# The sizes & UV luminosities of high-redshift galaxies from DRAGONS

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# DRAGONS project

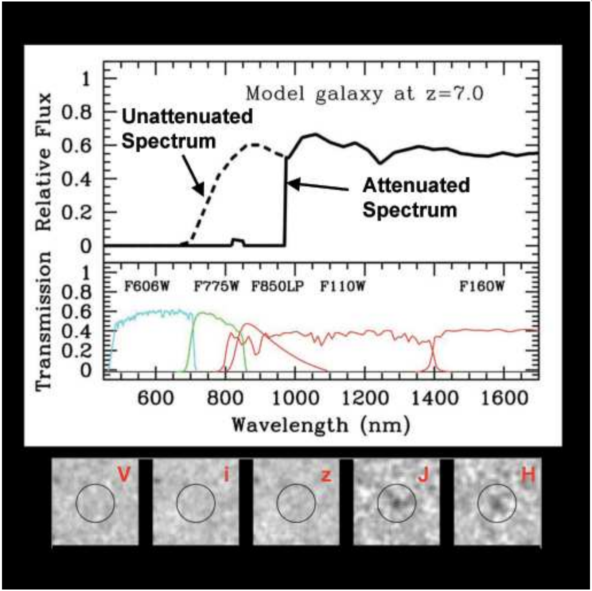
**D**ark ages **R**eionization **A**nd **G**alaxy formation **O**bservables from **N**umerical **S**imulations

**Paul Angel (Melb), Alan Duffy (Swin), Paul Geil (Melb), Chuanwu Liu (Melb), Andrei Mesinger (Pisa), Simon Mutch (Melb), Greg Poole (Melb), Yuxiang Qin (Melb) and Stuart Wyithe (Leader; Melb)**

- Dark matter N-body simulation TIAMAT **(Poole+2016; Angel+2016)**
  $L = 100$ Mpc, $N = 2160^3$, $m_{\rm p} = 2.64 \times 10^6 {\rm M}_\odot$, $\Delta t = 11$ Myr.
- Semi-analytic model MERAXES **(Mutch+2016, in press)**
  Including strong feedback from supernovae and photoionization background.
- UV luminosities from stellar population syntheses **(Liu+2016, in press)**
  Lyman-$\alpha$ absorption, dust attenuation, LBG selection.

