

Sussex Research

Observational constraints on supermassive dark stars

Erik Zackrisson, Pat Scott, Claes-Erik Rydberg, Fabio Iocco, Sofia Sivertsson, Göran Östlin, Garrelt Mellema, Ilian Iliev, Paul R Shapiro

Publication date

01-09-2010

Licence

This work is made available under the Copyright not evaluated licence and should only be used in accordance with that licence. For more information on the specific terms, consult the repository record for this item.

Document Version

Published version

Citation for this work (American Psychological Association 7th edition)

Zackrisson, E., Scott, P., Rydberg, C.-E., Iocco, F., Sivertsson, S., Östlin, G., Mellema, G., Iliev, I., & Shapiro, P. R. (2010). *Observational constraints on supermassive dark stars* (Version 1). University of Sussex. https://hdl.handle.net/10779/uos.23343200.v1

Published in

Monthly Notices of the Royal Astronomical Society: Letters

Link to external publisher version

https://doi.org/10.1111/j.1745-3933.2010.00908.x

Copyright and reuse:

This work was downloaded from Sussex Research Open (SRO). This document is made available in line with publisher policy and may differ from the published version. Please cite the published version where possible. Copyright and all moral rights to the version of the paper presented here belong to the individual author(s) and/or other copyright owners unless otherwise stated. For more information on this work, SRO or to report an issue, you can contact the repository administrators at sro@sussex.ac.uk. Discover more of the University's research at https://sussex.figshare.com/

10⁻⁸

dn/dt (Mpc⁻³ yr⁻¹) 0_____01

10⁻¹

10

5

Erratum: Observational constraints on supermassive dark stars

by Erik Zackrisson,* Pat Scott, Claes-Erik Rydberg, Fabio Iocco, Sofia Sivertsson, Göran Östlin, Garrelt Mellema, Ilian T. Iliev and Paul R. Shapiro

20

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

Figure 1. The corrected formation rate of $1-2 \times 10^8$ M_{\odot} 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.

z

15

10

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 $1\text{--}2\times10^8\,M_{\odot}$ cold dark matter haloes used was too high by factors of $\approx 10-30$. As a result, the observational constraints on $f_{\rm SMDS}$, the fraction of $1-2 \times 10^8 \,{\rm M_{\odot}}$ haloes that form $10^7 \,\mathrm{M_{\odot}}$ 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 $1-2 \times 10^8 \, {
m M_{\odot}}$ haloes is $dn/dt \approx 5 \times 10^{-9}$ haloes per comoving Mpc³ and year at z = 10, and $dn/dt \approx 1 \times 10^{-9}$ haloes per comoving Mpc³ 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 arcmin² 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

*E-mail: ez@astro.su.se



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

epochs). For instance, $\log_{10} f_{\text{SMDS}} \leq -3.2 (-2.5)$ if $\tau \sim 10^7$ yr and $\log_{10} f_{\text{SMDS}} \leq -2.2 \ (-1.5)$ if $\tau \sim 10^{6}$ yr for the $T_{\text{eff}} = 27\ 000$ (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 $\log_{10} f_{\text{SMDS}} \leq -2.9 \ (-2.2)$ for the $T_{\text{eff}} =$ 27 000 (51 000) K, $10^7\,M_{\bigodot}$ 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 $\sim 10^7 \,\mathrm{M_{\odot}}$ SMDS at z = 15 would suggest $\log_{10} f_{\text{SMDS}} \approx -1.8$ 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 $10^7 \,\mathrm{M_{\odot}}$ SMDS will be detectable within a single JWST field at z = 15. Of course, JWST observations would still be

L58 E. Zackrisson et al.

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.

ACKNOWLEDGMENTS

We are indebted to Cosmin Ilie and Katherine Freese for bringing this error to our attention.

REFERENCES

Freese K., Ilie C., Spolyar D., Valluri M., Bodenheimer P., 2010, ApJ, 716, 1397 Zackrisson E. et al., 2010, MNRAS, 407, L74

This paper has been typeset from a T_EX/LAT_EX file prepared by the author.