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A Statistical Study of Wave Activity in the Hermian Magnetosphere.

M. K. James, E. J. Bunce, T. K. Yeoman and S. M. Imber
Radio and Space Plasma Physics Group, University of Leicester, UK (mkj13@le.ac.uk)

Abstract

A statistical study of wave activity within the Hermian magnetosphere is undertaken using data obtained from the MESSENGER mission between March 2011 and March 2014. Wave activity is categorised by its predominant polarisation - allowing for the comparison between compressional wave events and those more Alfvénic in nature. The position of the spacecraft at the time of each spectrum is mapped both to the magnetic equatorial plane, and the planetary surface at Mercury in order to determine the location of each wave event within the magnetosphere.

1. Introduction

Wave activity is commonly observed within Mercury's magnetosphere (e.g. [1, 2]) using magnetic field data. Small amplitude, narrow bandwidth ULF waves observed by Mariner 10 in 1974 were suggested to be caused by a resonant interaction, driving standing waves on field lines possibly anchored to the planet's core [1]. As the wave frequencies often lie between the gyrofrequencies of protons and sodium ions, an alternative explanation for this wave activity is a hybrid resonance in a plasma with more than one significant component species (e.g. [3, 4]).

A recent survey of ULF waves at Mercury [2] searched MESSENGER magnetometer data between March 2011 and September 2011 for wave activity in the inner magnetosphere. This study observed maximum wave power near the equator of Mercury, suggesting a that the source of some of the wave activity observed lies in the equatorial plane. Polarisation analysis of these waves found evidence for ion cyclotron waves, compressional events and possible field line resonances.

This study performs a search for ULF wave activity in the MESSENGER magnetometer data between March 2011 and March 2014 with the aim of characterising wave activity in different regions of the magnetosphere, elucidating the source mechanisms responsible and examining the properties of the plasma in the vicinity of the waves.

2. Data Analysis

The parallel, $\mathbf{B}_{||}$, and radial, $\mathbf{B}_r$, components of the magnetic field were combined to form an overall compressional component, for direct comparison with the azimuthal, $\mathbf{B}_\phi$, component associated with Alfvénic wave activity. Fourier analysis was performed on both components using a 60 s sliding window where a peak detection algorithm searched for waves present in the data. A ratio, R, is defined by comparing the Fourier power of the two components, where $0 \leq R < 1$ indicates a compressionally dominant wave and $R > 1$ is azimuthally dominant.

3. Results

Wave activity has been traced to the magnetic equatorial plane at Mercury using the paraboloid field model [5] in order to help determine types of wave activity dominating in different regions of the magnetosphere. Figure 1 shows the occurrence rate of the azimuthally dominant wave events in the $X - Y$ MSM plane. The occurrence rate of azimuthally dominant waves is highest on the flanks of the magnetosphere near dawn and dusk. A possible explanation for these wave populations is in toroidal field line resonances, potentially driven by Kelvin-Helmholtz waves on the magnetopause.

The position of the spacecraft at the time of each spectrum has been mapped onto a 1 R_M sphere centred on the magnetic dipole at Mercury using the paraboloid model [5]. Figure 2 shows the standard deviation in the frequencies observed at each bin in magnetic latitude and MLT. A region of decreased standard deviation surrounded by an increase in frequency variation on the night-side of the planet may be indicative of the location of the polar cap at Mercury. This increase in variation is likely a result of dynamics of the polar cap at Mercury - each time a spectrum is traced

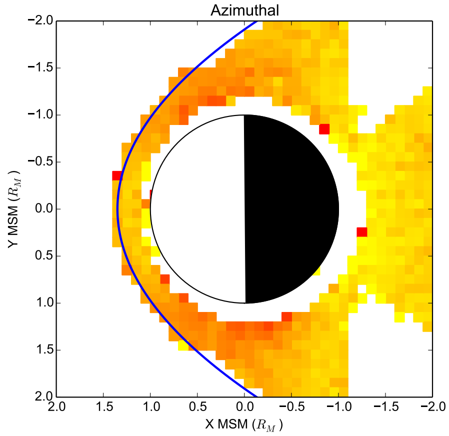

Figure 1: Occurrence rate of azimuthally oscillating waves traced to the equatorial plane.

to one of these highly variable locations, it may be in a different regime to the previous occurrence.

