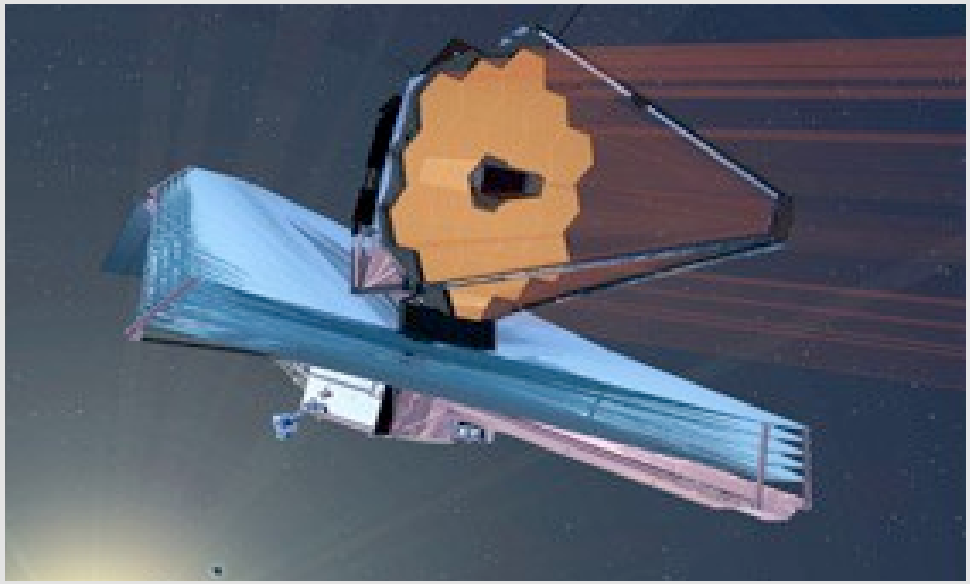
Observational constraints on dark stars with HST and JWST



Claes-Erik Rydberg

Department of Astronomy

Stockholm University

Erik Zackrisson, Pat Scott, Fabio Iocco, Bengt Edvardsson, Göran Östlin,

Sofia Sivertsson, Adi Zitrin, Tom Broadhurst, Paolo Gondolo, Garrelt Mellema,

Ilian T. Iliev, Paul R. Shapiro

Outline

- Dark stars, what, where, when?
- Counting dark stars in JWST field of view.
- Color identification of dark stars.
- Super massive dark stars, what are they?
- HST magnitudes of super massive dark stars and observational constraints on them.

