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Supercritical growth of seed BHs at cosmic dawn and co-evolution with host galaxies

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Supercritical growth of massive/stellar mass seed BHs at high-z universe is believed to be one of the possible solutions to grow the observed supermassive black holes (SMBHs) at z~6. We study the long-term evolution of the global structure of axisymmetric accretion flows onto a black hole (BH) at rates substantially higher than the Eddington value, performing two-dimensional radiation hydrodynamical (RHD) simulations. In the high-accretion optically thick limit, where radiation energy is efficiently trapped within the inflow, the accretion flow becomes adiabatic and comprises of turbulent gas in the equatorial region and strong bipolar outflows. As a result, the mass inflow rate decreases towards the center as a power law relation and only a small fraction of inflow gas feeds the nuclear BH. Energy transport via radiative diffusion accelerates the outflow near the poles in the inner region but does not affect the overall properties of accretion flow. Based on our simulation results, we provide a mechanical feedback model for super-Eddington accreting BHs, which can be applied to large-scale simulations that hardly resolve galactic nuclei. We applied the feedback model to the assembly of first massive BHs observed in high-redshift quasars and find that the existence of strong outflows can suppress the BH growth, while moderate outflows can coordinate the early BH-galaxy co-evolution.

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