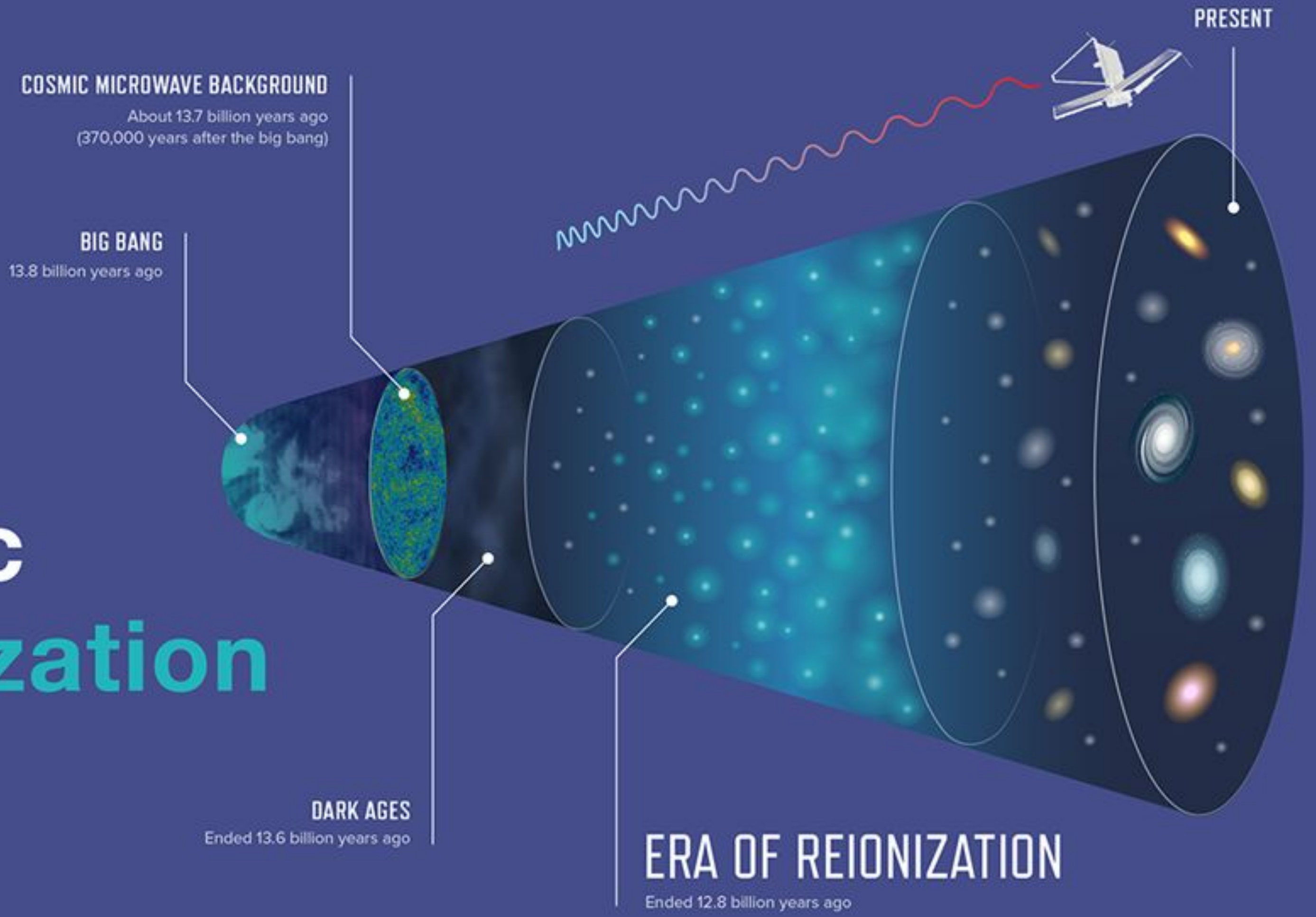
Lyman Break Galaxies and Lyman Alpha Emitters at $z > 6$: Implication on reionization

