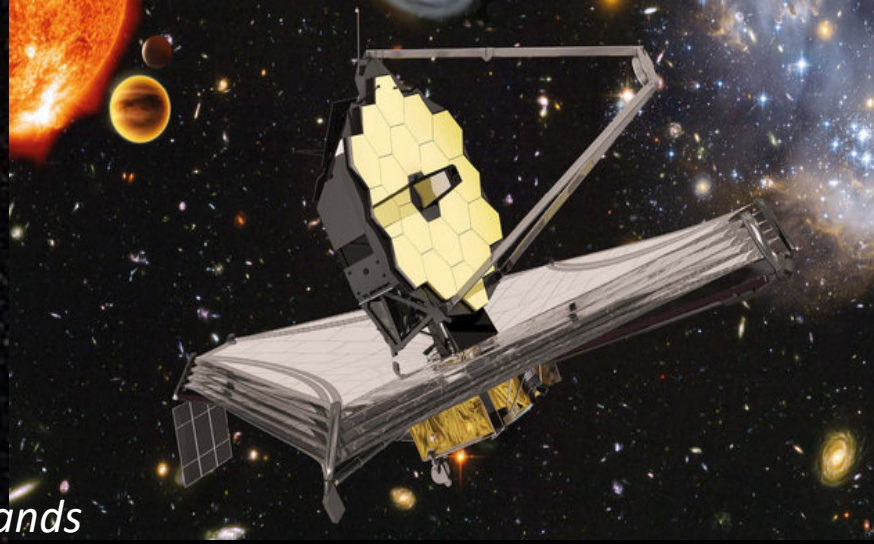
Studying the High Redshift Universe Combining Hubble, Webb, and Gravitational Lensing

Rachana Bhatawdekar

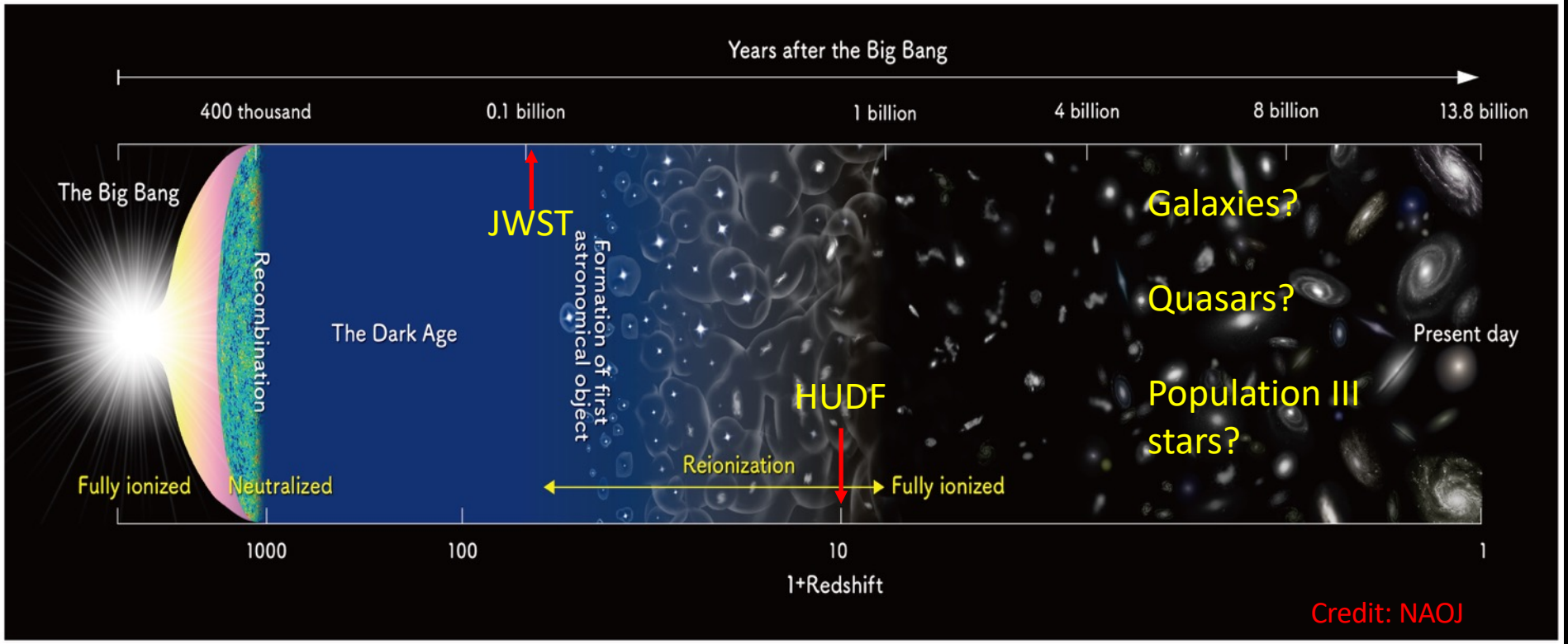
European Space Agency, ESA/ESTEC, Netherlands