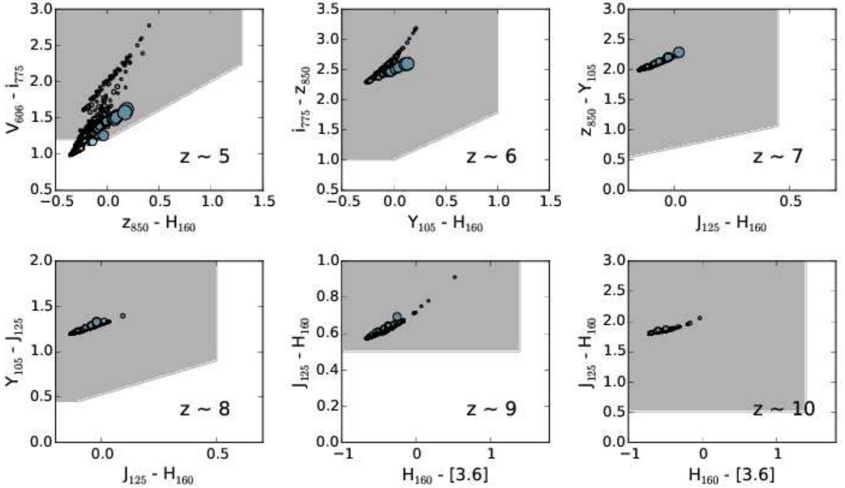
# Lyman-break galaxies

Credit: R. Bouwens



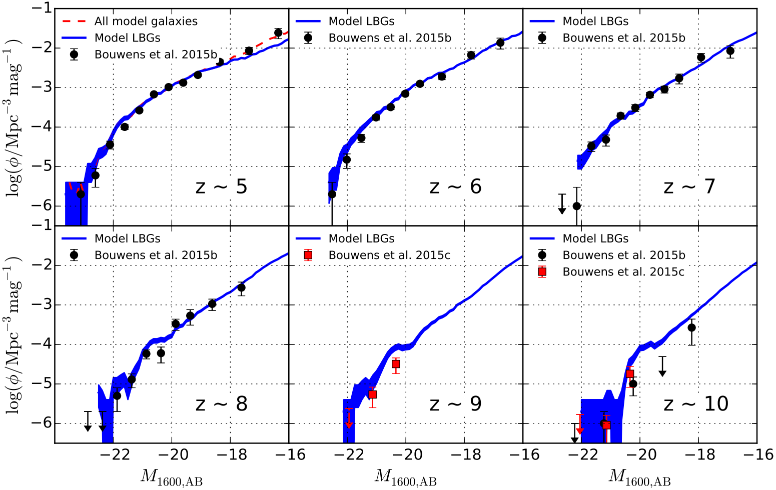
# Lyman-break selection criteria

Liu+2016, in press



# UV luminosity functions of galaxies

Liu+2016, in press



# UV luminosity functions of galaxies

Liu+2016, in press

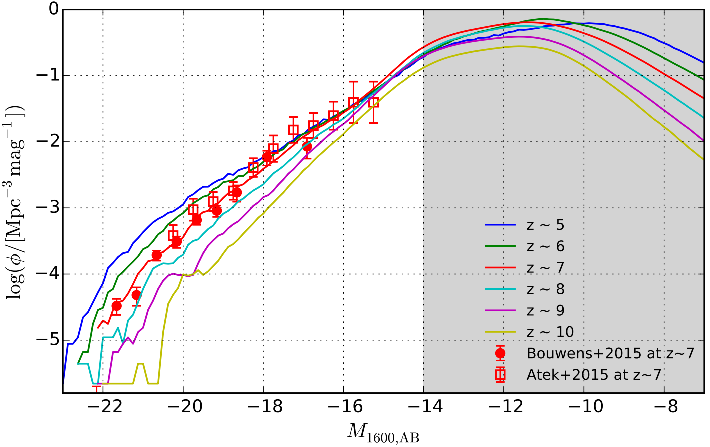



Figure: UV LFs for model galaxies at $z \sim$ 5–10. The slope of UV LFs remains steep below current detection limits until at least $M_{\rm UV} \sim -14$.

# UV flux from faint galaxies

Liu+2016, in press

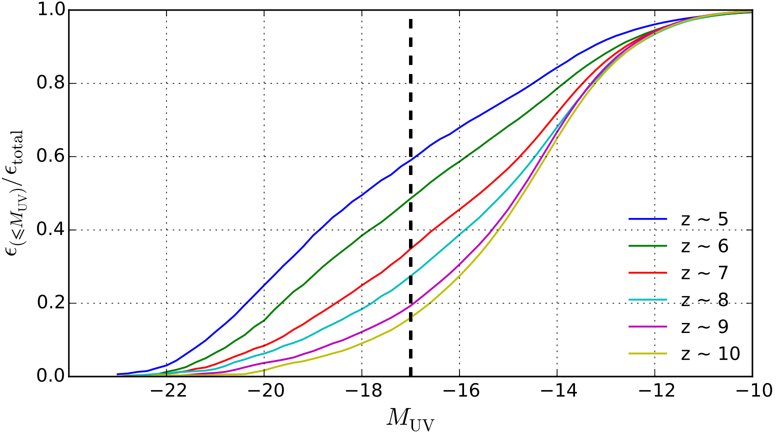



Figure: The cumulative fraction of UV flux from model galaxies brighter than the luminosity limit $M_{\rm UV}$.