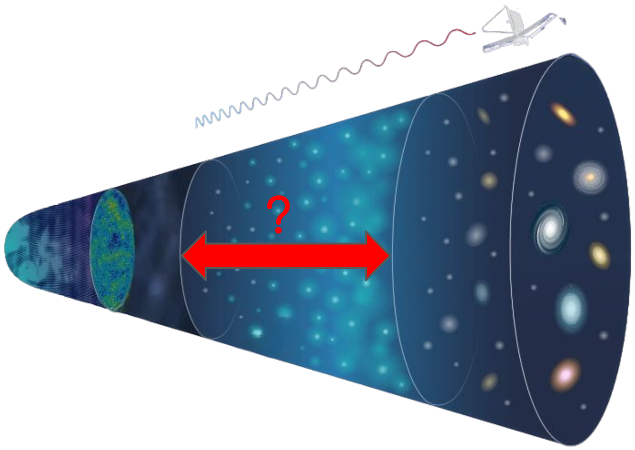
Prajnadipt Ghosh

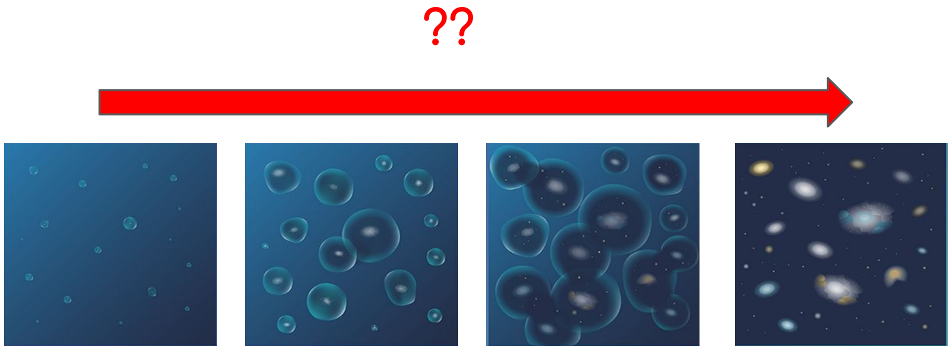
Cosmic Reionization



Credits: NASA, ESA, CSA, Joyce Kang (STScI)

the whys and the hows..



