温度異方性を考慮したMHDによる無衝突降着円盤の成層シミュレーション
Stratified Simulations of Collisionless Accretion Disks by Kinetic MHD with Anisotropic Pressure

*平林 孝太[1]、星野 真弘[1]
*Kota Hirabayashi[1], Masahiro Hoshino[1]

1.東京大学理学系研究科地球惑星科学専攻
1.Earth and Planetary Science, Graduate School of Science, The University of Tokyo

An accretion disk is one of the most ubiquitous astrophysical structure in the universe. In particular, the accretion disk around a supermassive black hole, such as Sgr A* in our galactic center, is thought to consist of a collisionless plasma, in which the gas is so hot and dilute that the mean free path of charged particles become larger than a scale size of the accretion disk. Particle-in-cell and Vlasov simulations are typical numerical approaches to investigate such a collisionless system. In the case of the accretion disk, however, the fact that the scale size of the disk and the kinetic scale of particles are different by orders of magnitude makes it impossible to apply the kinetic simulation techniques to this problem directly due to the limit of computational resources. To study the large-scale dynamics of collisionless accretion disks, therefore, the so-called kinetic magnetohydrodynamics (MHD), which can take into account some of kinetic effects, is required.

In this study, we pay attention to the effect of anisotropy of the thermal pressure. Including an anisotropic pressure tensor can modify the nature of the magnetorotational instability (MRI), which has been considered to play an important role for the angular momentum transport in accretion disks. We carried out series of kinetic MHD simulations using a *stratified* shearing box model, for the purpose of investigating the impact of pressure anisotropy on large scale dynamics of collisionless disks.

In the case of the standard MHD simulations with an isotropic pressure in a stratified domain, it is known that the disk threaded by a weak magnetic field is eventually filled with MRI-driven turbulence, which provides a sufficient rate of the angular momentum transport. This MRI-driven turbulence is considered to be responsible for production of a large-scale toroidal magnetic field observed in the stratified simulations, through some underlying disk dynamo process. We found that, once the effect of the anisotropic pressure is included, the resultant saturation level of the small-scale MRI-driven turbulence reduces to one third of that in the isotropic case with respect to the magnetic energy, due to the anisotropy with $P_{\perp}>P_{||}$ generated by the MRI itself. On the other hand, the magnetic energy contained in large-scale structure gets much smaller roughly by one order of magnitude, which implies that the dynamo action might not work efficiently in the collisionless disks. In our talk, we will discuss the dynamical behavior in more detail and try to give a theoretical explanation to the reduction of the turbulence and suppression of the disk dynamo.

キーワード：降着円盤、無衝突プラズマ、MHDシミュレーション
Keywords: accretion disk, collisionless plasma, MHD simulation

