[구HA-05] Radiation Driven Warping of Circumbinary Disks around Supermassive Black Hole Binaries in Active Galactic Nuclei

Kimitake Hayasaki[1], Bong Won Sohn[1,2], Atsuo T. Okazaki[3], Taehyun Jung[1], Guangyao Zhao[1] and Tsuguya Naito[4]
[1]Korea Astronomy and Space Science Institute, Daedeokdaero 776, Yuseong, Daejeon 305-348, Korea, [2]Department of Astronomy and Space Science, University of Science and Technology, 217 Gajeong-ro,, Daejeon, Korea, [3]Faculty of Engineering, Hokkai-Gakuen University, Toyohira-ku, Sapporo 062-8605, Japan, [4]Faculty of Management Information, Yamanashi Gakuin University, Kofu, Yamanashi 400-8575, Japan

We study a warping instability of a geometrically thin, non-self-gravitating disk surrounding binary supermassive black holes on a circular orbit. Such a circumbinary disk is subject to not only tidal torques due Line 8 to the binary gravitational potential but also radiative torques due to radiation emitted from each accretion disk. We find that a circumbinary disk initially aligned with the binary orbital plane is unstable to radiation-driven warping beyond the marginally stable warping radius, which is sensitive to both the ratio of vertical to horizontal shear viscosities and the mass-to-energy conversion efficiency. As expected, the tidal torques give no contribution to the growth of warping modes but tend to align the circumbinary disk with the orbital plane.

Since the tidal torques can suppress the warping modes in the inner part of circumbinary disk, the circumbinary disk starts to be warped at the radii larger than the marginally stable warping radius. If the warping radius is of the order of 0.1 pc, a resultant semi-major axis is estimated to be of the order of 10-2 pc to 10-4 pc for 107 Msun black hole. We also discuss the possibility that the central objects of observed warped maser disks in active galactic nuclei are binary supermassive black holes with a triple disk: two accretion disks around the individual black holes and one circumbinary disk surrounding them.

[구HA-06] Scaling law in MHD turbulence small-scale dynamo

Kiwan Park and Dongsu Ryu
Department of physics and astronomy, UNIST

Magnetohydrodynamics(MHD) dynamo depends on many factors such as viscosity γ, magnetic diffusivity η, magnetic Reynolds number Re_M, external driving source, or magnetic Prandtl number Pr_M. Pr_M, the ratio of γ to η (for example, galaxy $\sim 10^{14}$), plays an important role in small scale dynamo. With the high Pr_M, conductivity effect becomes very important in small scale regime between the viscous scale ($k_\gamma \sim Re^{3/4} k_f$ k_f:forcing scale) and resistivity scale ($k_\eta \sim PrM^{1/2} k_\gamma$). Since η is very small, the balance of local energy transport due to the advection term and nonlocal energy transfer decides the magnetic energy spectra. Beyond the viscous scale, the stretched magnetic field (magnetic tension in Lorentz force) transfers the magnetic energy, which is originally from the kinetic energy, back to the kinetic eddies leading to the extension of the viscous scale. This repeated process eventually decides the energy spectrum of the coupled momentum and magnetic induction equation. However, the evolving profile does not follow Kolmogorov's -3/5 law. The spectra of EV ($\sim k^{-4}$) and EM ($\sim k^{0}$ or k^{-1}) in high Pr_M have been reported, but our recent simulation results show a little different scaling law ($E_V \sim k^{-3} - k^{-4}$, $EM \sim k^{-1/2} - k^{-1}$). We show the results and explain the reason.