The Evolution of Supermassive Population III Stars

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Supermassive primordial stars forming in atomically-cooled halos at $z \sim 15$-20 are currently thought to be the progenitors of the earliest quasars in the Universe. In this picture, the star evolves under accretion rates of 0.1-1 Msun/yr until the general relativistic instability triggers its collapse to a black hole at masses of $\sim 10^5$ Msun. However, the ability of the accretion flow to sustain such high rates depends crucially on the photospheric properties of the accreting star, because its ionising radiation could reduce or even halt accretion. Here we present new models of supermassive Population III protostars accreting at rates 0.001-10 Msun/yr, computed with the GENEVA stellar evolution code including general relativistic corrections to the internal structure. We compute for the first time evolutionary tracks in the mass range $M > 10^5$ Msun. We use the polytropic stability criterion to estimate the mass at which the collapse occurs, which has been shown to give a lower limit of the actual mass at collapse in recent hydrodynamic simulations. We find that at accretion rates higher than 0.01 Msun/yr the stars evolve as red, cool supergiants with surface temperatures below 10^4 K towards masses $>10^5$ Msun. Moreover, even with the lower rates 0.001 Msun/yr $< dM/dt <$ 0.01 Msun/yr, the surface temperature is substantially reduced from 10^5 K to 10^4 K for $M > 600$ Msun. Compared to previous studies, our results extend the range of masses and accretion rates at which the ionising feedback remains weak, reinforcing the case for direct collapse as the origin of the first quasars. We provide numerical tables for the surface properties of our models.

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Comments:

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