

TWO-DIMENSIONAL SIMULATIONS OF THE PARKER INSTABILITY IN A SELF-GRAVITATING DISK

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Using a TVD MHD code, we have simulated the non-linear development of the Parker instability in an isothermal magnetized gas disk under the influence of self-gravity. The field lines run parallel to the y -axis. The initial state of the disk is assumed to be in a hydrostatic equilibrium. We truncated the density distribution at the boundary, $z_a = \pm 5H$, where H is a density scale height. Linear stability analyses show that the horizontal wavelength of the maximum growth rate is about $10H$. We thus set the computational domain to be $10H \times 10H$. The whole ranges of $10H$ are divided into 256 grids. Periodic boundary condition is taken along the y -axis and reflecting one along the z -axis.

We solved the self-gravitational potential by using a fourth-order accurated Fourier method and the Green function. Taking auxiliary scheme for correcting the magnetic fields (Ryu 1996), we could fully satisfy the $\nabla \cdot B = 0$ condition all through the simulation.

In the early stage of the evolution, vertical MHD wave propagates from the mid-plane toward the upper boundary. After they reach the boundary, convergent flow along the magnetic field lines develops in the whole disk, and the system gets into the linear stage. In this phase, the results of the nonlinear simulation agree well with those of the linear analysis. As perturbations grow, the high-density region forms in the central part of the disk, and the magnetic field lines become weekly bent. In the non-linear stage, the matter gathers from all quarters and forms a central core. The matter density in the core increases 10^3 times the initial value. The field lines strongly bend in the core, and the strength increases more than 50 times the initial value. Eventually the matter density becomes high enough to make the magnetic Jeans length smaller than the grid size, and the simulation could not follow the ensuing evolution.

These results will be compared with those of the Parker instability under a uniform external gravity.