Dark stars

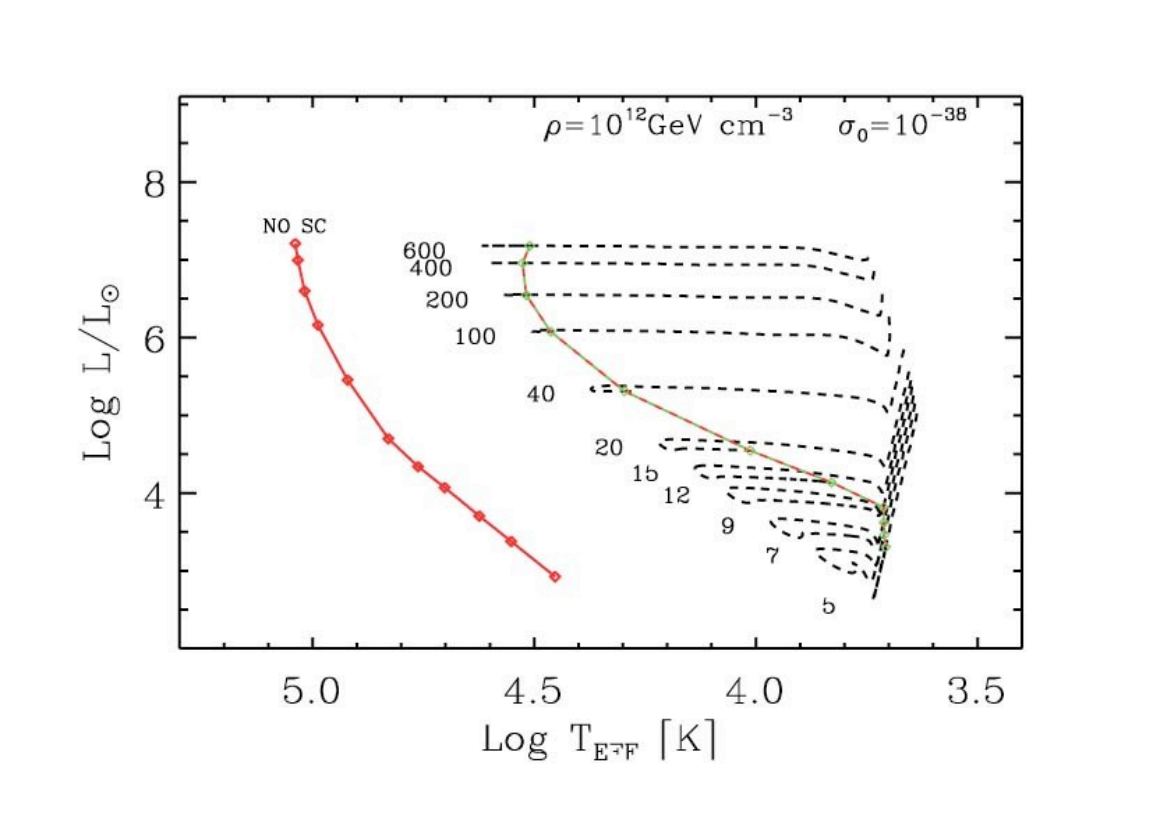


Figure from Iocco et al. 2008, 2009

- Early in the universe, among the first stars converting hydrogen and helium to heavier elements. z=10-30, t=100-500 Myr.
- Powered by self annihilating dark matter, wimps (Spolyar et al. 2008)
- ”Halted” evolution, might continue to population III star main sequence (Spolyar et al. 2008)
- Life time could be prolonged by scattering (Iocco et al. 2008, Freese et al. 2008)
- Current observational limit z=10. Observing dark stars would confirm wimps as dark matter candidate.

