Formation of Massive Pop III Galaxies through Photoionization Feedback: A Possible Explanation for CR7

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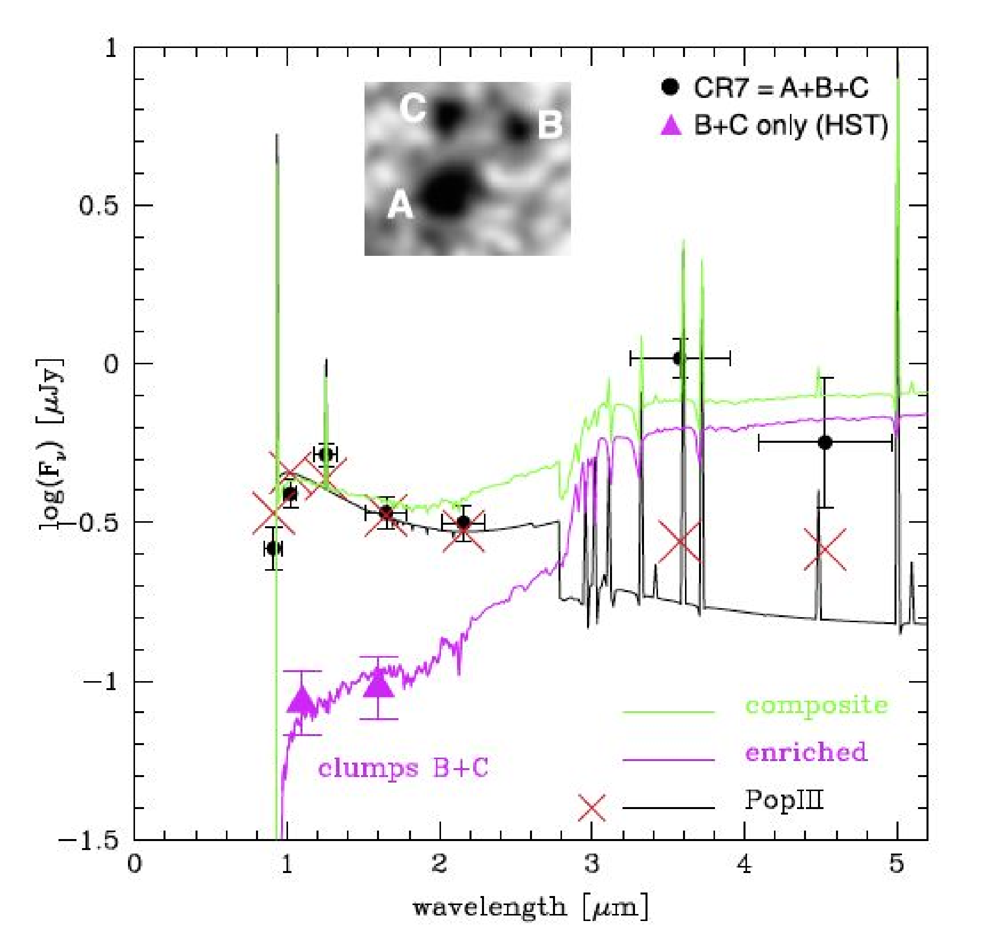
CR7 (Sobral et al. 2015)

- Brightest Lyman-alpha emitter at z=6.6
- Strong Lyman-alpha and HeII 1640 Å line emission
- No metal lines
- Three clumps (A, B, C) separated by ~5 kpc (projected)
- SED consistent with:
  - B and C: ~10^{10} $M_\odot$ older metal enriched stars
  - A: ~10^7 $M_\odot$ young Pop III stars

