A numerical study of low frequency wave in Hall MHD reconnection with various plasma β

Y. Li (1), S.P. Jin (1), H.A. Yang (1), G.C. Zhou (2) and S.L. Liu (1)

(1) School of Earth and Space Sciences, University of Science and Technology of China, Hefei 230026, (2) Center for Space Science and Applied Research, Chinese Academy of Science, Beijing, 100080 (lyii@mail.ustc.edu.cn / Phone: +86 551 3607227)

Magnetic reconnection with various plasma β (the ratio of plasma pressure to the magnetic pressure) is studied using a 2.5 dimensional Hall magnetohydrodynamics (MHD) code developed from a multi-step implicit scheme. The initial state of the Hall MHD simulation is an equilibrium Harris sheet with a zero guide field (i.e.B_{y0}=0 at t=0). Driven by a constant boundary inflow a quasi–steady fast reconnection occurs in the plasma with a low uniform resistivity. The reconnection rate $\partial A/\partial t|_{st}$ in the quasi–steady state is in the range of 0.15$> \partial A/\partial t|_{st} >$0.095 for the cases with plasma β ranging 0.5$< \beta <$6.5.

In this report, the waves in the Hall MHD reconnection are investigated: The time series of the out-of-plane magnetic field B_y and the velocity components V_x, V_z in the (x, z) plane at the given points are transferred into the power spectrums by the Fast Fourier Transform (FFT) for the cases with various plasma β. The results indicate that the frequencies of the B_y, V_x, V_z power spectrums are in the range of $\omega_{ci} < \omega <8\omega_{ci}$ where ω_{ci} is the proton cyclotron frequency. A shift of low frequency and the energy reduction in the power spectrum can be found as the plasma β increases.

Using the Minimum Variance Analysis (MVA) on **E,** the propagation directions of the waves are determined. The angles α between the wave vector **K** and the local magnetic field **B** are as follows: $\alpha <5^o$ for case1 (β=0.5), $\alpha <20^o$ for case2 (β=2.5) and $\alpha <28^o$ for case3 (β=6.5). It means that **K** is approximately parallel to **B** even though α increases with increasing β. In order to investigate the polarized features of waves the eigenvectors of electric field **E** are determined by MVA method and the hodographs of **E** eigenvectors are plotted in the plane perpendicular to the wave vector **K**. The hodographs for all three cases illustrate a right-hand circularly polarized feature. In case1 with β=0.5, it is a right-hand elliptical polarized, but in case2 (β=2.5) and case3 (β=6.5) the hodographs become a complicated right-hand circulation.

Such wave behaviors are the signatures of whistler wave, and so the present work might provide a link between the fast reconnection rate and whistler wave.