Dark stars in this presentation

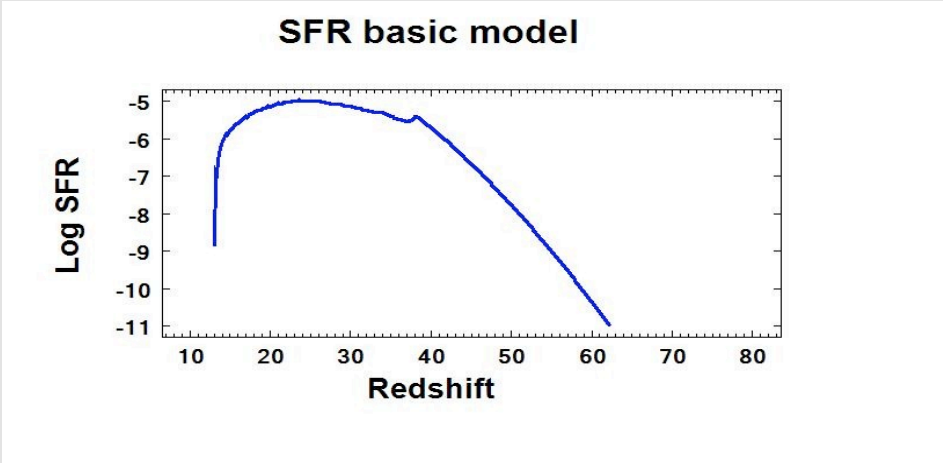
Massive, 690 solar masses

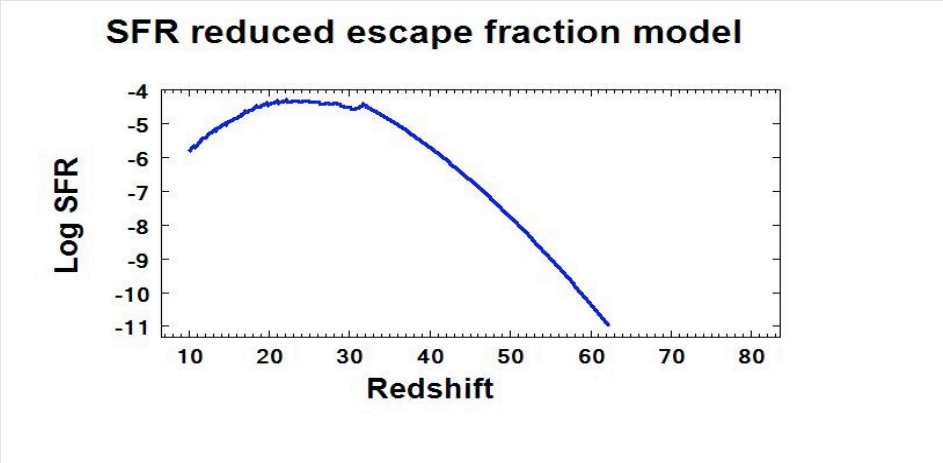
Cool, Teff=7,500 K

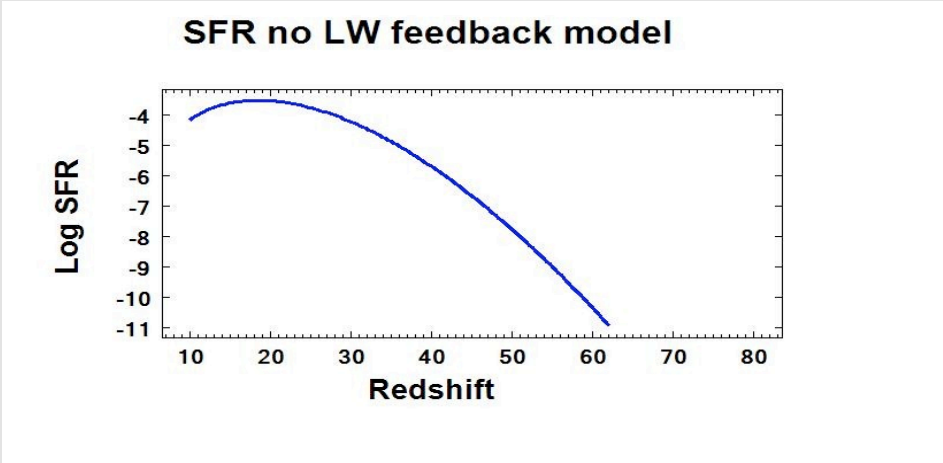
Life time range 1 Myr to 500 Myr

Sfr models from Trenti & Stiavelli

Super massive, Freese et al.



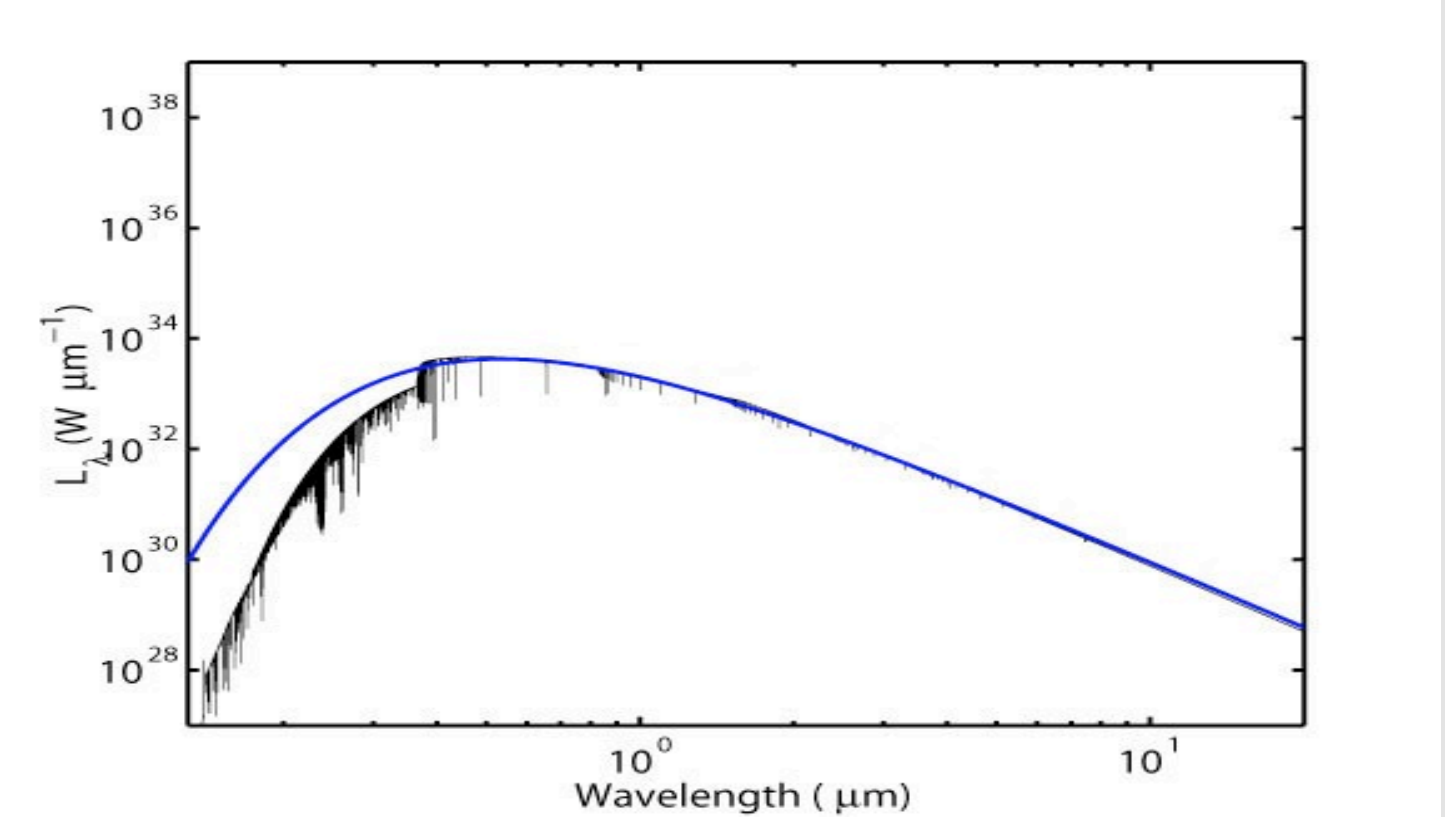




Counting stars in JWST FoV

- Star formation rate integrated to get number of stars formed per unit volume and year
- Area in early universe in field of view calculated with respect to expanding universe
- Depth for unit redshift calculated
- These three multiplied together gives number of stars in FoV

