コンパクト差分法とLAD法を用いたMHDスキームによる磁気回転不安定性の計算機実験

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Nonlinear evolution of MRI by an MHD simulation with the compact difference and the LAD method

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The magneto-rotational instability (MRI) (Balbus & Hawley, 1991) is one of the most important phenomena in accretion disks and causes turbulence driving the mass accretion in the disks. Recent studies suggested that MRI is saturated by the parasitic instability (Goodman & Xu, 1994; Pessah, 2010), which is related to the Kelvin-Helmholtz instability and magnetic reconnection. These phenomena generate not only turbulence but also discontinuities simultaneously. Therefore, for the study of the time variation of turbulence caused by MRI, we should use an MHD code of high accuracy, low dissipation, and robustness at discontinuities.

In the present study, we have developed an MHD simulation code using an 8th-order compact difference scheme (Lele, 1992), local artificial diffusivity (LAD) method (Kawai, 2013), and shearing box boundary condition (Hawley et al., 1995). Our developed code can solve the wide wave number range without numerical dissipation and thus our code can resolve the structure of MRI more accurately. We carry out a simulation of the evolution of MRI using the developed code in the local shearing box with the number of grid points (256, 256, 128) and the initial net B_z magnetic field. In the simulation result of MRI, we find the anisotropy of the energy cascade process and waves excited through the parasitic instability. We find that wave number spectra of generated waves are consistent to results of the previous analytical study. Our newly developed code enables us to solve the MRI driven turbulence accurately, which is important in solving not only a wide range of the evolution of the disk but also the fine structure of the saturation and nonlinear evolution of MRI.