降着円盤におけるトロイダル磁場に沿った不安定性

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Instability along Toroidal Magnetic Field in Accretion Disks

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We discuss a new type of instability expected to take place in an accretion disk, which contains a differentially rotating plasma threaded by a weak magnetic field. In particular, the stability of a disk with a localized, toroidal magnetic field varying in the radial direction, which can be expected in an accretion disk during the nonlinear evolution of the magneto-rotational instabilities (MRI), is investigated by using linear eigenvalue analysis and nonlinear magneto-hydro-dynamic (MHD) simulations.

The MRI is believed to be a strong source of MHD turbulence and the resultant angular momentum transport in the accretion disk, which is required for the gas to accrete onto the central object. Once the MRI grows, the disk is chiefly governed by the toroidal and radial magnetic field newly generated by the dynamo action of MRI. Such a situation allows Alfven waves to propagate along toroidal direction.

In this talk, we study the linear stability of the Alfven wave in the shearing periodic box, and show that the toroidally propagating Alfven wave can become unstable provided its wavelength is larger than the gradient scale of the magnetic field. We investigate our results of the linear eigenvalue analysis by changing the structure of the localized magnetic field, and discuss some properties of the instability with examining the eigenvectors and eigenvalues. While a differentially rotating plasma with an uniform toroidal filed is completely stable, it is revealed that weak non-uniform magnetic field can lead to instability and the resultant turbulence. We also find that this type of instability can be totally suppressed in a rigid body rotation, but the instability can be recovered in a non-rotating plasma. In addition to the linear analysis, the corresponding nonlinear behavior will also be discussed by using numerical simulations. This instability plays an important role in the plasma transport since it probably couples with the magnetic reconnection occurring in the equatorial plane and then contributes to the saturation mechanism of the MRI.