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The generalized self-similar solution of ADAF, SLE, slim disk and standard disk

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Accretion is the energy source for many high-energy astrophysical phenomena. Since 1970s four basic solutions describing the accretion processes have been established with specific assumptions, i.e., the standard thin disk (SSD), the Shapiro-Lightman-Eardley (SLE) solution, the slim disk and the advection-dominated accretion flow (ADAF). We present a generalized self-similar solution based on the axisymmetric height-average equations of ADAF, aiming to unify the four solutions. In addition to the advection, the radiation pressure and photon trapping are also included self-consistently. Our generalized solution can reproduce the ADAF, SLE, SSD and slim disk branches in a wide range of accretion rate from sub- to super-Eddington accretion. In particularly, it displays the regimes of accretion rate for the four solutions, the distinct advection fraction of accretion energy, the different temperatures and the thickness of the four accretion flow. A S-curve in $\dot{m}$-Σ plane is also reproduced, representing the SSD branch, the radiation pressure-dominant branch and the slim disk branch. A surprising solution occurs in the innermost region where the radiation pressure becomes dominant. This solution is characterized by high temperature (heated by a very small fraction of advection energy) and effectively optically thin, where the classic SSD solution is no longer self-consistent.

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