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Radiation Magnetohydrodynamic Simulations of Time Variabilities of Changing Look Active Galactic Nuclei

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Seyfert galaxies show rapid time variabilities when their luminosity is around 0.5% of the Eddington luminosity. Such activities can be driven by the cooling instabilities in hot, optically thin accretion flows.

The broadband spectrum of Seyfert galaxies and quasars ranges from radio emission, optical-UV emission, soft X-ray emission, to hard X-ray emission. The hard X-ray component is explained by the inverse Compton scattering by inner hot ($T>10^9$ K) flow, and the UV component is explained by the disk black body emission from the outer cold ($T<10^5$ K) disk. However, the spectrum of luminous AGNs has a soft X-ray excess component. Apossible origin of the soft X-ray excess is warm ($T\sim10^6$-10^7 K) region optically thick for electron scattering (Done et al. 2012; Petrucci et al. 2018).

Recently, Changing Look Seyfert galaxies are found, in which state transitions between type 1 with broad emission lines and type 2 without broad emission lines are observed. The state transition is accompanied by luminosity variation (e.g., Shappee et al. 2014). When the source is bright, soft X-ray excess and broad emission lines are observed. Meanwhile, when the source is dim, the soft X-ray excess region and broad emission lines disappear. These Seyfert galaxies are called Changing Look AGN (CLAGNs). Noda & Done 2018 showed that the soft X-ray component increase when the source becomes bright. During the changing look phenomena, time variabilities whose time scale is shorter than the transition are observed.

We carried out 3-dimensional radiation magnetohydrodynamic simulations of CLAGNs by using CANS+R (Matsumoto et al. 2019; Takahashi & Ohsuga 2013). CANS+R is the radiation magnetohydrodynamic code based on the M1-closure approximation. We apply CANS+R to accretion disk around a supermassive black hole with a 10% of Eddington accretion rate. We found that the inner region stays hot, optically thin flow. On the other hand, the cool region ($T<10^8$ K) is formed outside of the hot inner flow by cooling instability driven by radiative cooling. The cool region becomes optically thick for electron scattering and emits soft X-ray. Since almost all radiation is emitted from the region, it is indicated that the primary source of CLAGN is the soft X-ray emitting region. Furthermore, we found that the cool region oscillates quasi-periodically. In the early stage, the cool region shrinks in the radial and vertical direction, so that g-mode oscillations are excited. Subsequently, the cool region deformed into non-axisymmetric one-armed structure and that the amplitude of the radial oscillation increases with time. A possible mechanism of such radial pulsation is viscous pulsational instability in the radiation pressure dominant region (Kato 1978, Blumenthal et al. 1984). The oscillation of the soft X-ray emitting, cool (or warm) region induces the luminosity variation.

In this talk, we discuss the possible effects of inverse Compton scattering on the temperature distribution and the broadband spectrum in CLAGNs.

References

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