P105a Supermassive stars forming with episodic accretion in the early universe

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Supermassive stars (SMSs) with $\sim 10^5\ M_\odot$ can be progenitors of seed BHs for SMBHs at $z \sim 6$. SMSs may form in rare halos in which rapid accretion of $\gtrsim 0.1\ M_\odot$/yr continues during accretion phases. In the case of rapid constant accretion, UV feedback is suppressed because of large stellar radius and low effective temperature. However, accretion rates can vary vigorously due to fragmentation of disks which induces episodic accretion. Such accretion experiences both burst phases and quiescent phases. If the quiescent phases are long enough, stars may contract and UV feedback may occur.

In our study, we examined the impact of episodic accretion on SMS formation by calculating stellar evolution with episodic accretion rates obtained from 2D hydrodynamical simulations. Our results show that stars do not contract for $M_* \lesssim 10^4\ M_\odot$. This behavior can be explained by comparison between a surface KH timescale and the length of quiescent phases as follows. During the stellar evolution, the surface KH timescale is much larger than ~ 1000 yr for almost all time. In contrast, the length of quiescent phases does not much exceed ~ 1000 yr. This means that the former timescale is not relevant for the stellar evolution and that the thermal relaxation of stars does not occur. We will discuss possible evolution of stars for $M_* \gtrsim 10^4\ M_\odot$.