Spectra



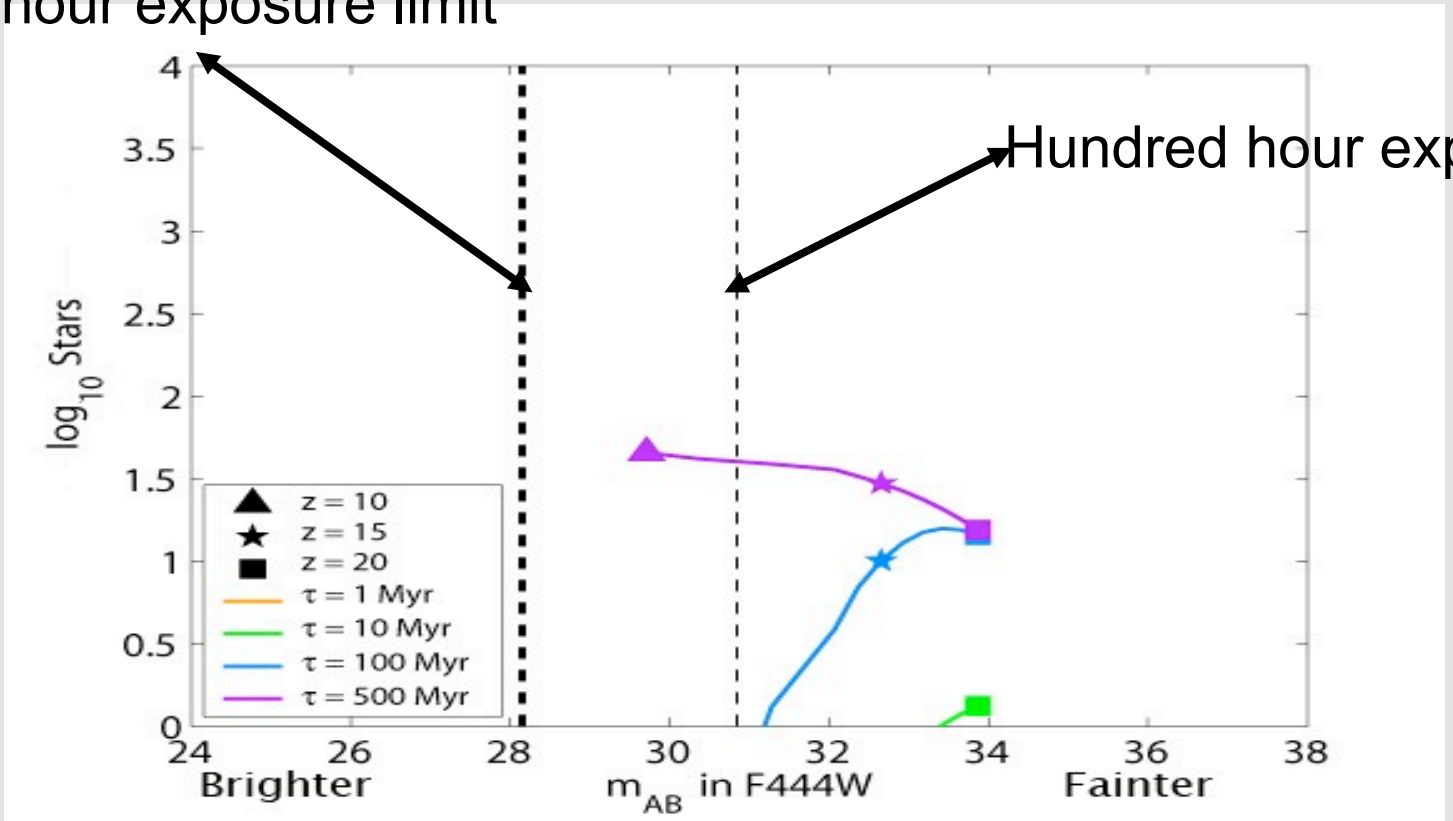
The intensity of the radiation at different wavelength. Blackbody compared to model atmosphere of dark star. An observational filter measures the flux at a limited wavelength area.

Observation of dark stars

- Too faint for direct detection
- Gravitational lensing magnifying >100 times needed
- Long lifetime needed
- High fraction pop III stars going through dark star phase needed
- Long exposure time needed

