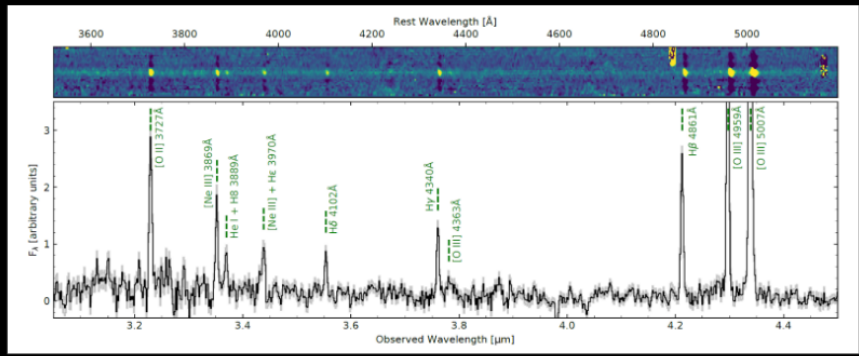
The chemical enrichment in the early Universe as probed by JWST via direct metallicity measurements at z ~ 8.
By Mirko Curti +, Sept 2022.
Review by Omar French
Summary:

1. Before JWST, galaxy metallicity was not inferred for redshifts $z > 4$. With JWST, this paper achieves that for the first time (at $z \sim 8$, or ~13.2 Gyr lookback time) using direct electron temperature method.
2. For these galaxies, dust attenuation appears to play an unimportant role in absorbing/scattering light.
3. The ratio O[II]/Hβ is low but O[III]/O[II] is very high, indicative of photoionization from a metal-poor galaxy.
4. Galaxy mass-metallicity models applicable to the $z < 4$ regime do not seem able to explain the inferred metallicities at $z \sim 8$. The authors speculate this results from a lack of equilibrium between the cycle of supernovae, ISM metal enrichment, and star formation.

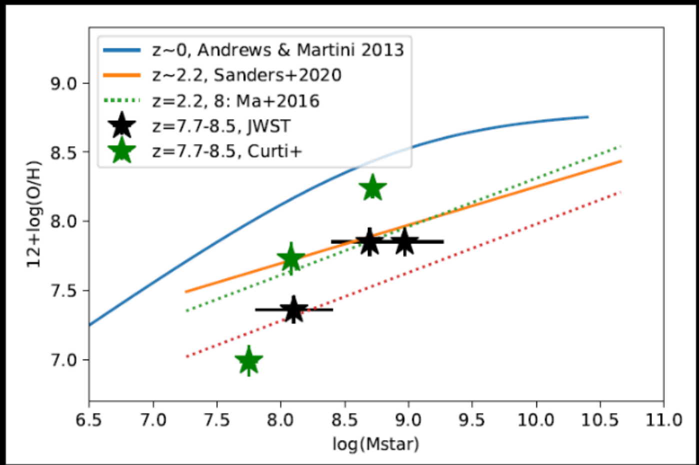
Galaxy Cluster SMACS 0723, From JWST

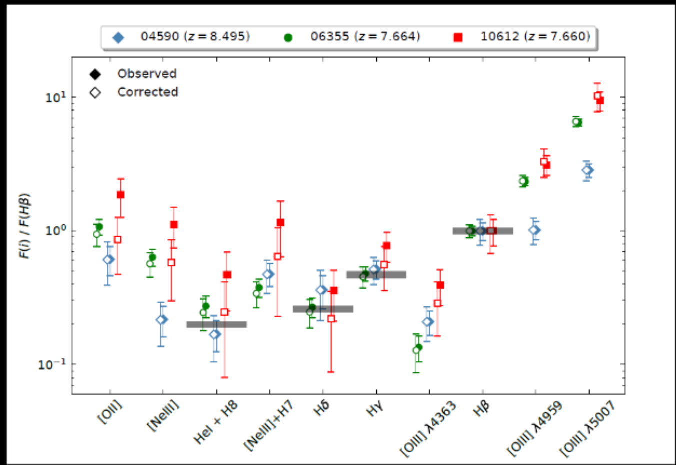
First look with JWST spectroscopy: z ~ 8 galaxies resemble local analogues

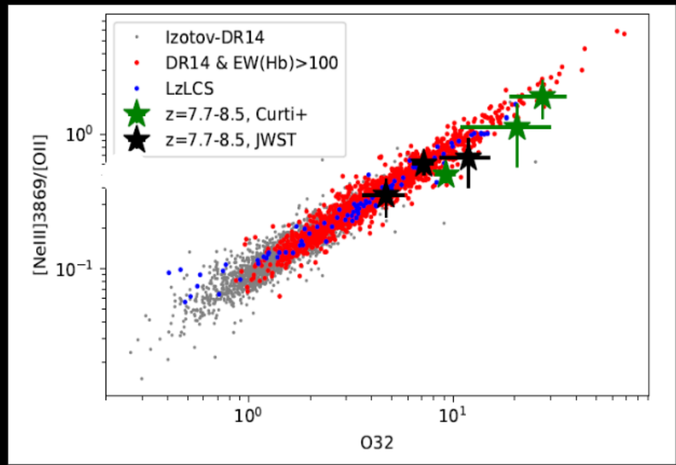


Summary:

- Measure spectra of 3 high-z galaxies
- Determine line ratios
- Compare ratios and galaxy properties