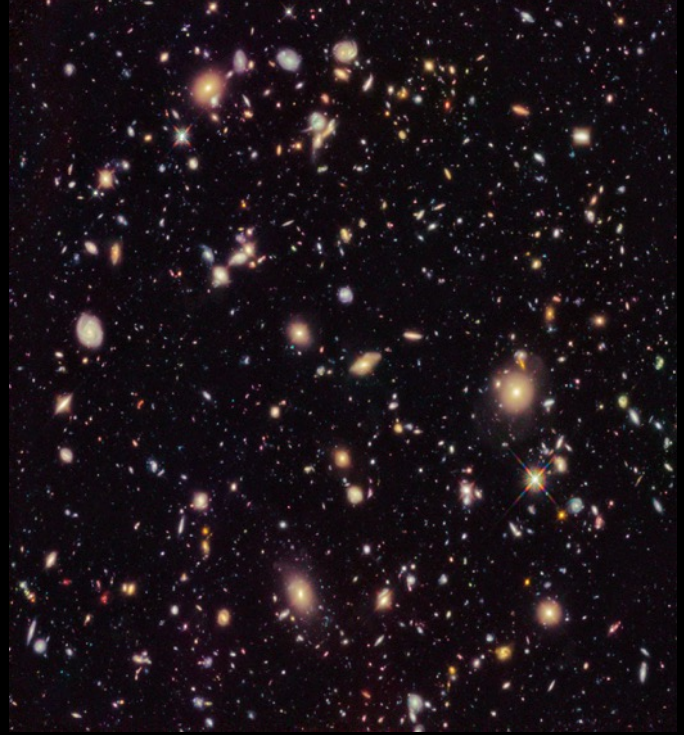
and *Christopher Conselice*
University of Nottingham

Rachana.Bhatawdekar@esa.int
AstroRach
+44 - 7564061028



Epoch of Reionization





Hubble Ultra Deep Field (HUDF)
Credit: NASA, ESA, R. Ellis (Caltech), and the HUDF 2012 Team