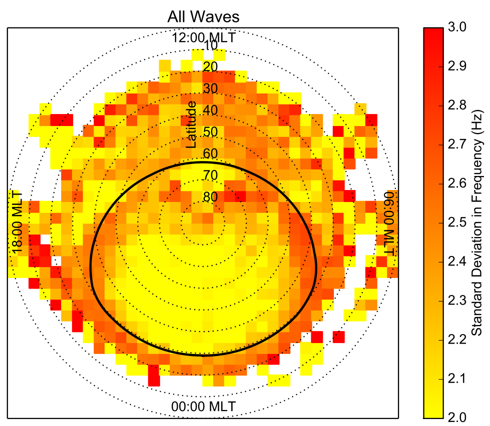

Figure 2: Standard deviation in wave frequency at the field line footprints, projected onto a 1 R_M sphere centred on the magnetic dipole, oriented such that noon is at the top and dawn to the right. The polar cap boundary found using the paraboloid field model is shown in black for comparison.

Figure 3 shows the occurrence rate of spectral peaks at various frequencies and magnetic field strengths. Between 50 and 150 nT, wave activity is commonly close the the proton cyclotron frequency (in green), suggesting that the source of many of the waves found could be related to local cyclotron resonances. Above 150 nT the activity is diverted from the proton gyrofrequency, suggesting that a different mechanism is responsible for wave generation closer to the planet.

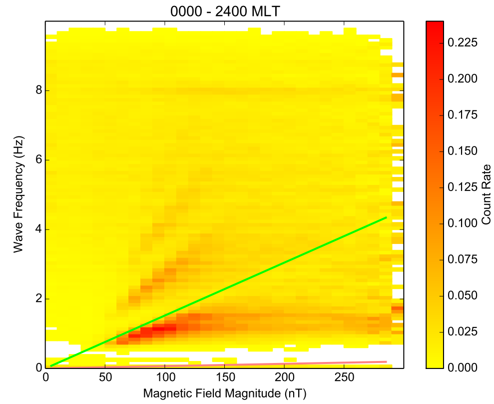

Figure 3: Occurrence rate of spectral peaks in different magnetic field strengths. Proton and sodium ion gyrofrequencies are shown in green and pink respectively.

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References

[1] Russell, C. T. (1989), Ulf waves in the mercury magnetosphere, *Geophys. Res. Lett.*, *16*(11), 1253–1256, doi:10.1029/GL016i011p01253.

[2] Boardsen, S. A., J. A. Slavin, B. J. Anderson, H. Korth, D. Schriver, and S. C. Solomon (2012), Survey of coherent 1 hz waves in mercury's inner magnetosphere from messenger observations, *J. Geophys. Res.*, *117*(A12), doi:10.1029/2012JA017822.

[3] Othmer, C., K.-H. Glassmeier, and R. Cramm (1999), Concerning field line resonances in mercury's magnetosphere, *J. Geophys. Res.*, *104*(A5),10,369–10,378, doi:10.1029/1999JA900009.

[4] Klimushkin, D. Y., P. N. Mager, and K.-H. Glassmeier (2006), Axisymmetric Alfvén resonances in a multi-component plasma at finite ion gyrofrequency, *Ann. Geophys.*, *24*(3), 1077–1084, doi:10.5194/angeo-24-1077-2006.

[5] Alexeev, I. I. and Belenkaya, E. S. and Yu. Bobrovnikov, S. and Slavin, J. A. and Sarantos, M. (2008), Paraboloid model of Mercury's magnetosphere, *J. Geophys. Res.*, *113*A12,2156–2202,doi:10.1029/2008JA013368