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Oscillations of the Soft X-ray Emitting Region of AGN Accretion Disks.

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Some active galactic nuclei (AGNs) show state transitions between X-ray hard state with narrow emission lines and X-ray soft state with broad emission lines. They are called Changing Look AGNs (CLAGN). These objects show rapid time variabilities whose time scale is shorter than the accretion time scale. Origin of the time variabilities is still unclear.

A possible mechanism of the time variabilities of CLAGN is the radial oscillation excited around the interface between radiatively inefficient accretion flow (RIAF) near the black hole and the outer, optically thick, cool disk. Igarashi et al. (2020) showed by three-dimensional radiation magnetohydrodynamic simulations that in AGNs, Thomson thick, soft X-ray emitting region is formed in this interface when the accretion rate is around 10 percent of the Eddington accretion rate. Furthermore, they showed that the radial oscillation becomes over stable when the radiation pressure becomes dominant in the soft X-ray emitting region.

When the accretion rate approaches the Eddington accretion rate, limit cycle oscillations similar to that observed in a micro quasar GRS 1915+105 can be excited. Theoretically, the oscillation is the transition between radiation pressure dominant, super critical accretion flow (Slim disk) and standard disk (Homma et al. 1991, Watarai & Mineshige 2003). Ohsuga (2006) reported the limit cycle oscillations in GRS 1915+105 by global, two-dimensional radiation hydrodynamic simulations assuming axial symmetry and alpha viscosity. However, the oscillation time scale is too long to explain rapid time variabilities in CLAGNs.

Here we show by three-dimensional radiation magnetohydrodynamic simulations that the oscillation period becomes shorter in magnetized disks. When the magnetic field is considered, accretion flow can be supported by magnetic pressure when the disk contracts vertically by radiative cooling (Machida et al. 2006). Since the total azimuthal magnetic flux is conserved, the strength of azimuthal magnetic field increases as the disk shrinks in the vertical direction. Oda et al. (2009) showed that magnetic pressure dominant, steady disk solutions exist between the optically thin RIAF solutions and optically thick, radiation pressure dominant, standard disk solutions.

Thus, there can be limit cycles not only between the radiation pressure-dominant disk and the gas pressure-dominant disk, but also between the radiation pressure-dominant disk and the magnetic pressure dominant disk.

In this study, we performed 3-dimensional global radiation magnetohydrodynamic simulations of accretion disks around a super-massive black hole including inverse-Compton scattering cooling. As a result of the simulations, when the accretion rate approaches the Eddington accretion rate, the accretion flow changes between torus-like highly advective flow (slim disk) and cooler, magnetized, slowly accreting disk. This oscillation could be the origin of quasi-periodic oscillations observed in AGNs. In this talk, we discuss whether the disk oscillation induced by thermal instability can explain the light curves of highly variable AGNs.

References

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