Steep Faint-end Slopes of Galaxy Mass and Luminosity Functions at z ≥ 6 in Cosmological SPH Simulations

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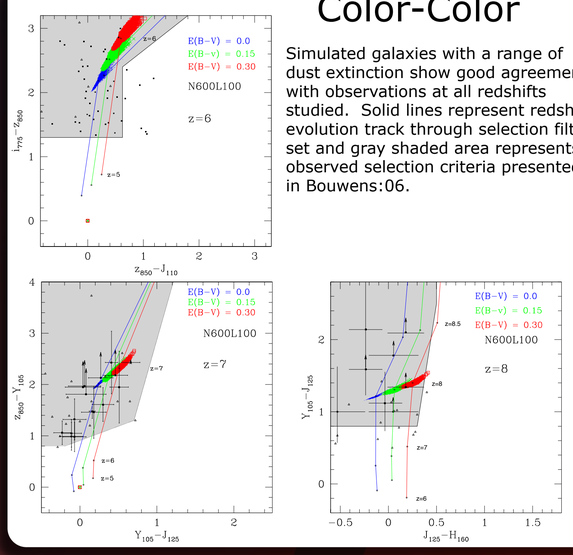
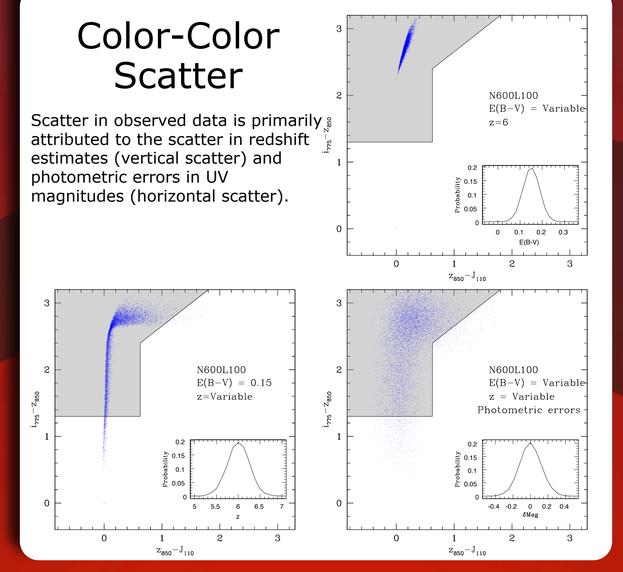
Color-Color



Simulated galaxies with a range of dust extinction show good agreement with observations at all redshifts studied. Solid lines represent redshift evolution track through selection filter set and gray shaded area represents observed selection criteria presented in Bouwens:06.

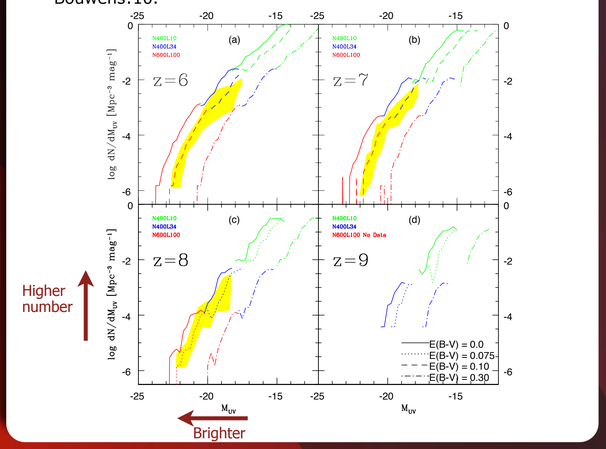
Color-Color Scatter

Scatter in observed data is primarily attributed to the scatter in redshift estimates (vertical scatter) and photometric errors in UV magnitudes (horizontal scatter).



Luminosity Function

Luminosity functions assembled by combining multiple box size runs, show the need for a small amount of dust extinction. E(B-V)=0.10 at z=6,7 and E(B-V)=0.075 at z=8. Yellow shade observed range taken data assembled in Bouwens:10.



Methods

- Simulation (Choi & Nagamine:09ab, 10):
  - Gadget-3 (Springel:05)
    - 400^3 & 600^3 particles x 2.
    - Multiple runs with different box sizes:
      - 10 Mpc, 34 Mpc, 100 Mpc.
- SED's:
  - Bruzual and Charlot 2007 Stellar Population Synthesis.
  - Madau Absorbtion in IGM (Madau: 95).
  - Calzetti Dust Extinction in ISM. (Calzetti:97)
  - Multiple dust extinction values E(B-V)=0.0, 0.075, 0.10, 0.15, 0.30
- Magnitudes: AB (Oke and Gunn '83)
  - Across HST filter sets
  - UV centered at 1700

Ω_m=0.26 Ω_Λ=0.76 Ω_b=0.044

h=0.72 σ_8=0.80

Run	Box-size (h^{-1}Mpc)	N_p (Dark Matter, Gas)	m_{DM} ($h^{-1}M_\odot$)	m_{gas} ($h^{-1}M_\odot$)	ϵ (h^{-1}kpc)	z_{end}
N400L10	10.0	2×400^3	9.37×10^5	1.91×10^5	1.0	2.75
N400L34	33.75	2×400^3	3.60×10^6	7.34×10^5	3.38	1
N400L100	100.0	2×400^3	9.37×10^6	1.91×10^6	6.45	0
N600L100	100.0	2×600^3	2.78×10^6	5.65×10^5	4.30	0