Hubble Ultra Deep Field (HUDF) showed a plethora of faint galaxies

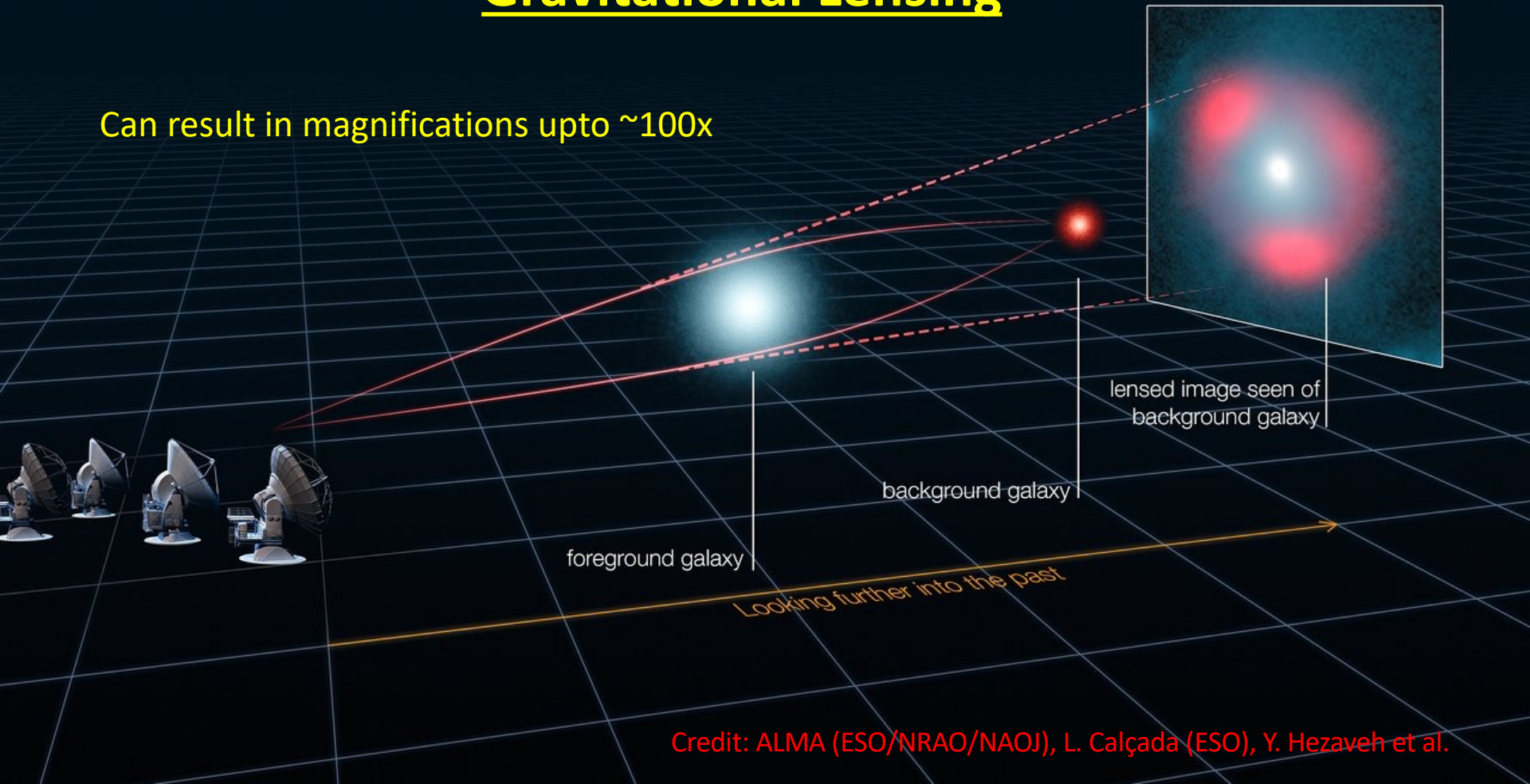
Early star-forming galaxies best candidates to drive reionization (Finkelstein et al 2015, Bouwens et al 2015).

Galaxy powered reionization – Early Universe must be significantly ionised by faint galaxies

Need to observe galaxies ~ 100× fainter than the HST limits (M_{UV} ~−17 AB). (Finkelstein et al. 2015; Robertson et al. 2015)

Gravitational Lensing

Can result in magnifications upto ~100x



Credit: ALMA (ESO/NRAO/NAOJ), L. Calçada (ESO), Y. Hezaveh et al.

Hubble Frontier Fields

Abell 2744

MACSJ0416

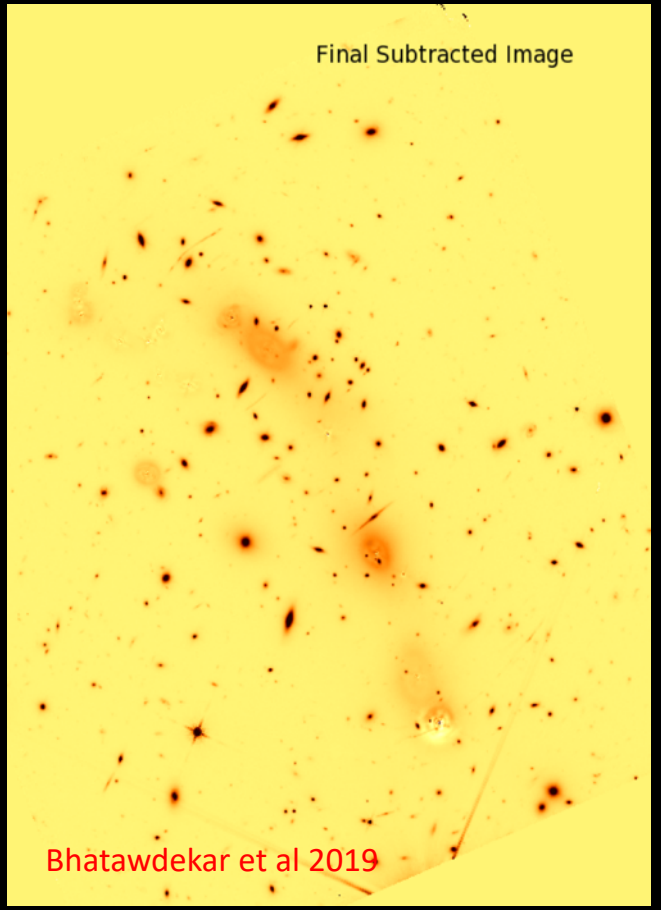
MACS1149

MACSJ0717

Abell 370

Abell S1063


Foreground light inhibits the detection of faint sources!
MACSJ0416 cluster
Credit: NASA, ESA


Final Subtracted Image
Bhatawdekar et al 2019

What we discovered?

