

Global Magnetohydrodynamic Simulations of State Transitions in Black Hole Candidates

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ABSTRACT

We present the results of global three-dimensional magnetohydrodynamic simulations of hard-to-soft state transitions in black hole candidates. We included radiative cooling term in the energy equation. When the accretion rate exceeds the threshold for the onset of the cooling instability in optically thin, hard state disk, the vertical contraction of the disk enhances the strength of mean azimuthal magnetic fields. We found that the disk can stay in an optically thin, intermediate state supported by magnetic pressure. We computed the photon spectrum by post processing the simulation results using the Monte Carlo method and found that when the cooling instability takes place, the black hole candidate evolves from a low/hard state to the bright hard state. Hard X-ray luminosity further increases when the increase of the accretion rate from the cool region triggers the cooling instability in the inner region. When the magnetic flux supporting the disk is lost either by buoyant rise of magnetic flux or by dissipation in the disk, the disk will complete the transition to the soft state. The increase of the radio flux observed during the transition from the bright hard state to the soft state can be explained by the release of the magnetic energy stored in the disk.