# Luminosity–halo mass relations of Galaxies

Liu+2016, in press

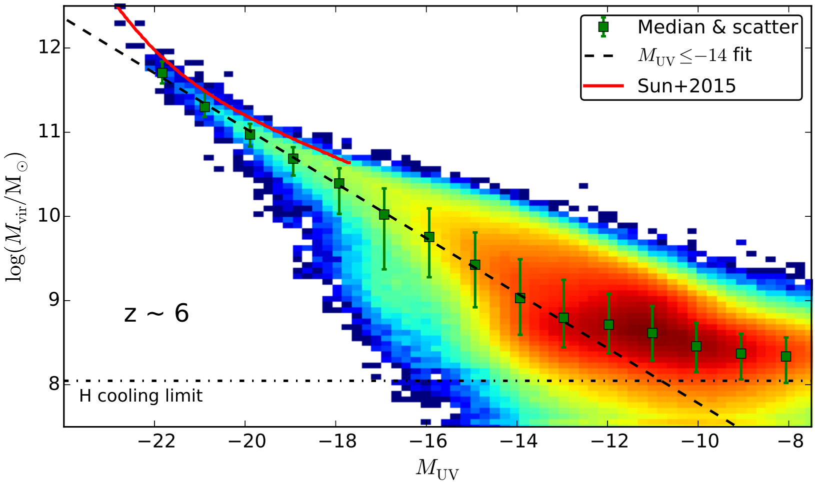
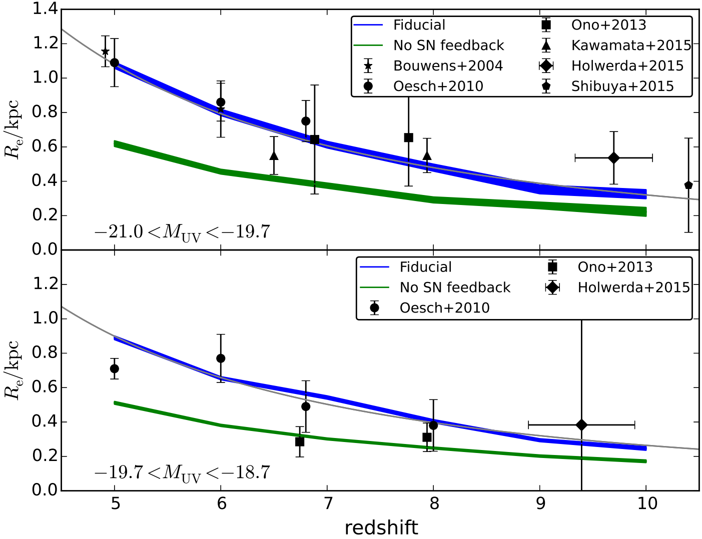



Figure: The luminosity–halo mass relation for model galaxies at $z \sim 6$. We find $M_{\rm vir} \propto 10^{-0.35 M_{\rm UV}}$ ($M_{\rm vir} \propto {L_{\rm UV}}^{0.88}$) for galaxies with $M_{\rm UV} < -14$.

# Size evolution of galaxies

Liu+, in preparation



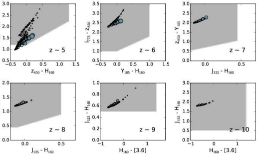
# Summary

By using stellar population syntheses with the star formation histories from the semi-analytic model in DRAGONS, we successfully reproduce UV LFs and sizes for high-$z$ galaxies. We find that:

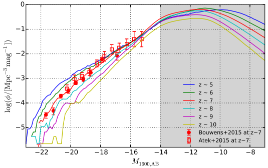
- **The slope of UV LFs remains steep below current detection limits until $M_{\rm UV} \gtrsim -14$.**
- **At $z \geq 7$, galaxies fainter than $M_{\rm UV} = -17$ are the dominant contributors of UV flux.**
- **The luminosity-halo mass relation has the form $M_{\rm vir} \propto L_{\rm UV}^{0.88}$ at $M_{\rm UV} < -14$.**
- **The evolution of galaxy sizes provides an additional probe for understanding galaxy formation during the EoR.**

Thank you!