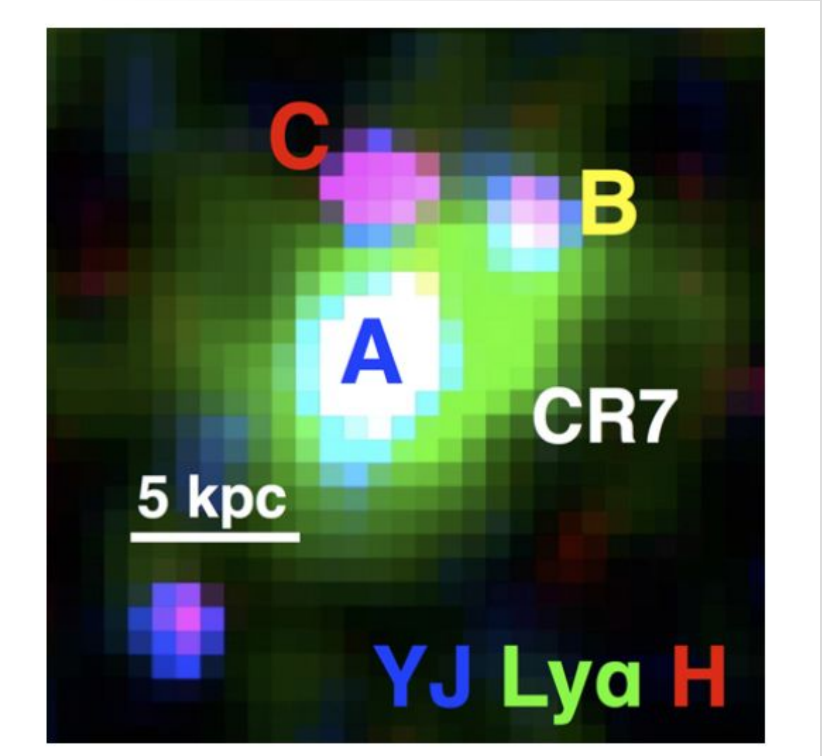


Too High Mass for Pop III?

- $\sim 10^7 M_\odot$ much larger than expected for Pop III star clusters
- Progenitor halos should have led to Pop II transition
- Even if LW radiation prevents star formation in minihalos, atomic cooling should occur in $\sim 10^8 M_\odot$ dark matter halos at z~7
(only $\sim 1.5 \times 10^7 M_\odot$ in gas)
- DCBH has been suggested (Pallottini et al. 2015, Agarwal et al. 2015, Hartwig et al. 2015, Smith et al. 2016, Smidt et al. 2016)

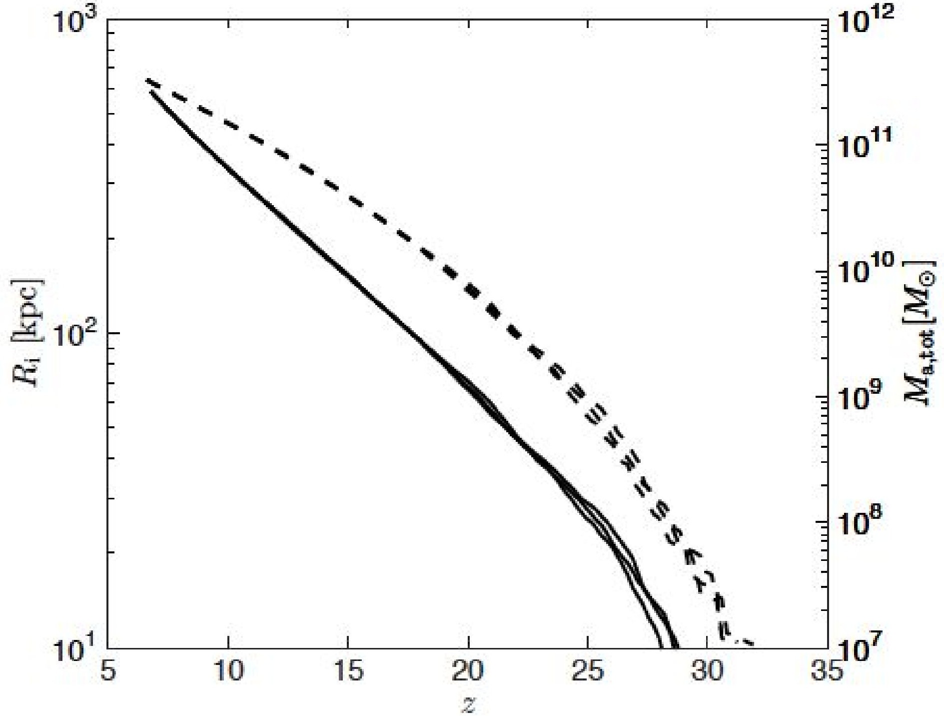
Massive Pop III Galaxies through Photoionization Feedback