Results basic model

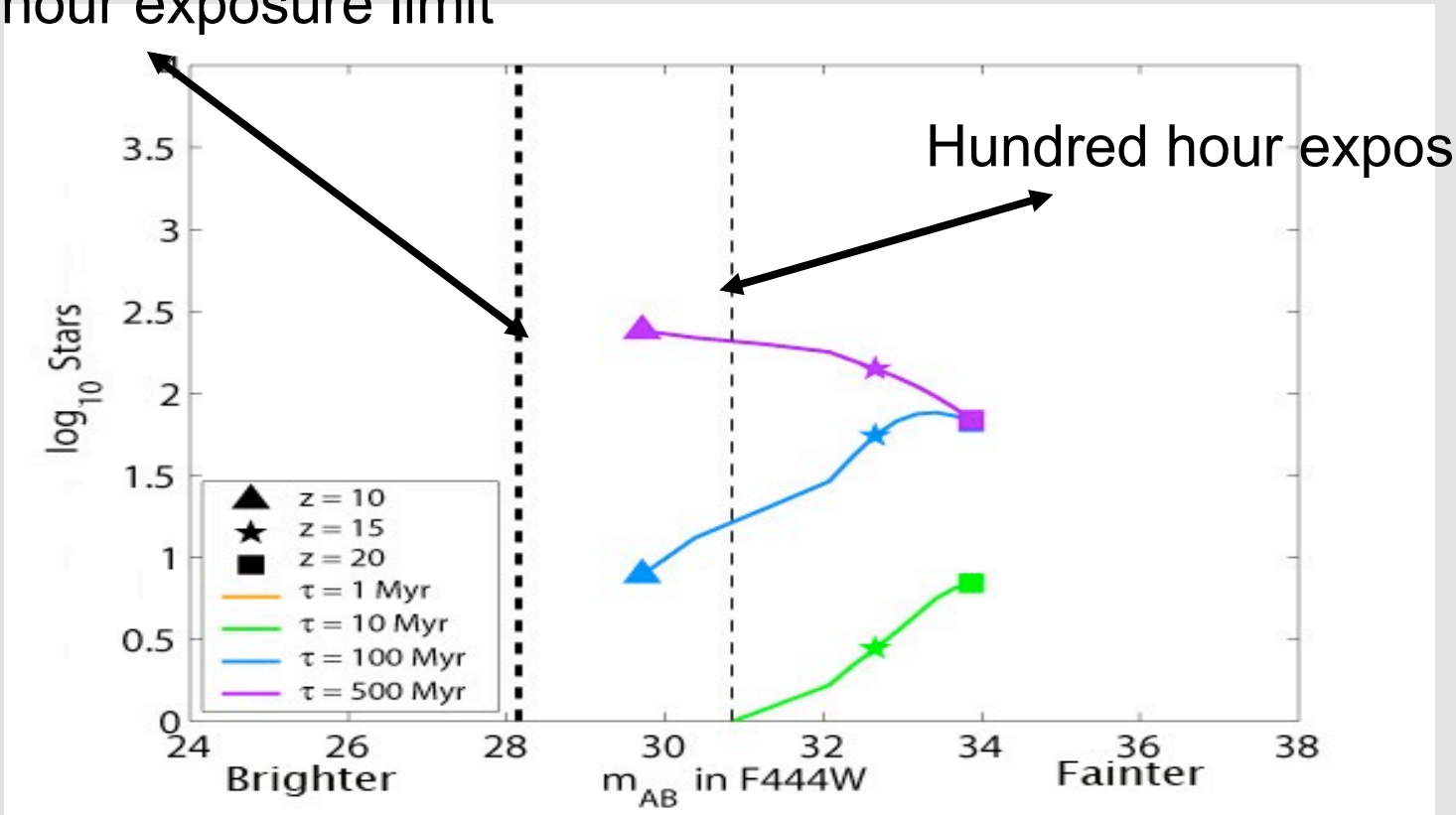
Three hour exposure limit



Number of dark stars expected to be within one field of view with JWST. Using basic model from Trenti and Stiavelli. (Zackrisson et al. 2010)