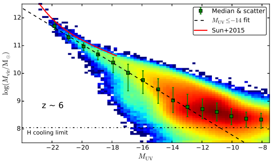
## Page 4: LBG selection



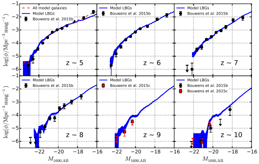

## Page 6: Faint-end UV LFs




## Page 8: L-$M_\mathrm{h}$ relation

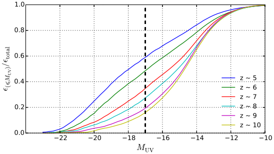



## Page 5: UV LF comparison

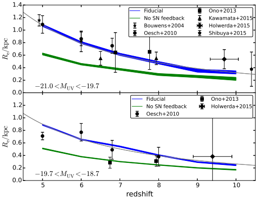



# Thank you!

## Page 7: UV contribution




## Page 9: galaxy sizes




File: http://www.ph.unimelb.edu.au/∼chuanwul/

# Transitions

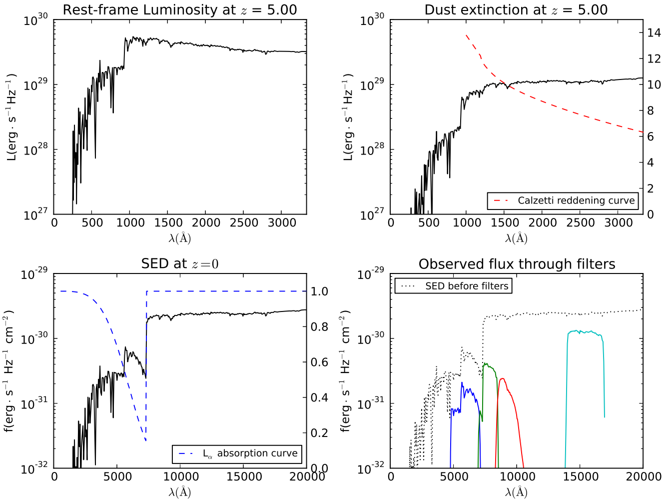



Figure: Example for a $z \sim 5$ model galaxy ($M = 10^{10} M_{\odot}$)

## UV luminosity functions of galaxies

Liu+2016, in press

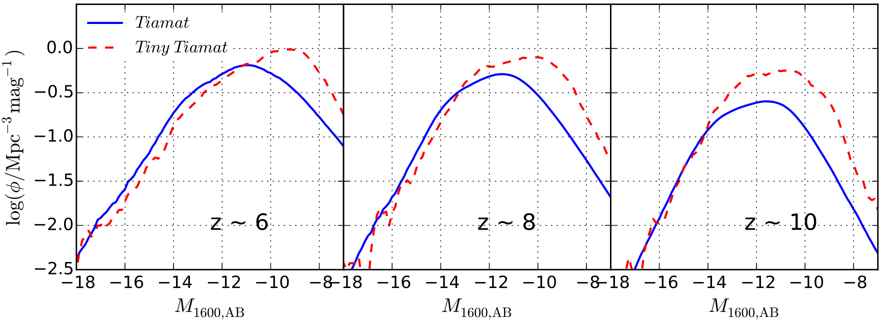



Figure: UV LFs for model galaxies at $z \sim 6$, 8 and 10. The slope of UV LFs remains steep below current detection limits until at least $M_{\mathrm{UV}} \sim -12$ for Tiny Tiamat which has higher mass resolution.

# UV flux from faint galaxies

Liu+2016, in press

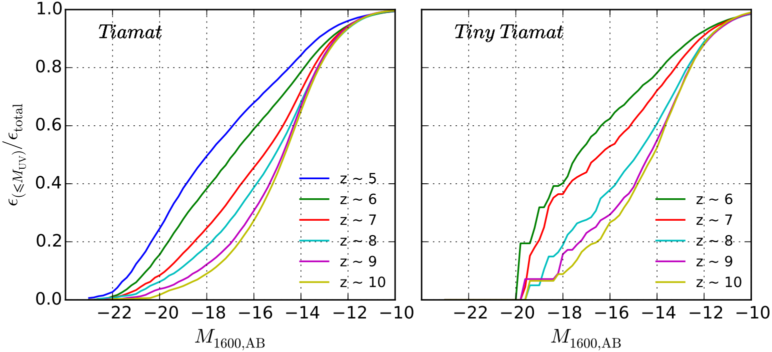



Figure: The cumulative fraction of UV flux from model galaxies brighter than the luminosity limit $M_{\rm UV}$.

## Determining galaxy sizes

$$R_{\rm e} = 1.678 R_{\rm d} \tag{1}$$

$$R_{\rm d} = \frac{\lambda}{\sqrt{2}} \left( \frac{j_d}{m_d} \right) R_{\rm vir} \tag{2}$$

$$\lambda = \frac{J_{\rm vir}}{\sqrt{2} M_{\rm vir} V_{\rm vir} R_{\rm vir}} \tag{3}$$