The Contribution of Low Mass Galaxies to Reionization

Lauren Anderson
Tom Quinn :: Fabio Governato
Nbody Shop University of Washington
Steep Faint End Slopes + $f_{\text{esc}}(M_{\text{UV}})$

$z \sim 5$

= Evolving Ionizing Emissivity Consistent with Observations
Charm Nbody GrAvity solver

- Massively parallel SPH
- SNe feedback creating realistic outflows
- SF linked to shielded gas
- SMBHs
- Optimized SF parameters

Menon+ 2014, Governato+ 2014
Subgrid Parameter Search

$\log(M_{\text{star}} / M_{\text{halo}})$

$\log(M_{\text{halo}} [M_\odot])$

Moster+ 2013
The VULCAN

[25 Mpc]$^3$
2 billion particles
$z \sim 100-4$
Gravity resolution $\sim 350$ pc
SPH resolution $\sim 40$ pc
Morphologies $\sim 1e11 M_{\text{tot}}$ ($1e9 M_*$)
5 TB dataset
Evolution of the UVLF

$\phi \left[ \text{mag}^{-1} \text{cMpc}^{-3} \right]$ vs $M_{UV}$

- $z \sim 4$
- $z \sim 5$
- $z \sim 6$
- $z \sim 7$
- $z \sim 8$
- $z \sim 10$

Anderson+ in prep
Evolution of UVLF Parameters

The faint end slope is getting steeper with redshift

Relatively more faint galaxies at high redshift

Larger contribution of ionizing photons?

Anderson+ in prep
We may have a large enough ionizing photon budget...

Can these ionizing photons escape their host halo to reionize the IGM?
Optical Depths Seen by One Individual Stellar Particle

5.8 Myr \quad 0.58 f_{\text{esc}}
Optical Depths Seen by One Individual Stellar Particle

39 Myr  0.26 $f_{esc}$

Stellar Feedback
Optical Depths Seen by One Individual Stellar Particle

73 Myr 0.12 $f_{esc}$

Stellar Feedback
Optical Depths Seen by One Individual Stellar Particle

$1.1 \times 10^2$ Myr $\quad 0.051 f_{esc}$

Stellar Feedback
Optical Depths Seen by One Individual Stellar Particle

1.4e+02 Myr  
9.7e-06 f_{esc}

Stellar Feedback
Optical Depths Seen by One Individual Stellar Particle

1.7e+02 Myr  4.5e-16 $f_{esc}$

Stellar Feedback
Faint Galaxies dominate contribution to Ionizing Emissivity
Faint Galaxies dominate contribution to Ionizing Emissivity

![Graph showing the relationship between $\dot{N}_{\text{ion}}|_{M_{\text{UV}} > -17}/\dot{N}_{\text{ion}}$ and $Z$.](graph.png)
Flat evolution of Ionizing Emissivity due to $n(M_{UV} \sim -15)$ not evolving much

Bouwens+ 2015
Steep Faint End Slopes $+$ $f_{\text{esc}}(M_{\text{UV}})$

$= $ Evolving Ionizing Emissivity Consistent with Observations
Ionizing photons must escape the star’s birth cloud...

and the host galaxy!
Subsample of Resolved Halos at z ~ 4 (80 total)
Observed Holes in Neutral Hydrogen: THINGS Survey

Simulated Holes in Neutral Hydrogen

Christensen+ 2012
SF correlates with the Lyman continuum escape fraction.

High-z low mass galaxies bursty!
Optical Depths Seen by One Individual Stellar Particle

Stellar Feedback + BH

23 Myr  0.062 $f_{esc}$

$\log \tau$

3/8/16  Aspen EoR

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Optical Depths Seen by One Individual Stellar Particle

Hole: shine free

Stellar Feedback + BH

56 Myr 0.096 $f_{esc}$

$\log \tau$

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Optical Depths Seen by One Individual Stellar Particle

Stellar Feedback + BH

90 Myr  0.15 $f_{esc}$

$\log \tau$

3/8/16
Optical Depths Seen by One Individual Stellar Particle

Stellar Feedback + BH

1.2e+02 Myr  0.035 $f_{esc}$

3/8/16

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Optical Depths Seen by One Individual Stellar Particle

Stellar Feedback + BH

1.6e+02 Myr  0.0096 $f_{esc}$
Optical Depths Seen by One Individual Stellar Particle

Stellar Feedback + BH
Black Holes Affect UV LF

\[
\phi(L) \quad \text{theory (CDM-motivated)}
\]

\[
L^* \sim 3 \times 10^{10} L_\odot
\]

Galaxy luminosity

SN

AGN

observations
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