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Hall MHD simulation of large amplitude Alfven waves in the solar wind

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Alfven waves are common feature in space plasmas, and have been observed in the solar wind.

The propagation of Alfven waves in the solar wind show highly nonlinear processes because of large amplitude (dB/B=1-2). Therefore, magnetohydrodynamic (MHD) simulations have been used to study nonlinear evolutions of Alfven waves by many authors. To include the dispersive effect of plasmas, Hall MHD equation can be used. For small but finite amplitude (dB/B is less than unity)

Alfven waves, Derivative Nonlinear Schrodinger (DNLS) equation can be reduced from Hall MHD equation. DNLS equation has been widely used to investigate nonlinear evolution of Alfven waves, and also applied to the solar wind. Most studies have been limited in the local scale phenomena where solar wind plasmas are assumed to be homogeneous. In the solar wind, however, temperature, density, magnetic field vary with distance. In this case DNLS equation could be insufficient to describe behavior of the waves, and one has to solve Hall MHD equation.

The goal of our study is to investigate nonlinear evolution in the solar wind in global scale where plasma parameter vary significantly with distance. For simplicity, we assume a radially flowing solar wind (transonic solution), and Alfven waves propagating along open magnetic field line. We perform Hall MHD simulation in the one-dimmensional spherical coordinate. Because the proton inertial length is much smaller than the scale length of pressure gradient in the solar wind plasma, we need a large number of grids to include Hall effect. we develop a simulation code parallelized for massive parallel computation. We will discuss nonlinear evolution of Alfven waves in the solar wind from the result of simulation.