- Near large galaxy star formation suppressed
  - LW radiation prevents star formation in minihalos
  - Gas photoevaporated
- Once halo reaches Jeans mass (~$10^9\ M_\odot$ at z=6.6), pristine gas collapses to form massive Pop III starburst
- We estimate the abundance of these large Pop III galaxies
- See also Johnson (2010)



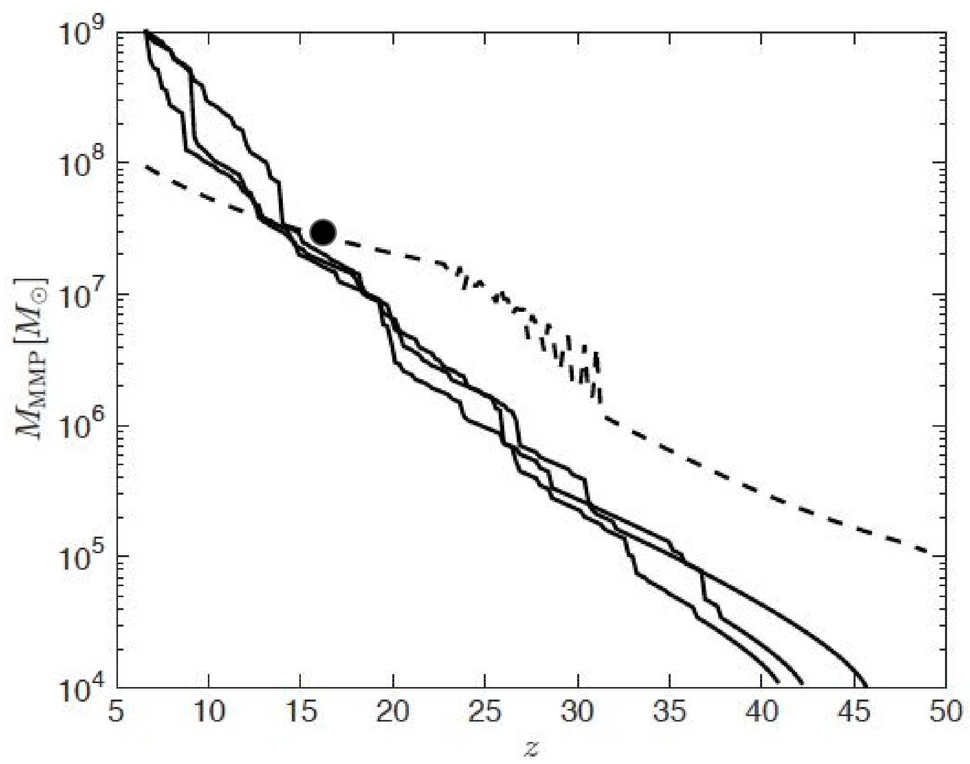
Halo BC

- Treat B+C as one halo
- Assume $3.3 \times 10^{11}\ M_{\odot}$ at z=6.6
- Merger trees (Parkinson et al. 2008)
- Stars above $T_{vir}=10^4$K
- Assume 4000 ionizing and LW photons per baryon in stars
- Compute ionizing flux and size of ionized bubble



