temperature anisotropy and corresponding free energy in the ion distributions. It is likely that the anisotropy plays a role in exciting the waves and also that the waves contribute to scattering of ions into this loss cone, promoting precipitation to the planetary surface. Since these waves most likely occur on closed field lines, their occurrence could be used as an indicator of regions with closed magnetic field topology.

To understand the wave generation mechanism, mode structure, and their implications for plasma dynamics and magnetic topology signatures, the observed distribution of the waves and their associated frequencies, amplitudes, and polarization properties are being carefully examined in the light of plasma theory and wave-wave coupling processes in the Mercury system.

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References

[1] Boardsen, S. A., et al., Narrow-band ultra-low-frequency wave observations by MESSENGER during its January 2008 flyby through Mercury's magnetosphere, Geophys. Res. Lett., 36, L01104, doi: 101029/2008GL036034, 2009.

[2] Boardsen, S. A., et al., Comparison of ultra-low-frequency waves at Mercury under northward and southward IMF, Geophys. Res. Lett., 36, L18106, doi: 10.1029/2009GL03952, 2009.

[3] Russell, C. T., ULF waves in the Mercury magnetosphere, Geophys. Res. Lett., 16, 1253–1256, 1989.

[4] Anderson, B. J., et al., The Magnetometer instrument on MESSENGER, Space Sci. Rev., 131, 417–450, doi: 10.1007/s11214-007-9246-7, 2007.