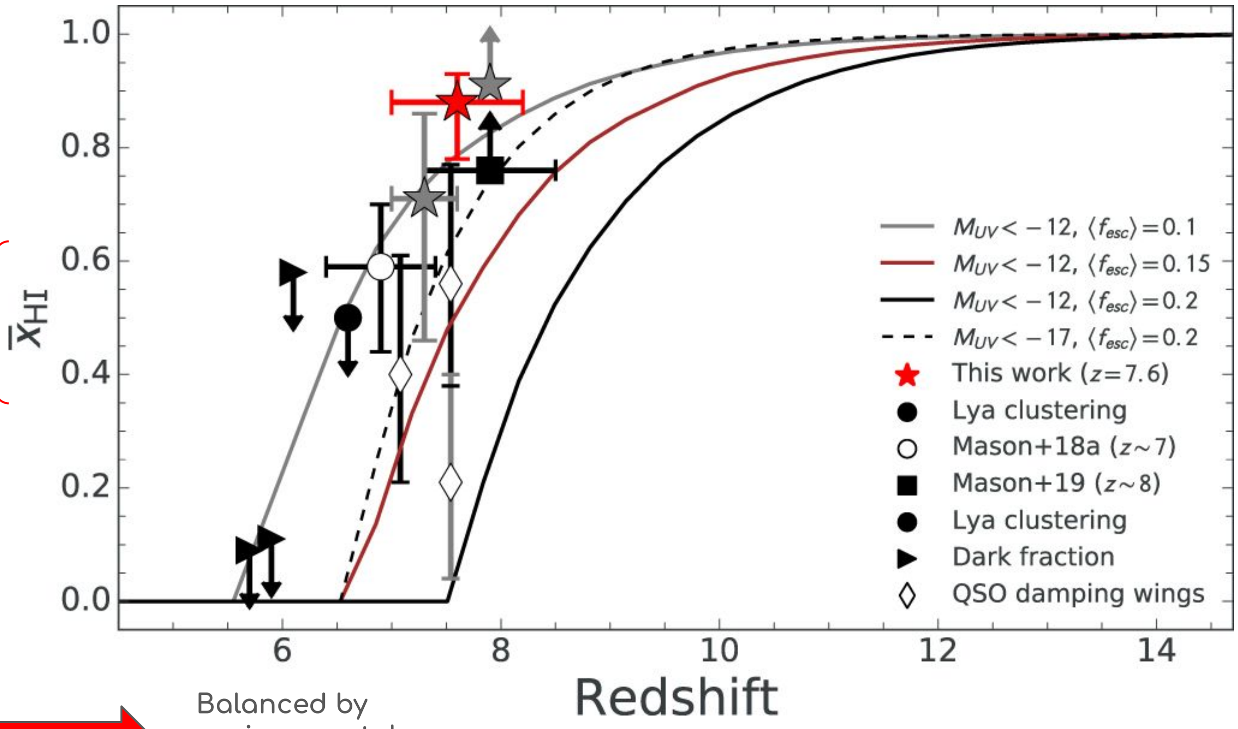


Timeline of reionization

Topology of the reionization

Timeline of reionization

Hoag + 19

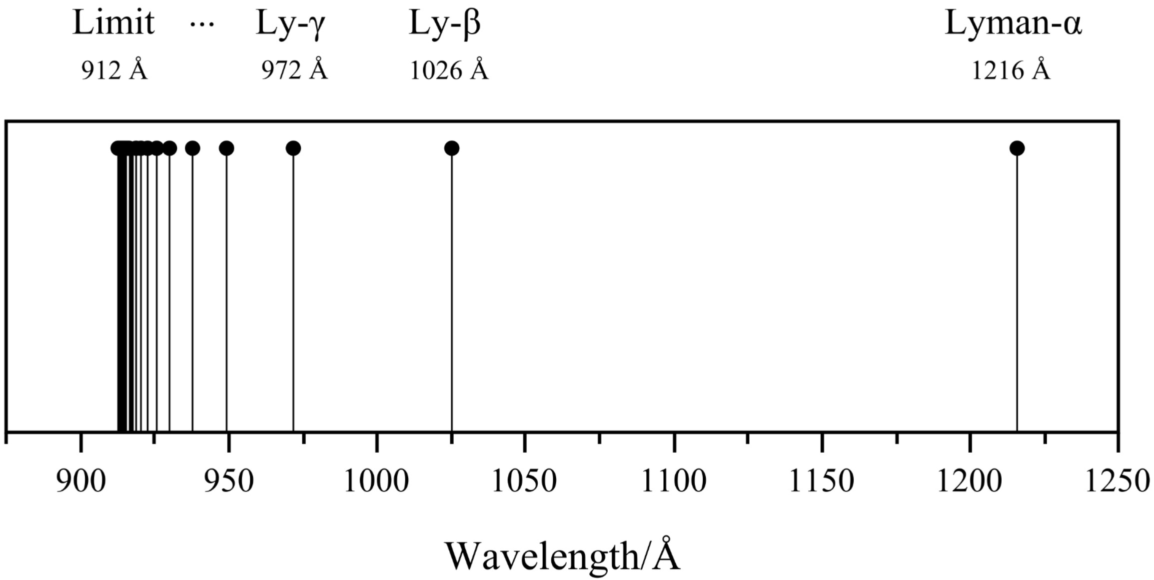


Neutral hydrogen fraction

Less M_{UV} more galaxies, faster reionization

Balanced by environmental factors like f_{esc}

Lyman Continuum photons (LyC)

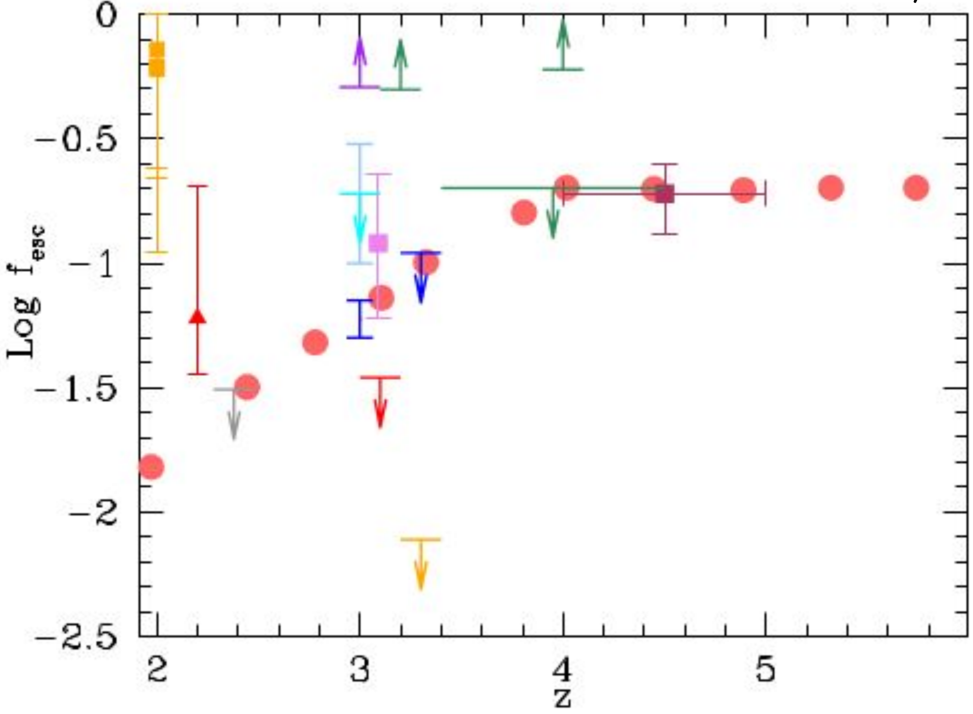


Credits: Wikipedia

Escape Fraction

Important Reionization quantity

Dayal+18



Reionization Sources

Galaxies

Quasars

Reionization Sources

Galaxies

Quasars

1000 times rarer than galaxies

How do we detect these sources?

