Geophysical Research Abstracts, Vol. 9, 00553, 2007
SRef-ID: 1607-7962/gra/EGU2007-A-00553

Nonlinear Dynamics of Hall MHD Equations: Spontaneous Excitation of Magnetosonic Fluctuations

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High frequency fluctuations (of the order of ion plasma frequency) have been commonly observed in a variety of space plasmas, for example in the solar wind, in the Earth magnetopause, in auroral regions, in dense molecular clouds and in accretion disks. This kind of fluctuations can be described in the framework of Hall Magnetohydrodynamics (HMHD) equations, in which the effect of ion inertia is taken into account. The model, derived from the two fluid MHD description by neglecting the electron inertia, differs from the traditional MHD equations. The former contains a characteristic scale length, namely the ion skin depth. The nonlinear dynamics of a compressible Hall MHD plasma have been investigated in a 2.5D geometric configuration, by performing direct numerical simulations. In a forced regime, the systems reaches a turbulent stationary state in which small-scale fluctuations develops. Two main features occur at small-scale, where the Hall effect dominates, namely: i) a breakdown of the strong link between velocity and magnetic field typical of Alfvenic MHD cascade; ii) the excitation of small-scale fluctuations characterized by an anti-correlation between density and magnetic field intensity. Finally, we performed comparisons between our model's results and Cluster satellite data, which turn out to be in very good agreement.