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Global Radiation Magnetohydrodynamic Simulations of Hard-to-Soft Transition in Black Hole Accretion Flows

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Black hole candidates show that transitions between two distinctive states, hard state and soft state which are characterized by hard and soft X-ray emission, respectively. An optically thin high-temperature disk, the so-called radiatively inefficient accretion flow (RIAF), has been found useful in the description of the hard state. A geometrically thin and optically thick disk, the so-called standard disk , is the most successful model in describing the soft state. During an onset of hard-to-soft transition, it has been observed that the luminosity exceeds the upperlimit of RIAF ($L{\sim}0.01L_{Edd}$). Machida et al. (2006) carried out magnetohydrodynamic(MHD) simulations including optically thin radiative cooling and found that a low-β magnetic pressure dominated disk is formed when the disk shrinks in vertical direction by cooling. But we believe that the disk can eventually become optically thick in which the amount of radiative cooling can be evaluated using radiation transfer equations. In order to investigate optically thick regime of the disk, we therefore perform radiation MHD simulations by using CANS+R, in which the resistive MHD equations are solved by the HLLD+MP5 scheme (Matsumoto et al. 2006, and reference therein) and the temporal evolution of radiation field is solved by the M1-closure scheme developed by Takahashi & Ohsuga (2013). Our new code can handle both optically thin and optically thick region simultaneously. In our three dimensional global simulation of a black hole accretion flow with moderate mass accretion rate, we find that an optically thin hot disk near the black hole coexists with an optically thick cool disk in the outer region.

References
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