Results reduced LW feedback

Three hour exposure limit

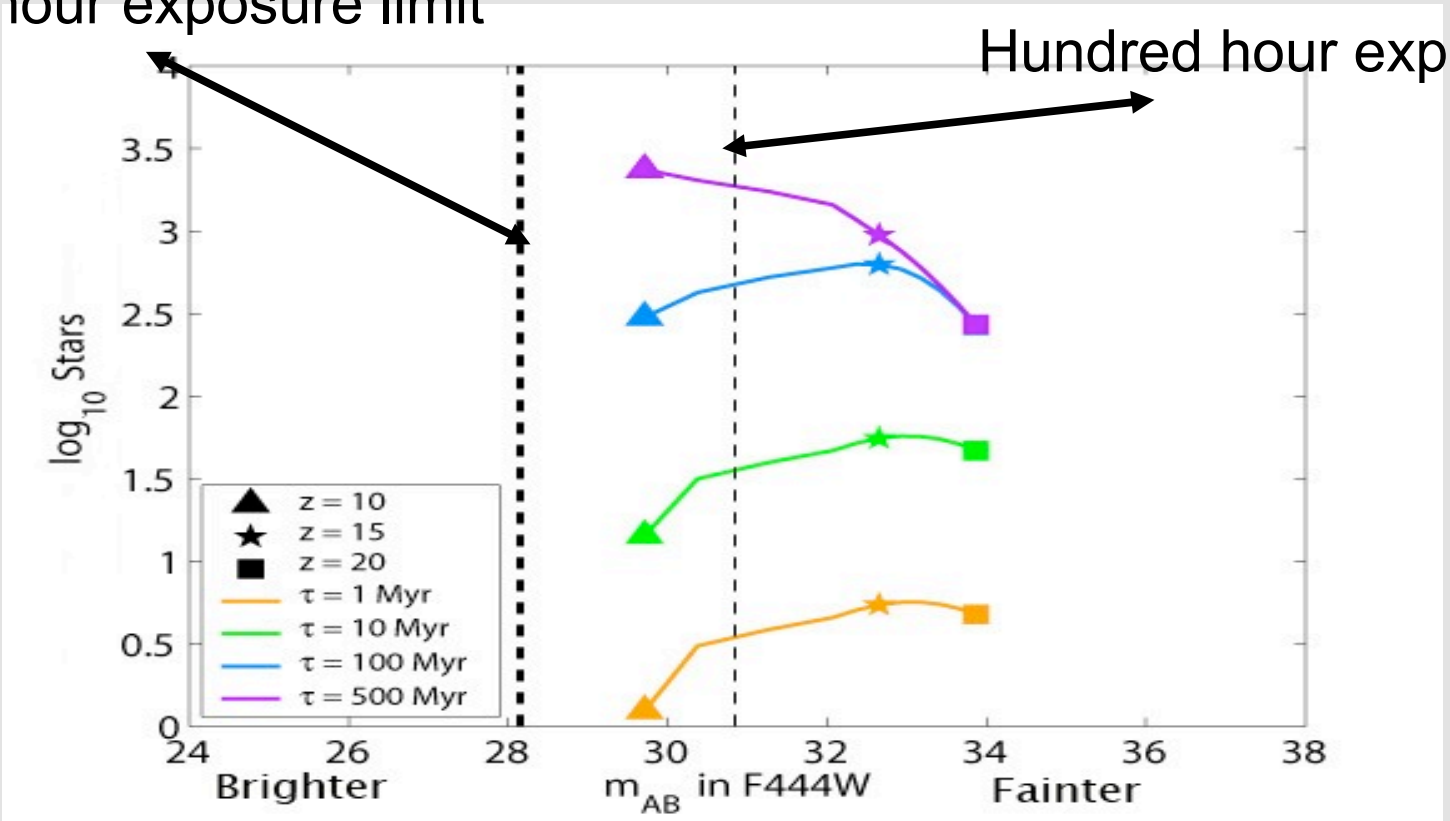


Number of dark stars expected to be within one field of view with JWST. Using reduced LW feedback model from Trenti and Stiavelli. (Zackrisson et al. 2010)

