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Wavelet analysis of low frequency plasma oscillations in the magnetosheath of Mars

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Abstract

Wavelet analysis was employed to identify the major frequencies present in the Martian magnetosheath. The Morlet wavelet transform was selected and applied to the density and temperature data, obtained from the Analyzer of Space Plasmas and Energetic Atoms experiment (ASPERA-3), onboard the Mars Express (MEX). From a preliminary study of 836 magnetosheath crossings, observed in the years of 2005 and 2006, we have found 2357 periods with enhanced power between 5 and 60 mHz for the electron density data. The principal frequencies observed were in the range 5-20 mHz, where we found about 60 % of the frequencies identified. For electron temperature data, we have found about 57.5% of the periods with enhanced power were in the same range as for the density. This is an ongoing work which is part of a PhD Thesis which aims to study all the electron density and temperature data in the Mars magnetosheath during the MEX interval (2004-2015).

1. Introduction

Mars does not currently have an intrinsic magnetic field, the interaction between the solar wind and the Mars environment occurs directly with the upper atmosphere and ionosphere of the planet. Thus its magnetosphere is an induced one [1, 2, 3].

Magnetosheath of unmagnetized planets have an addition of a new population of planetary ions to their hydrogen magnetoplasma, which drastically alters the dispersion of hydromagnetic waves and can produce new types of MHD (Magnetohydrodynamics) discontinuities in the transition region [4].

The study of wave propagation is very important due to the fact that they have an important role in the energy and momentum transfer between the solar wind and the Mars magnetosphere. Consequently, these waves are related to the processes of atmospheric loss at Mars via interaction with the solar wind. Knowing the importance to study fluctuations in Mars magnetosheath, the aim of this work is to determine the major periods of low frequency plasma oscillations in the Mars magnetosheath.

2. Data and methodology

In order to perform this work, we have used data from electron density and electron temperature from ELS/ASPERA3/MEX (Electron Spectrometer/ Analyzer of Space Plasma and Energetic Atoms Experiment/ Mars Express). Figure 1 shows an example of a MEX orbit plot, showing the interval where MEX crosses the magnetosheath.

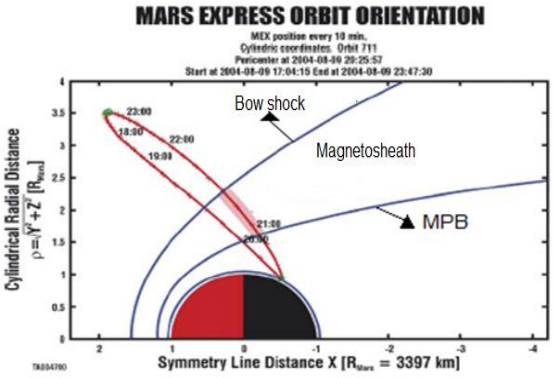

Figure 1: Mars Express orbit on August 9, 2004[5].

The Wavelet Transform (WT) was applied on the data set studied in this work. The Morlet wavelet was used here, since this wavelet has good location in frequency, which is the aim in this work. Then, the

Global Wavelet Spectrum (GWS) was used in order to identify the major periods (most energetic) in each magnetosheath crossing [6].

3. Preliminary results

Figure 2 shows an example of the WT results applied to the electron density for the interval wherein the MEX crossed the Mars magnetosheath, between 15:49 UT and 16:12 UT on March 21, 2006. In Figure 2-c) we note the presence of four main periods: 0.43 min (39 mHz), 0.73 min (22 mHz), 1.36 min (12 mHz) and 3.26 minutes (5 mHz), approximately.

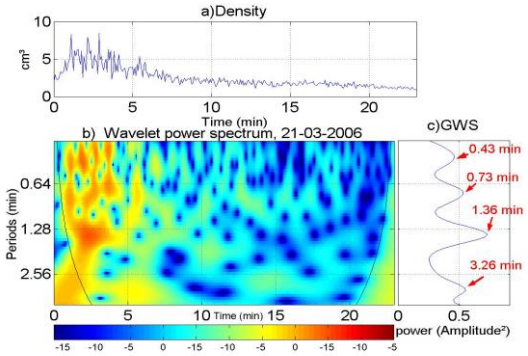

Figure 2: Panel a) electron density **Erro! Fonte de referência não encontrada.**data. Panel b) Wavelet spectrum. c) Global Wavelet Spectrum. Magnetosheath crossing of 21 march 2006.

A total of 836 magnetosheath crossings that occurred between the years 2005 and 2006 were analysed in this preliminary study. After we have applied the WT in these 836 magnetosheath crossings, 2357 frequencies with enhanced power between 5mHz and 60 mHz were identified, which were divided into different ranges in order to conduct a statistical analysis. The principal frequencies observed were in the range 5-20 mHz with 59.73 % of the 2357 frequencies identified. For temperature data, 2556 periods were found where the principal frequencies were in the same range as for the density, with 57.43% of the periods identified.

Summary and Conclusions

In this work, we intend to find the main frequencies of plasma oscillations using electron density and electron temperature in the Martian magnetosheath. From a preliminary study, we found that the main frequencies observed in electron density were in the range 5 mHz − 20 mHz with 59.73% of the 2357 frequencies identified. The same range was found for the electron temperature.

This work intends to study the full interval of MEX observations in order to identify the major low frequency plasma oscillations in Martian magnetosheath. Further, we will look for events where there is wave penetration from the magnetosheath through the ionopause.

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