To detect high-z galaxies we exploit the IGM and the properties of their young stellar populations based on their imprint on the IGM!

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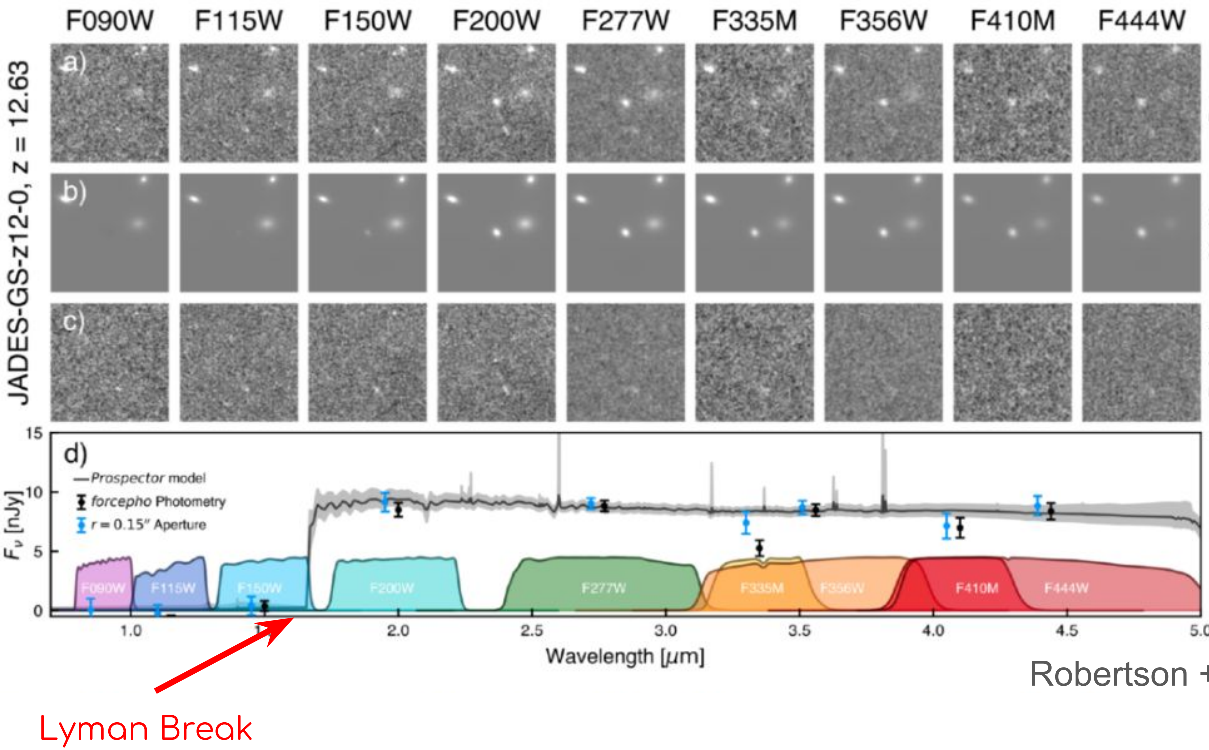
Based on technique of detection, there are two main types of galaxies:

a) Lyman Break Galaxies (LBG's)
b) Lyman Alpha Emitters (LAE's)