Results no LW feedback

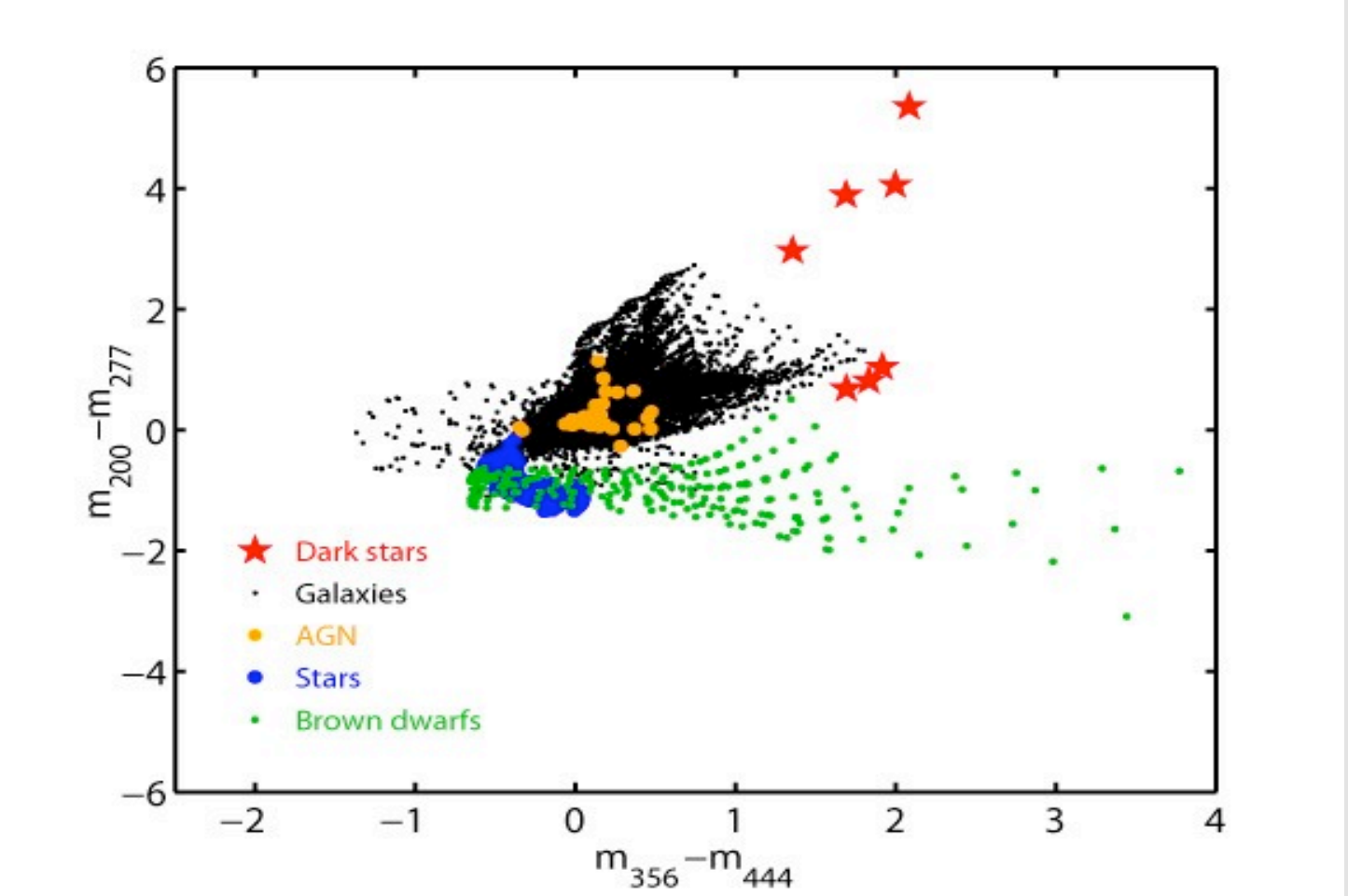
Three hour exposure limit

Hundred hour exposure limit



Number of dark stars expected to be within one field of view with JWST. Using no LW feedback model from Trenti and Stiavelli. (Zackrisson et al. 2010)

