Observational constraints on supermassive dark stars

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Erratum: Observational constraints on supermassive dark stars

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Key words: errata, addenda – stars: Population III – dark ages, reionization, first stars – dark matter.

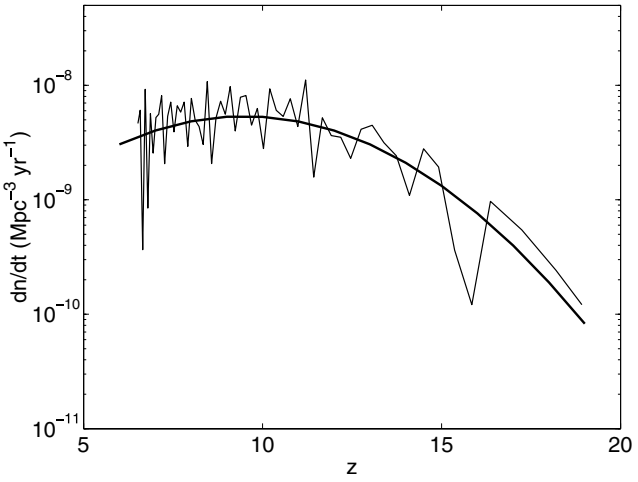

Figure 1. The corrected formation rate of 1–2 × 10^8 $M_\odot$ haloes per comoving Mpc^3 and year, as a function of redshift. The raw simulation data are represented by the thin line, whereas the thick line traces a second-degree polynomial fitted to the data.

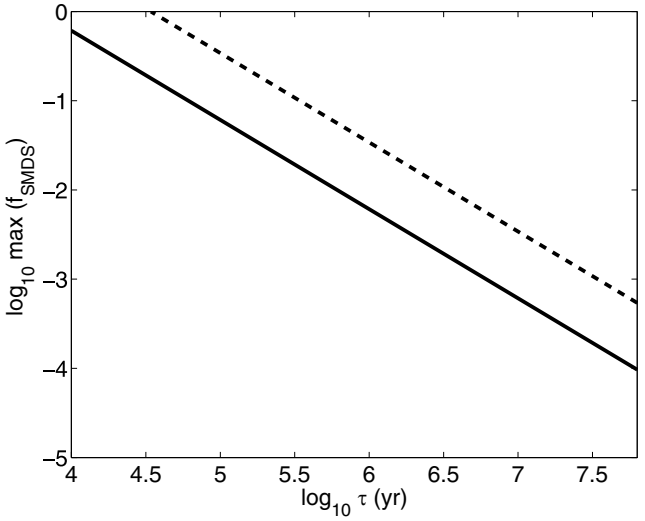

Figure 2. Corrected upper limits on the fraction f_{SMDS} of 1–2 × 10^8 $M_\odot$ dark matter haloes that form T_{eff} = 27 000 K (solid line) and T_{eff} = 51 000 K (dashed line) 10^7 $M_\odot$ dark stars at $z \approx 10$ (i.e. scenario A), as a function of their lifetimes τ.

The Letter 'Observational constraints on supermassive dark stars' was published in Mon. Not. R. Astron. Soc. **407,** L74–L78 (2010).

An error has been uncovered in the Letter. Owing to a numerical mistake, the formation rate of 1–2 × 10^8 $M_\odot$ cold dark matter haloes used was too high by factors of ≈10–30. As a result, the observational constraints on f_{SMDS}, the fraction of 1–2 × 10^8 $M_\odot$ haloes that form 10^7 $M_\odot$ supermassive dark stars (SMDS), should be relaxed accordingly.

The corrected halo formation rate is presented as a function of redshift in Fig. 1. Because of the smaller number of haloes involved, the scatter between adjacent redshift bins is now considerably larger than in the original plot. By fitting a second-order polynomial (thick solid line) to the simulation data, we estimate that the formation rate of 1–2 × 10^8 $M_\odot$ haloes is $dn/dt \approx 5 \times 10^{-9}$ haloes per comoving Mpc^3 and year at $z = 10$, and $dn/dt \approx 1 \times 10^{-9}$ haloes per comoving Mpc^3 and year at $z = 15$. This converts into $\dot{N} \approx$ 580 haloes forming per unit redshift and arcmin^2 at $z = 10$, and $\dot{N} \approx 30$ haloes forming per unit redshift and arcmin^2 at $z = 15$.

The resulting constraints on f_{SMDS}, as a function of the SMDS lifetime τ, are plotted in Fig. 2 for our scenario A (where SMDS continue to form at $z \approx 10$ rather than merely survive from previous epochs). For instance, $\log_{10} f_{SMDS} \leq -3.2$ (−2.5) if $\tau \sim 10^7$yr and $\log_{10} f_{SMDS} \leq -2.2$ (−1.5) if $\tau \sim 10^6$yr for the T_{eff} = 27 000 (51 000) K SMDS from Freese et al. (2010). These upper limits are a factor of 10 weaker than those originally reported.

In scenario B, where f_{SMDS} is assumed to be effectively zero at $z = 10$, current observational data can be used to set upper limits on f_{SMDS} at $z = 15$ (the formation redshift assumed by Freese et al. 2010), provided that the SMDS forming at $z = 15$ have sufficiently long lifetimes to survive until $z = 10$. In the adopted cosmology, this requires $\tau > 2.1 \times 10^8$ yr. For SMDS that obey this age criterion, the constraints relax to $\log_{10} f_{SMDS} \leq -2.9$ (−2.2) for the T_{eff} = 27 000 (51 000) K, 10^7 $M_\odot$ SMDS. These upper limits are a factor of 30 weaker than those originally reported.

Despite these revisions, our discussion concerning the prospects of detecting SMDS with the *James Webb Space Telescope* (*JWST*) remain unimpeded. Given the corrected halo formation rates, a single *JWST* detection of an ∼10^7 $M_\odot$ SMDS at $z = 15$ would suggest $\log_{10} f_{SMDS} \approx -1.8$ if $\tau = 10^7$yr. However, this combination of f_{SMDS} and τ is still ruled out at $z = 10$ (Fig. 2). Hence, if f_{SMDS} and τ are approximately the same at $z = 15$ and 10, our constraints predict that no 10^7 $M_\odot$ SMDS will be detectable within a single *JWST* field at $z = 15$. Of course, *JWST* observations would still be

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highly relevant for dark stars at lower masses, and for scenarios in which $f_{\rm SMDS}$ evolves strongly with redshift.

A corrected version of the Letter has been posted on arXiv.

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REFERENCES

Freese K., Ilie C., Spolyar D., Valluri M., Bodenheimer P., 2010, ApJ, 716, 1397

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