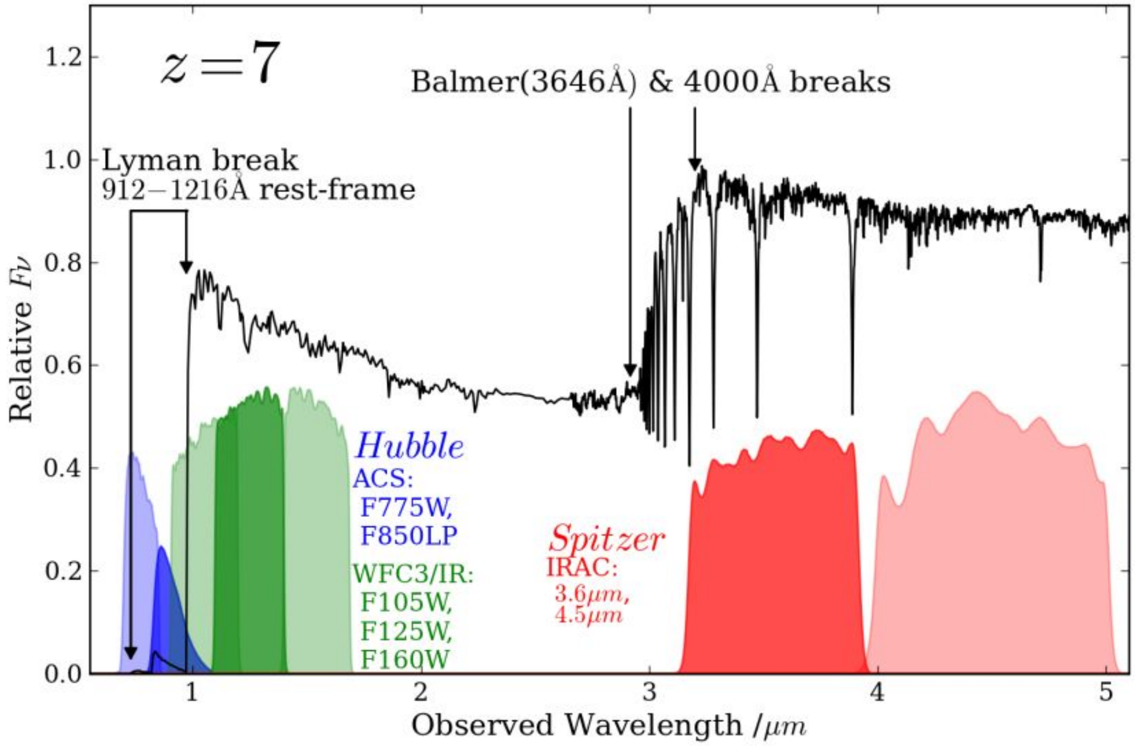
a) Lyman Break Galaxies



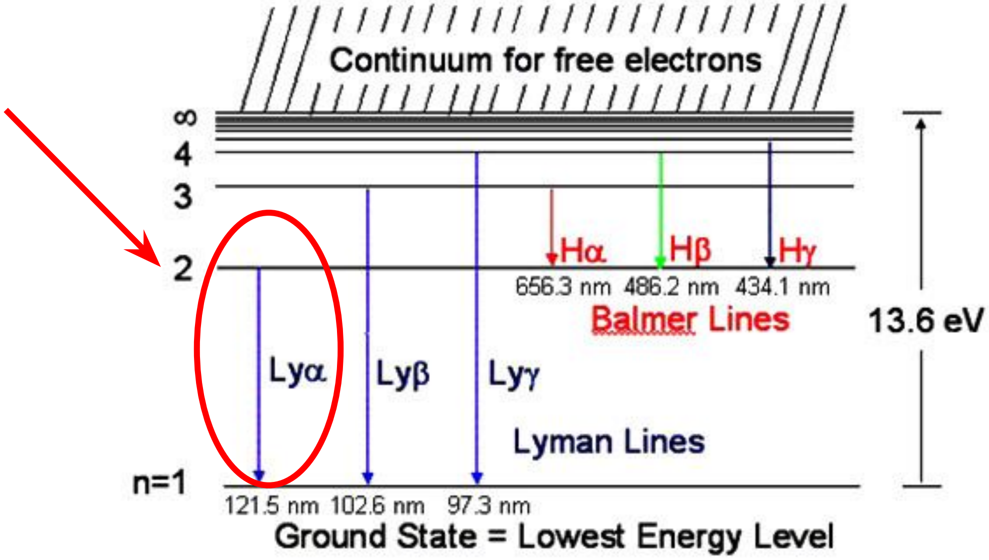
Robertson + 23

a) Lyman Break Galaxies

Dunlop+12

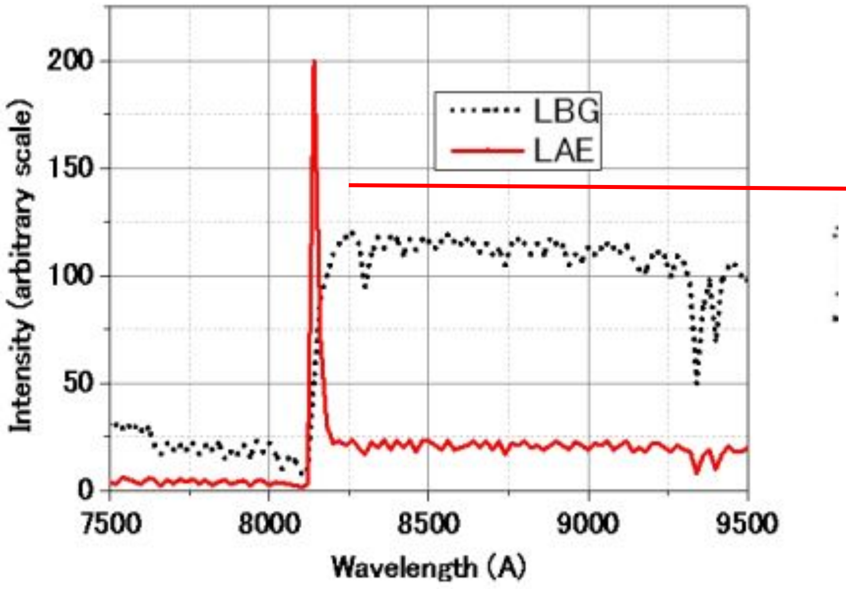


b) Lyman Alpha Emitters



b) Lyman Alpha Emitters

Dunlop+12



One of the strongest feature of star forming galaxies

b) Lyman Alpha Emitters

- Case B Recombination approximation: assuming recombined HI is optically thick and there is 2/3rd probability of a recombination leading to a Lyα photon:

$$L_\alpha = \frac{2}{3}(1 - f_{esc})\,\dot{N}_s h\nu_\alpha [\mathrm{erg\,s^{-1}}]$$