- We have discovered the lowest mass galaxies ($10^{6.8}$ $M_{\odot}$) for the very first time with HFF

- We have discovered galaxies as faint as absolute magnitude (M_{UV}) = −13.5 (approx. 40 times fainter than what Hubble can observe)

- We found more low mass galaxies in the early Universe than previously observed with Hubble alone

Pop III stellar populations??

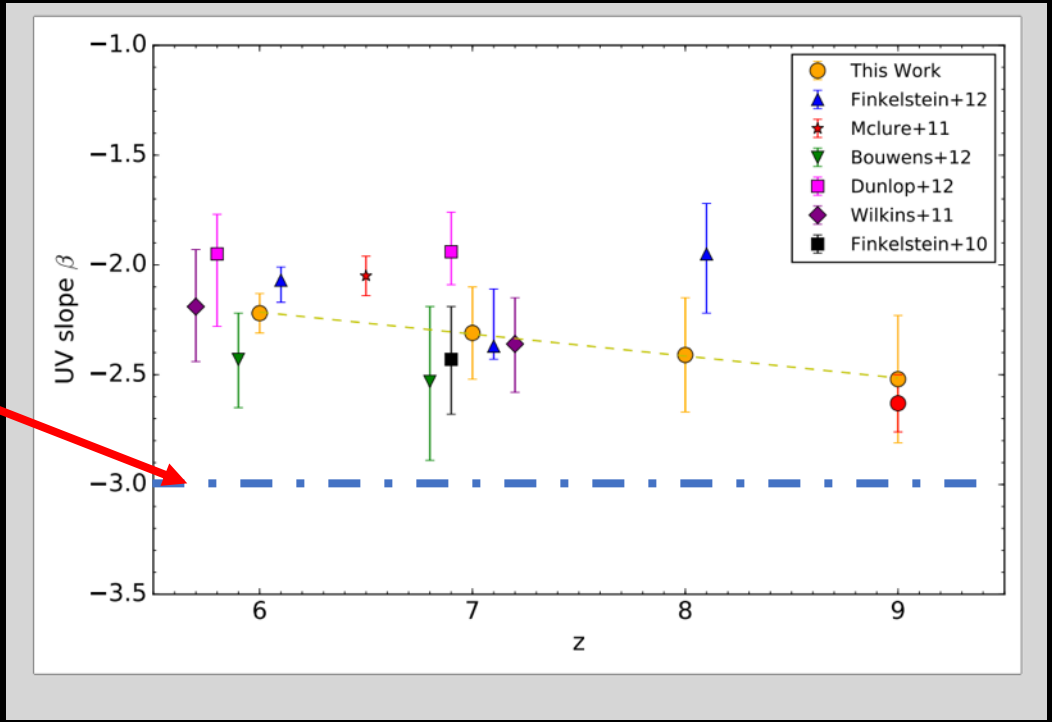
(Very first generation of stars)

- ”First-born” stars composed entirely of pristine gas –hydrogen, helium
- Extremely Hot, massive stars → blue (much bluer than any star with normal metals/elements other than hydrogen and helium)
- UV colours (β)→ UV light reveals ongoing star formation

Colours of our sample of galaxies

Expected colours of galaxies with stars of very little metals (elements other than hydrogen and helium)

No evidence as of yet for extreme stellar populations!



Bhatawdekar et al. 2020 (submitted), arXiv:2006.00013

Results

- We have discovered the lowest mass galaxies ($10^{6.8}$ $M_{\odot}$) for the very first time with Frontier Fields

- We found more low mass galaxies in the early Universe than previously observed with Hubble alone

- We find a lack of evidence for exotic or Pop III Stellar Populations when the Universe was ~500 million years old

What these results tell us?

- Strongly support the idea that low mass/faint galaxies in the early Universe are responsible for reionization.

- Formation of the first stars and galaxies in the Universe is even earlier than Hubble can probe.

Future

- Shows the potential science that can be done with lensing + JWST

- JWST will look even further back in time and provide a clearer picture of the first stars and first galaxies.

Contact information and URL for press release

Email: Rachana.Bhatawdekar@esa.int

Press release : www.spacetelescope.org/news/heic2010

Twitter: AstroRach