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MHD instabilities at the Mercury's magnetopause

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Abstract

Based on a flexible numerical incompressible magnetohydrodynamic (MHD) approach implemented for studying a coupled Kelvin-Helmholtz (KH) and tearing mode (TM) instabilities [1], we investigate the applicability of this mixing-boundary-layer MHD approach to the Mercury's magnetopause and by means of numerical simulations perform parameters study using the MESSENGER data [2].

We report results from numerical simulations of the coupled Kelvin-Helmholtz (KH) and tearing mode (TM) instability on the dayside magnetopause layer. Numerical tests with different sets of dimensionless input parameters are performed. The computational domain in this context is taken to lie on the equatorial magnetopause region.

Introduction

How the transport of momentum and plasma occurs across a boundary remains a question of outstanding scientific interest. Kelvin-Helmholtz (KH) waves and magnetic reconnection are believed to be the key drivers of plasma transport and planetary magnetospheres are excellent laboratories to investigate them. The ESA/JAXA BepiColombo mission will be launched in October 2018 and among its scientific objectives is the investigation of the physical conditions in which magnetic reconnection occurs. In the phase of preparation of the BepiColombo data, we take advantage of two datasets of MESSANGER data and use them to study numerically the development of MHD instabilities that can imply magnetic reconnection phenomena at Mercury's magnetopause.

1. The Model

The model, used to describe the flow dynamics of the magnetopause mixing layer in a fluid limit, is earlier proposed by [1]. The simulation domain consists of a rectangular region in (x,z)-plane, which is defined on locally introduced Cartesian grid, neglecting the realistic curvature, with co- ordinate x pointing direction along the velocity of the incident magnetosheath flow; z is in the direction downward to the Mercury's center (from the magnetosheath to the magnetosphere) and y-direction is ensuring a right-handed coordinate system. The governing MHD equations are for incompressible, viscous, electrically-conductive fluid with the following restriction: the derivatives of all the parameters along y-direction are assumed to be zero.

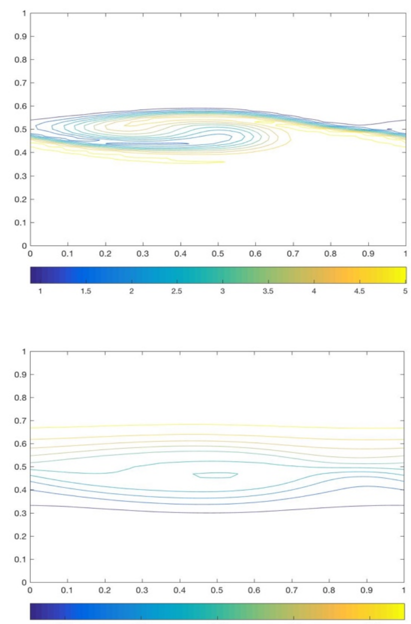

Figure 1. KH and TM instabilities of density (top) and B_y **(bottom)** in the case of high-shear

magnetopause reconnect, 24 November 2011, based on the MESSENGER data [2].

2. Results and conclusions

A full 3D MHD system of equations for incompressible and conducting fluid is reduced only by neglecting the partial derivatives in one direction. Two MESSENGER data case studies were simulated by means of numerical modelling of coupled Kelvin-Helmholtz (KH) and tearing mode (TM) instabilities at the dayside Mercury magnetopause mixing layer.

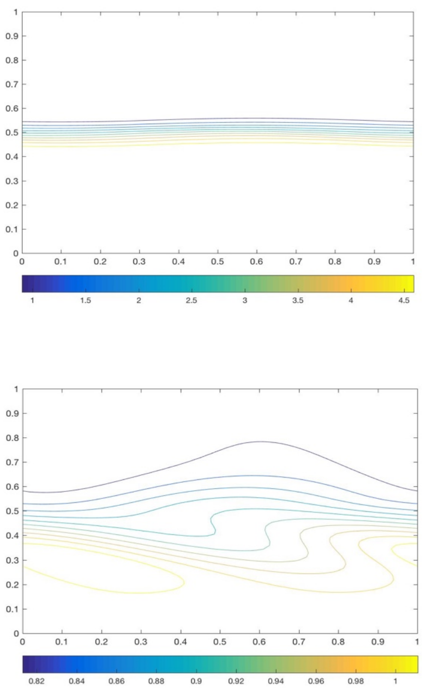

Figure 2. Density (top) and B_x **(**bottom**)** in the case of low-shear magnetopause reconnect, 21 November 2011, based on the MESSENGER data [2].

We were only focused on investigating the observed magnetic reconnection in terms of developed instability configurations: the high shear magnetic reconnection was clearly evidenced in the time evolution of the simulated MHD instabilities. In the case of high-shear magnetopause reconnect, i.e. on 24 November 2011, we obtained the typical vortex features that exhibit magnetic reconnection in the developed KH and TM instabilities (Figure 1). While in the case of low-shear magnetopause reconnection, i. e. 21 November 2011, we obtained no manifestation of magnetic reconnection (Figure 2).

Acknowledgements

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References

[1] Ivanovski et al. 2011, JTAM, vol. 41, No. 3, pp. 31–42.
[2] DiBraccio et al. 2013, JGR, 118, 997-1008