Detecting population III galaxies with HST and JWST

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Outline

• Pop III galaxies – what, when, where?
• JWST/HST detection limits
• Hunting for pop III galaxies behind lensing clusters
• Spectral signatures of pop III galaxies
How to form a Pop III galaxy

E.g. Stiavelli & Trenti (2010)
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The formation history of pop III galaxies

Based on Trenti et al. (2009)

Halo masses
\sim 10^{7-8} \text{ Msolar}

Zackrisson et al. (2012, arXiv:1204.0517)
Yggdrasil code

A spectral synthesis model for the first galaxies

Model grids available at: www.astro.su.se/~ez


- Pop I, II, III stars + dark stars
- Nebular emission (Cloudy)
- Dust
- HST/JWST fluxes @ z=0-15
10σ detections of 3 Myr old pop III galaxies in JWST Ultra Deep Field (100 h per filter) assumed

JWST detection limits

Pop III galaxies with SFE below 1% cannot be detected with JWST in unlensed fields

Lensed pop III galaxies

• Cluster lensing can push these JWST limits to ~0.1%
• The ongoing HST/CLASH survey → Multiband photometry in 17 filters for 25 low-z galaxy clusters (Postman et al. 12)
• With HST/CLASH, you get a pop III galaxy detection threshold similar to a JWST, 100 hour Ultra Deep Field!

Zackrisson et al. (2012, arXiv1204.0517)
Magnification map of J0717.5+3745

Based on Zitrin et al. 09

Zackrisson et al. (2012, arXiv:1204.0517)
Identifying pop III galaxies at z>6

Photometric signatures

• Very blue UV slope (e.g. Raiter et al. 10)
  – Good: In principle sensitive to the pop III IMF
  – Bad: Requires very high LyC escape fraction (>90%)
    → Extremely faint object + very difficult to measure

• Metal-free nebular spectrum (Inoue 11, Zackrisson 11a)
  – Good: Lack of [OIII] @ 5007 Å → strange JWST colours
  – Bad: Not sensitive to the pop III IMF

• Very strong Lyα (e.g. Schaefer 02, Zackrisson 11b)
  – Good: Sensitive to the pop III IMF + detectable with HST
  – Bad: IGM absorption & non-pop III contributions (AGN, cooling)
The colour signatures of strong Lyα

Zackrisson et al. 2011b, MNRAS 418, L104
The colour signatures of strong Ly$\alpha$

Zackrisson et al. 2011b, MNRAS 418, L104
Lensed pop III galaxy candidates in CLASH?

A few objects in this region...

What are they?

If Lyα → Spectroscopic confirmation possible from the ground

Deep field locus

Interlopers

Y-dropouts (z≈8)

Pop III region

Pop I/II region

Y_{105-J_{125}}
Summary

• The Yggdrasil model → spectral signatures of pop III galaxies (www.astro.su.se/~ez)

• Search strategy: HST + lensing clusters → Detection threshold similar to a JWST Ultra Deep Field

• Search for pop III galaxies at z>6 in CLASH underway