Observational constraints on supermassive dark stars

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Erratum: Observational constraints on supermassive dark stars

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Figure 1. The corrected formation rate of 1–2 × 10³ M⊙ haloes per comoving Mpc³ 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.


An error has been uncovered in the Letter. Owing to a numerical mistake, the formation rate of 1–2 × 10³ M⊙ cold dark matter haloes used was too high by factors of 10–30. As a result, the observational constraints on fSMDS, the fraction of 1–2 × 10³ M⊙ haloes that form 10³ M⊙ 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 × 10³ M⊙ haloes is dn/dz ∼ 5 × 10⁻⁶ haloes per comoving Mpc³ and year at z = 10, and dn/dz ∼ 1 × 10⁻⁸ haloes per comoving Mpc³ and year at z = 15. This converts into ≈ 500 haloes forming per unit redshift and arcmin² at z = 10, and ≈ 30 haloes forming per unit redshift and arcmin² at z = 15.

The resulting constraints on fSMDS, as a function of the SMDS lifetime τ, are plotted in Fig. 2 for our scenario A (where SMDS continue to form at z ≈ 10 rather than merely survive from previous epochs). For instance, log₁₀ fSMDS ≤ −3.2 (−2.5) if τ ∼ 10⁷ yr and log₁₀ fSMDS ≤ −2.2 (−1.5) if τ ∼ 10⁵ yr for the T eff = 27 000 K (solid line) and T eff = 51 000 K (dashed line) 10³ M⊙ dark stars at z ≈ 10 (i.e. scenario A), as a function of their lifetimes τ.

In scenario B, where fSMDS is assumed to be effectively zero at z = 10, current observational data can be used to set upper limits on fSMDS 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 τ ≥ 2.1 × 10⁷ yr. For SMDS that obey this age criterion, the constraints relax to log₁₀ fSMDS ≤ −2.9 (−2.2) for the T eff = 27 000 (51 000) K, 10³ M⊙ SMDS from Freese et al. (2010). 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 ∼10³ M⊙ SMDS at z = 15 would suggest log₁₀ fSMDS ≈ −1.8 if τ = 10⁷ yr. However, this combination of fSMDS and τ is still ruled out at z = 10 (Fig. 2). Hence, if fSMDS and τ are approximately the same at z = 15 and 10, our constraints predict that no 10³ M⊙ 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 $f_{SMD}$ evolves strongly with redshift.

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

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REFERENCES


This paper has been typeset from a TeX/LaTeX file prepared by the author.