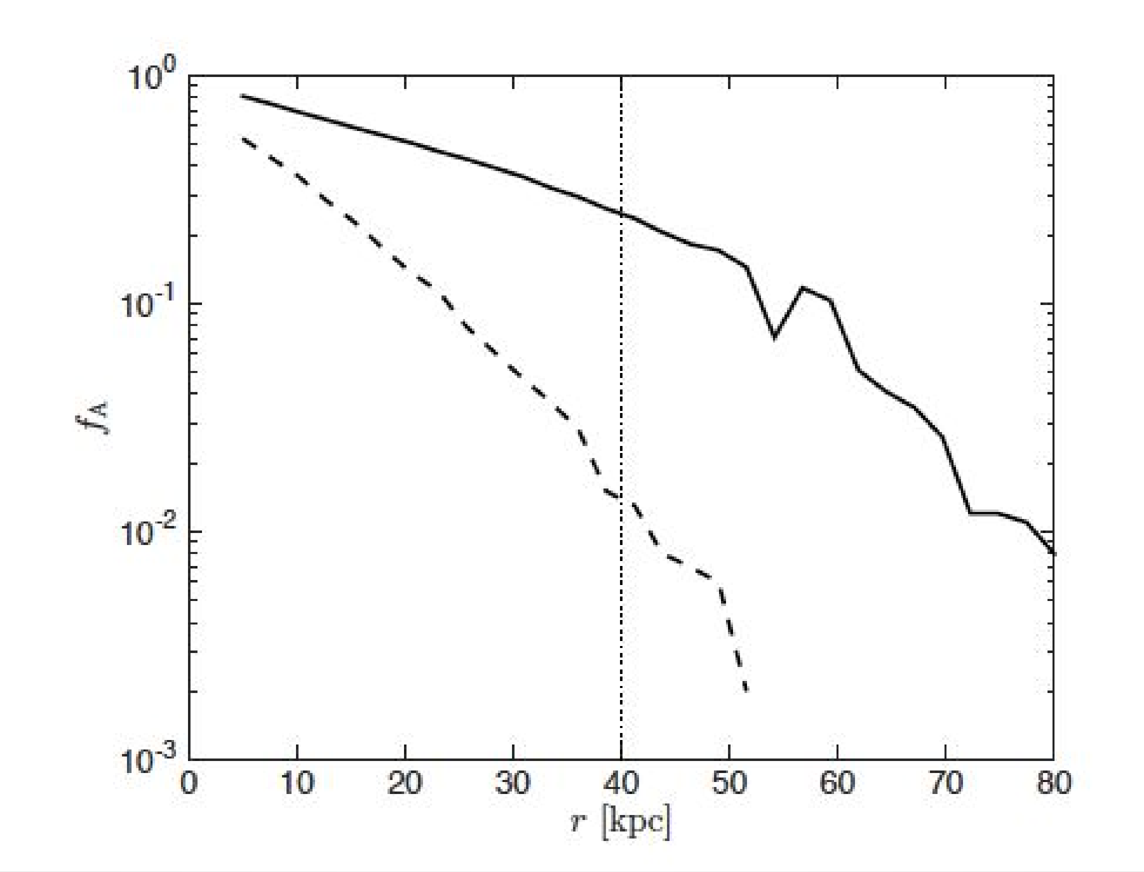
Halo A

- Assume 10^9 $M_\odot$ at z=6.6
- Follow MMP from merger trees
- Require MMP gas to be photoevaporated before star formation
- Photoevaporation fits from Iliev et al. (2005)
- If no star formation occurs before z=6.6 may result in massive Pop III starburst



Halo A

Fraction of realizations with complete suppression of star formation:



Abundance

$$n_{\rm PopIII} = n_{\rm BC} \frac{dN_{\rm A}}{dt} t_{\rm duty} f_{\rm A}$$

- Number density ~10^{-6} Mpc^{-3} at $z=6.6$
- Consistent with density of brightest Lyman-alpha emitters
- Highly uncertain

Conclusions

- CR7 has HeII line consistent with ~$10^7 M_\odot$ Pop III stars
- Radiation from halo BC can suppress all star formation in halo A
- Could lead to massive Pop III starburst when halo A reaches Jeans mass
- Predicted number density consistent with CR7 observations
- External metal enrichment may lower abundance estimate
- For more details see astro-ph:1602.04843