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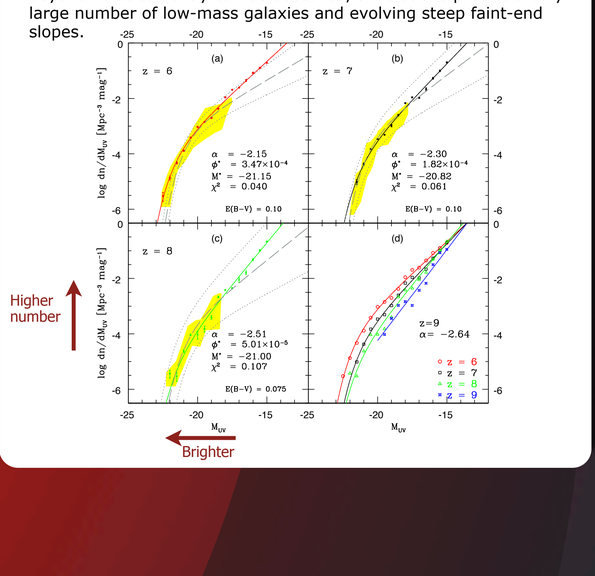
We present the results of a numerical study comparing photometric and physical properties of simulated z=6–9 galaxies to the observations taken by the WFC3 instrument aboard the Hubble Space Telescope. Using cosmological hydrodynamical simulations we find good agreement with observations in color-color space at all studied redshifts. We also find good agreement between observations and our Schechter luminosity function fit in the observable range, $M_{UV} \leq -18$. However beyond what currently can be observed, simulations predict a very large number of low-mass galaxies and evolving steep faint-end slopes from $\alpha_L = -2.15$ at z=6 to $\alpha_L = -2.64$ at z=9, with a dependence of $|\alpha_L| = (1+z)^{0.59}$. During the same epoch, the normalization ϕ_* increases and the characteristic magnitude M_{UV}^* becomes moderately brighter with decreasing redshift. We find similar trends for galaxy stellar mass function with evolving low mass end slope from $\alpha_M = -2.26$ at z=6 to $\alpha_M = -2.87$ at z=9, with a dependence of $|\alpha_M| = (1+z)^{0.65}$. Together with our recent result on the high escape fraction of ionizing photons for low-mass galaxies, our results suggest that the low-mass galaxies are important contributor of ionizing photons for the reionization of the Universe at z ≥ 6.

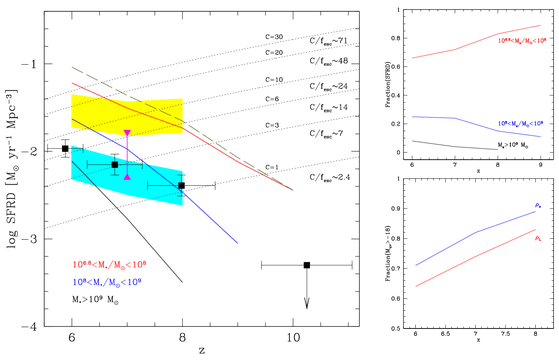
Schechter Fit

Schechter fits to UV luminosity functions agree well with observations with in the observable range, $M_{UV} \leq -18$. However beyond what currently can be observed, simulations predict a very large number of low-mass galaxies and evolving steep faint-end slopes.



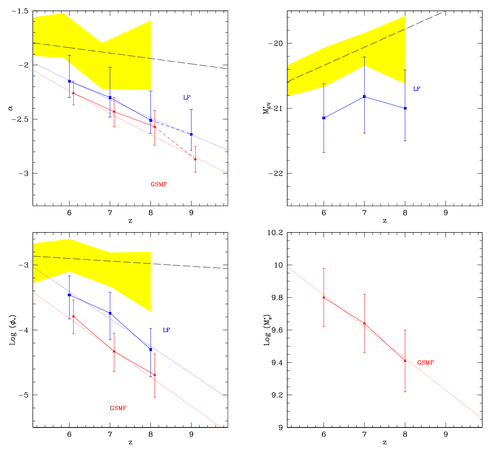
Reionization

We find that galaxies with $M_s = 10^{6.8} - 10^8\ M_\odot$ are the primary contributor to the total SFRD at z ≥ 6 and therefore to the ionizing photon budget as well. Our simulation suggests that these faint galaxies can reionize the Universe by z = 6 as long as the clumping factor is C < 30.



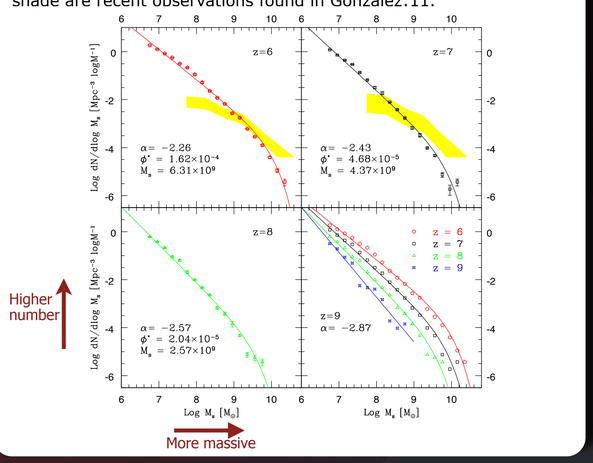
Schechter Parameter Evolution

Redshift evolution can be seen in all fit parameters for LF and GSMF, a trend which is seen in recent observations by Bouwens:11 and indicated by the yellow shaded area and dashed black line.



Galaxy Mass Function

Schechter fits to the galaxy stellar mass functions, here too we find redshift evolution of the Schechter fit parameters. Show in yellow shade are recent observations found in Gonzalez:11.



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