- High optical depth against neutral hydrogen atom (Madau+00)

$$\tau_\alpha = \frac{\pi e^2 f \lambda_\alpha}{m_e c H(z)} \chi_{HI}(z) n_H(z) \approx 1.5 \times 10^5 \chi_{HI}(z) h^{-1} \Omega_M^{-\frac{1}{2}} \left(\frac{\Omega_b h^2}{0.019}\right) \left(\frac{1+z}{8}\right)^{\frac{3}{2}}$$

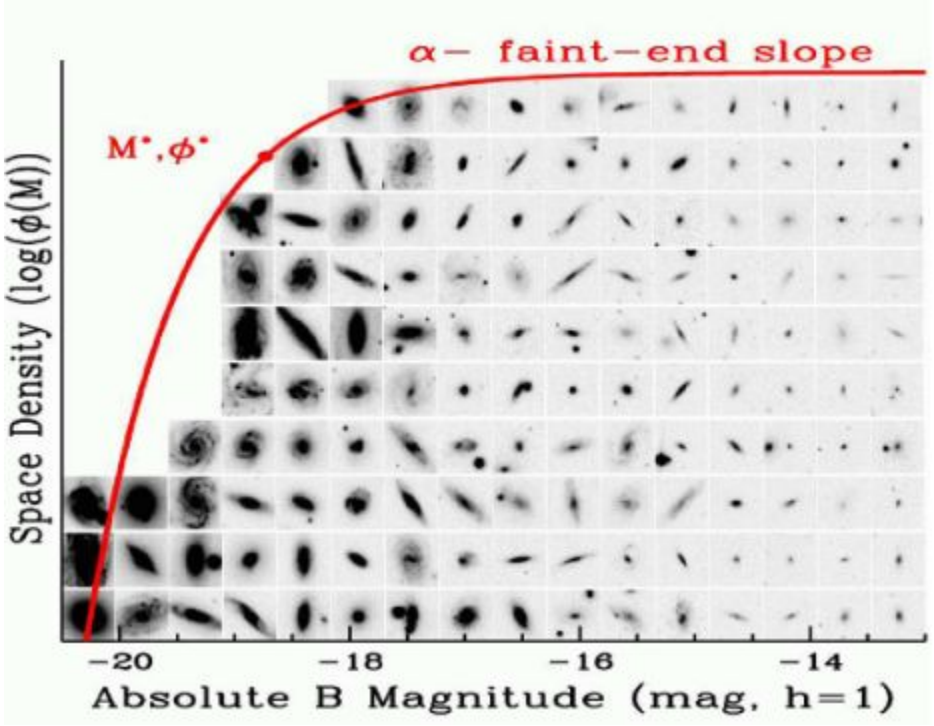
Luminosity Function

- Best way to summarise the demographics of the high redshift galaxies

$$\frac{dn}{dL} = \phi(L) = \left(\frac{\phi^*}{L^*}\right)\left(\frac{L}{L^*}\right)^{\alpha} e^{-(L/L^*)}$$