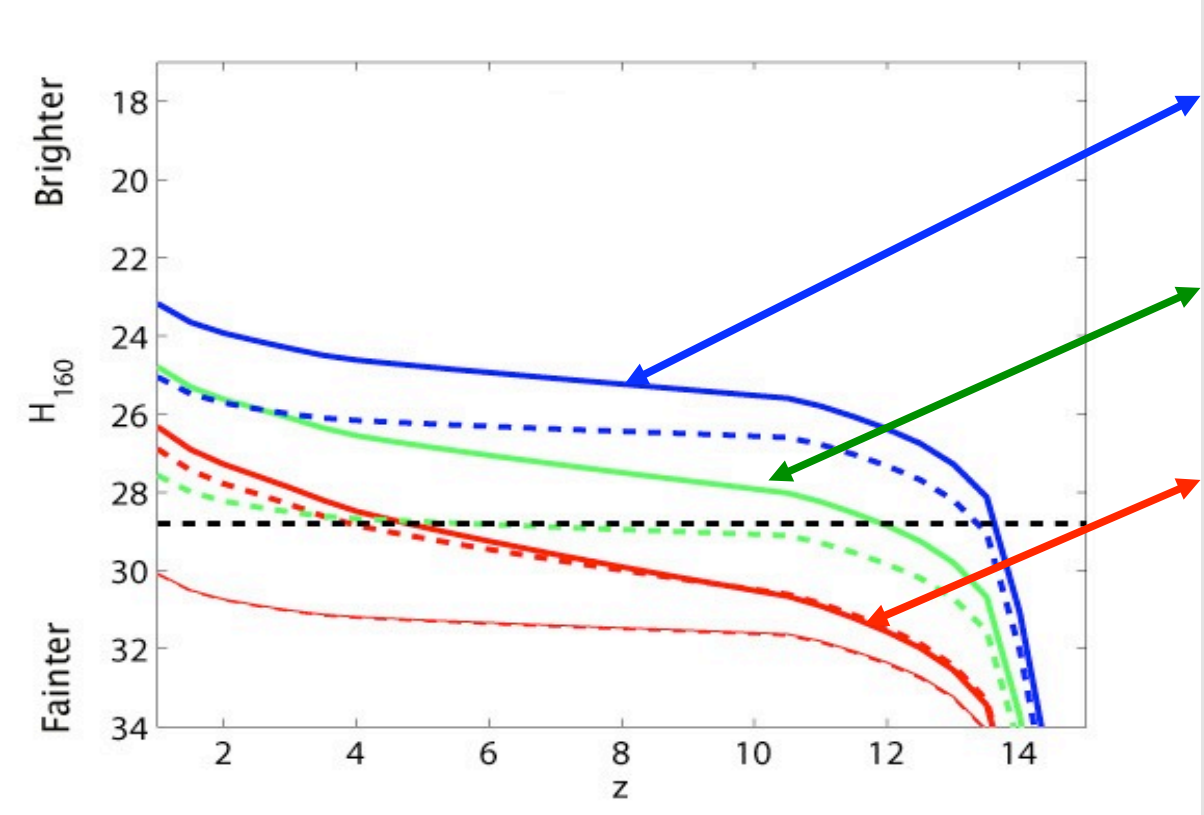
Color comparison



Supermassive dark stars

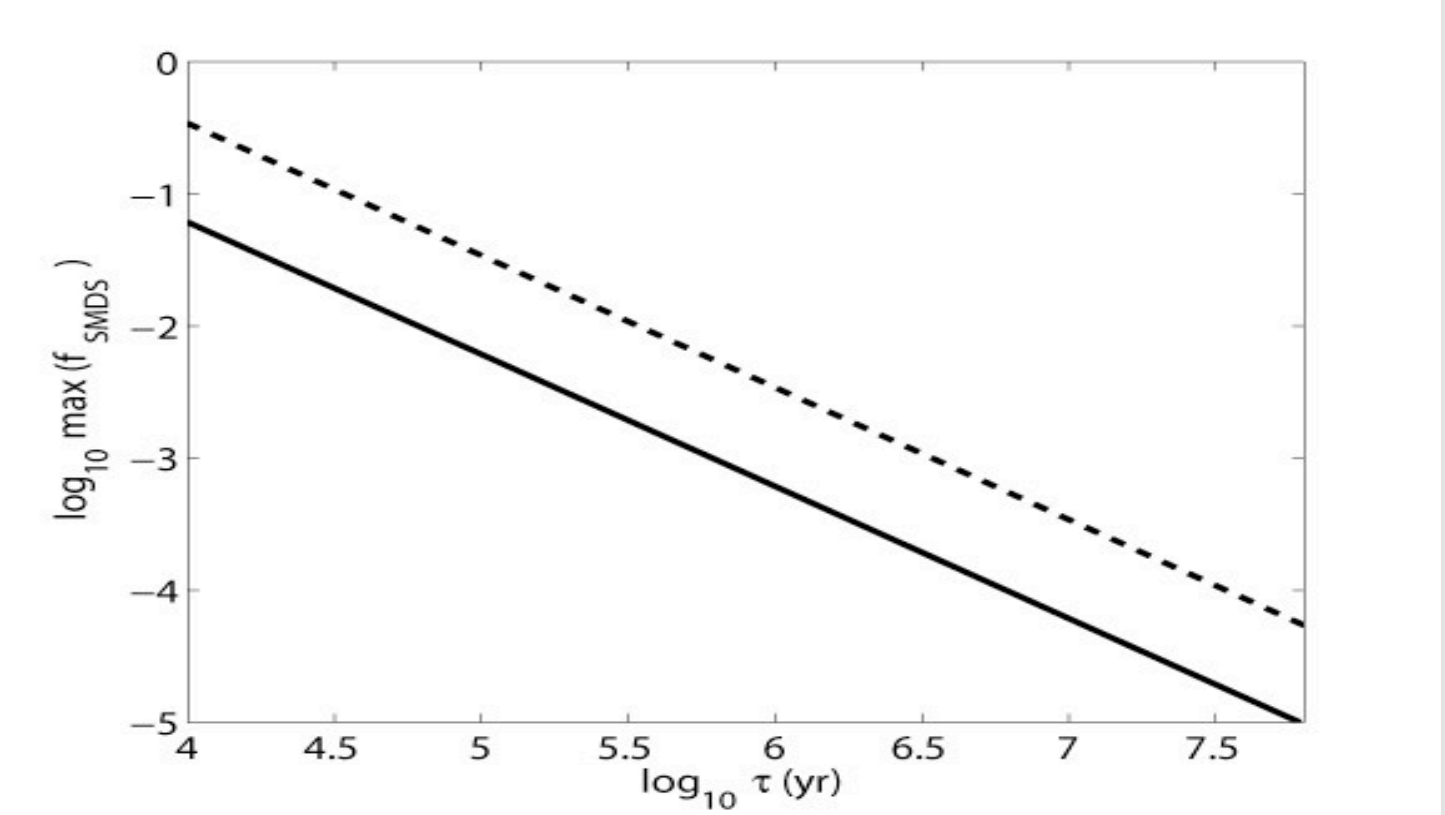
- Suggested by Freese et al. 2010.
- Masses between 10^3 and 10^7 solar masses.
- High resolution N-body simulations used for arriving at the number of dark halos used for star formation.
- Converted to constraint on formation probability.

Magnitudes of SMDS



HST apparent magnitude for different model parameters.

Constraints on SMDS



Upper limit of the fraction of 1-2 * 10^8 solar masses dark halos that form 10^7 solar masses dark stars as a function of their life time. Solid line is for Teff=27,000 K and dashed line is for Teff=51,000.

Summary

- To detect dark stars we need gravitational lensing and long exposure time.The dark stars have to be long lived and a rather normal evolutionary step for early universe stars.
- We might be able to distinguish dark stars from other objects by using color diagram.
- HST data puts strong constraints on the formation of super massive dark stars.