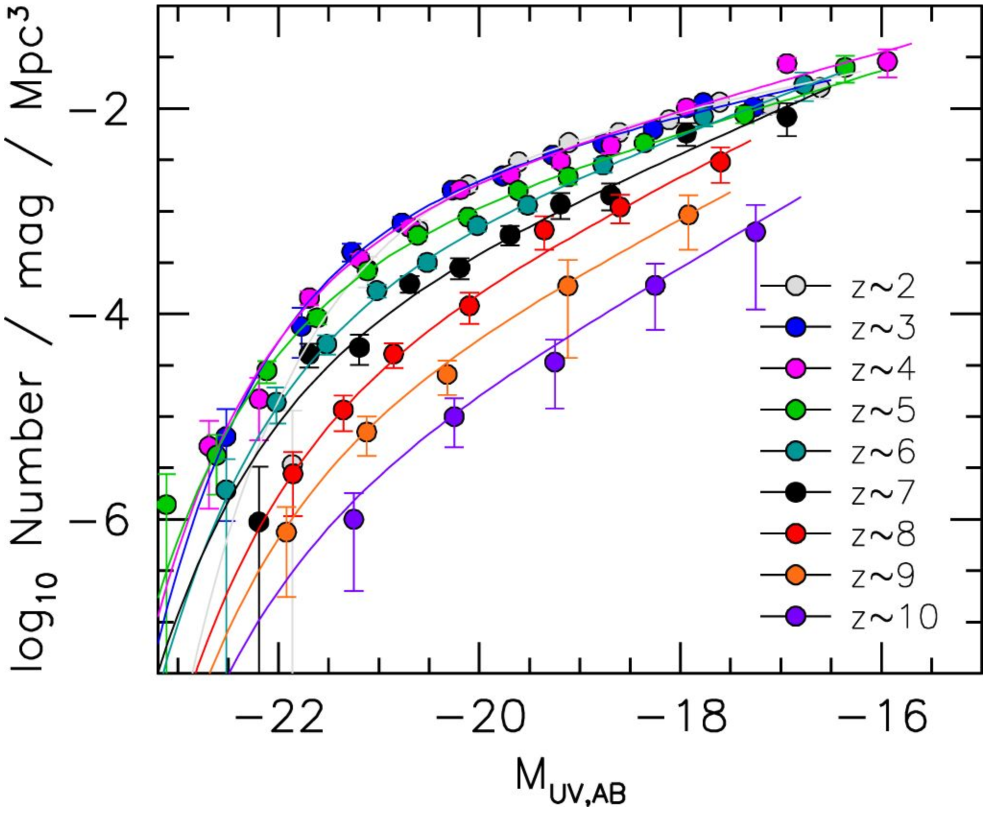
Schechter Function

Important tool to calculate SFRD and total number of ionizing photons produced



LBG Luminosity Function

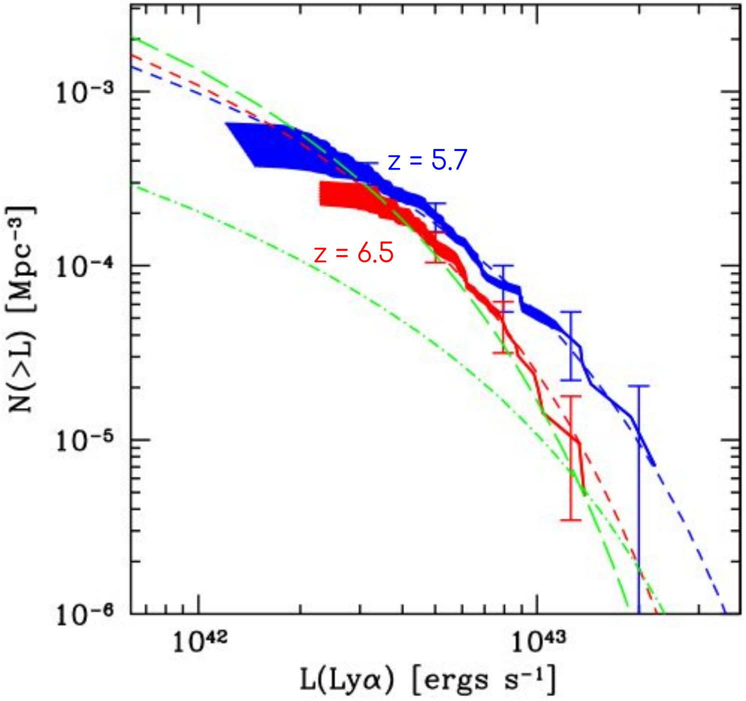
Bouwens+21



Number density of LBG's decrease with increasing redshift

LAE Luminosity Function

Kashikawa+11

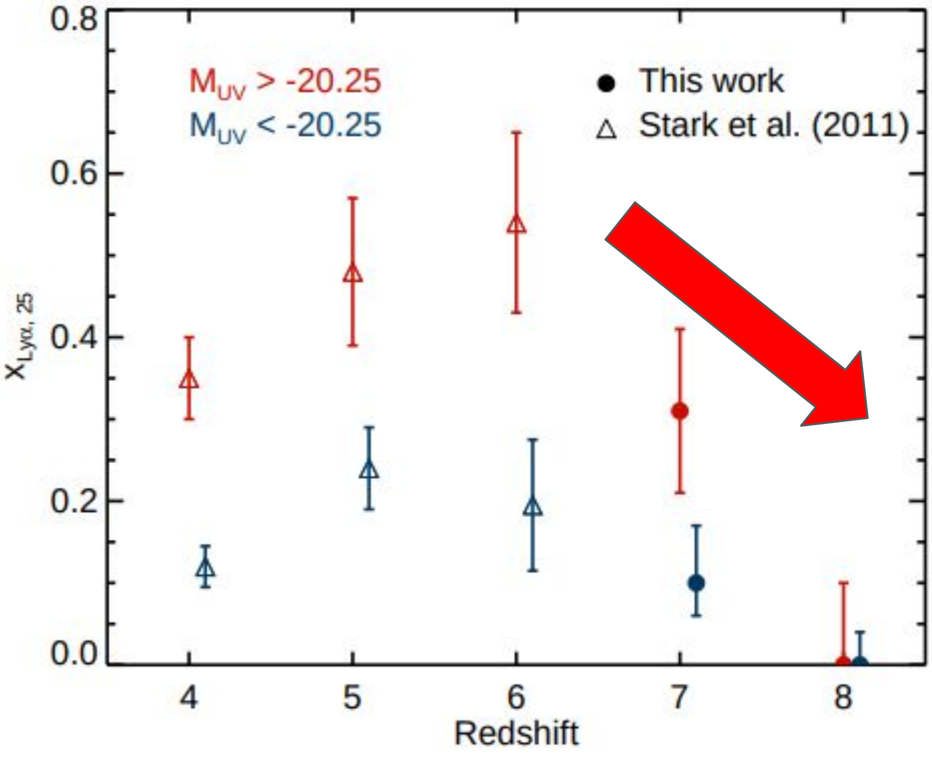


Dotted line represent best Schechter fit

Lyman Alpha Emitters

Schenker+14

Fraction of LBG also emitting LAE



How to resolve this discrepancy?

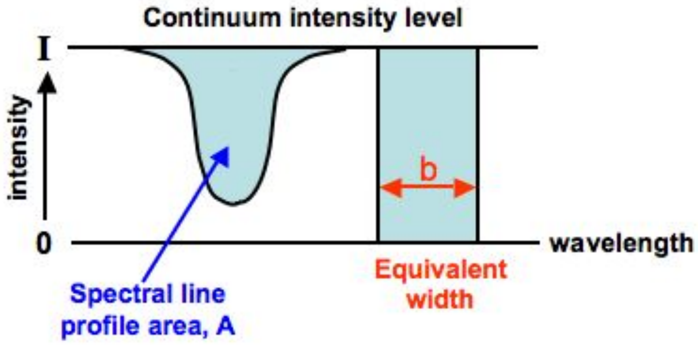
- Late reionization?
- is the reionization taking place slowly? Is the universe not completely neutral by z ~ 6 ?

- Dust extinction?
- is the interstellar dust obscuring the Lyα?

How to resolve this discrepancy?

- The line strength of a spectral line is measured using **Equivalent width.**

- Equivalent width is the ratio of peak flux of the spectral line to that of the continuum.



- $EW_{obs} = T \times EW_{emitted}$. T can be modelled as $P(T|\overbrace{\overline{x_{HI}}}^{\text{Medium properties}}, \underbrace{M_h, M_{UV}, \Delta v}_{\text{Galaxy Properties}})$

$$T = 1 - e^{-\tau_{eff}}$$

Effective optical depth

Conclusion

- Cosmic Reionization is poorly understood in terms of its timeline and the topology.
- The less understood reionization stems from poor understanding of the reionization sources especially the LAEs and how they affect the environment around it.
- Reionization is a multiscale problem, hence we need to understand how the IGM, ISM and the CGM evolve.
- Various techniques like high resolution simulations, forward modelling are used to understand the nature of the high z galaxies and the effect on transmission.

Thank you!