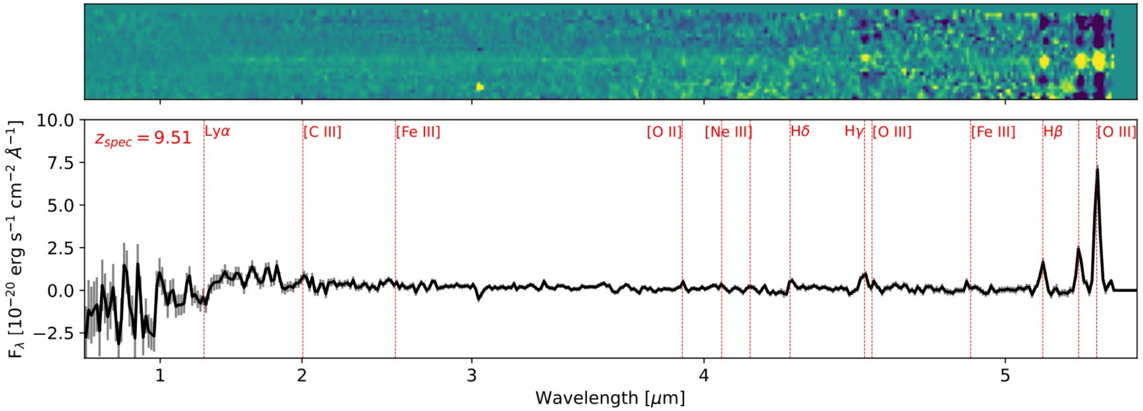
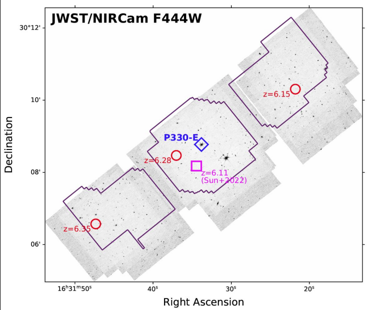


Fig. 2: Fully reduced NIRSpec PRISM 1D and 2D spectra of galaxy ID 11027 ($z_{spec} = 9.51$), with the identified emission lines shown in red and the 1σ uncertainties shown in gray. Flux measurements of the emission lines are given in Table 1 and Gaussian fits for each emission line are shown in Figure S3. The spectrum is not corrected for magnification due to lensing.

SPECTROSCOPY FROM LYMAN Α TO [O III] Λ5007 OF A TRIPLY IMAGED MAGNIFIED GALAXY AT REDSHIFT Z = 9.5

Hayley Williams et al. (2022)

First Sample of Hα+[O III] λ5007 Line Emitters at z > 6 through JWST/NIRCam Slitless Spectroscopy: Physical Properties and Line Luminosity Functions by Sun et al.



ATOMIC AND MOLECULAR PHYSICS

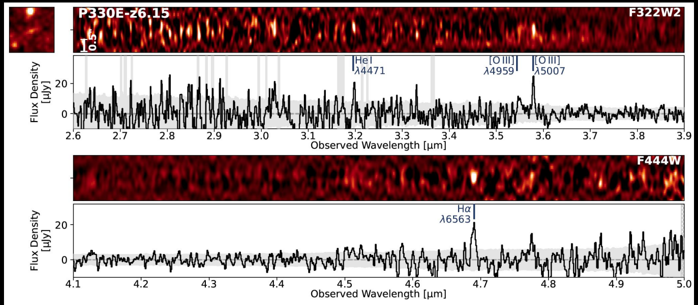
- Ionizing photon production efficiency (ξ_{ion})

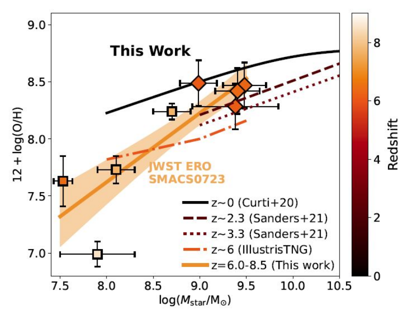
$$\xi_{\rm ion} = N(\mathrm{H}^0)/L_{\rm UV}$$
$$N(\mathrm{H}^0) = 7.35 \times 10^{11} L_{\mathrm{H}\alpha}$$

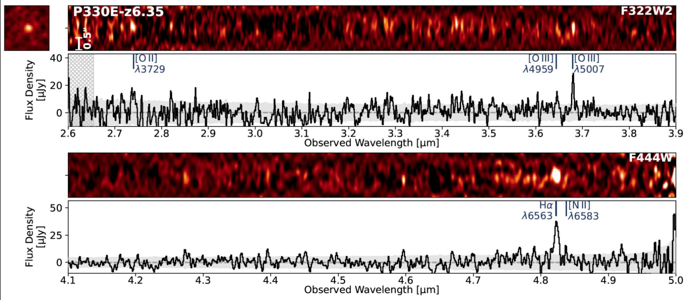
- Metallicity
  - Abundance of elements present in an object that are heavier than hydrogen and helium.
  - Object's age, history, or genesis
  - 12 + log(O/H) = 8.5±0.2.

- Luminosity function:

$$\Phi(L) = \frac{1}{d\log L}\sum_i \frac{1}{C_i V_{\max,i}}$$







Judit Bergfalk

Summary (Laporte+ 2015)

1. Bright Lyα emission at high z → Distinct Property?
    - 1 out of 3 z~6-7 luminous UV galaxies shows bright & broad Lyα

      ∴ the hypothesis is still supported (?)
2. Non-thermal radiation field (e.g., AGNs) responsible for the ionized bubbles? → Maybe? Or location @ Over-density?
    - COSY: hard AGN component: broad Lyα, He II & N V
    - COSz1: normal SFG: C III]: nebular line
    - COSz2: normal SFG: broad Lyα BUT no AGN key lines.

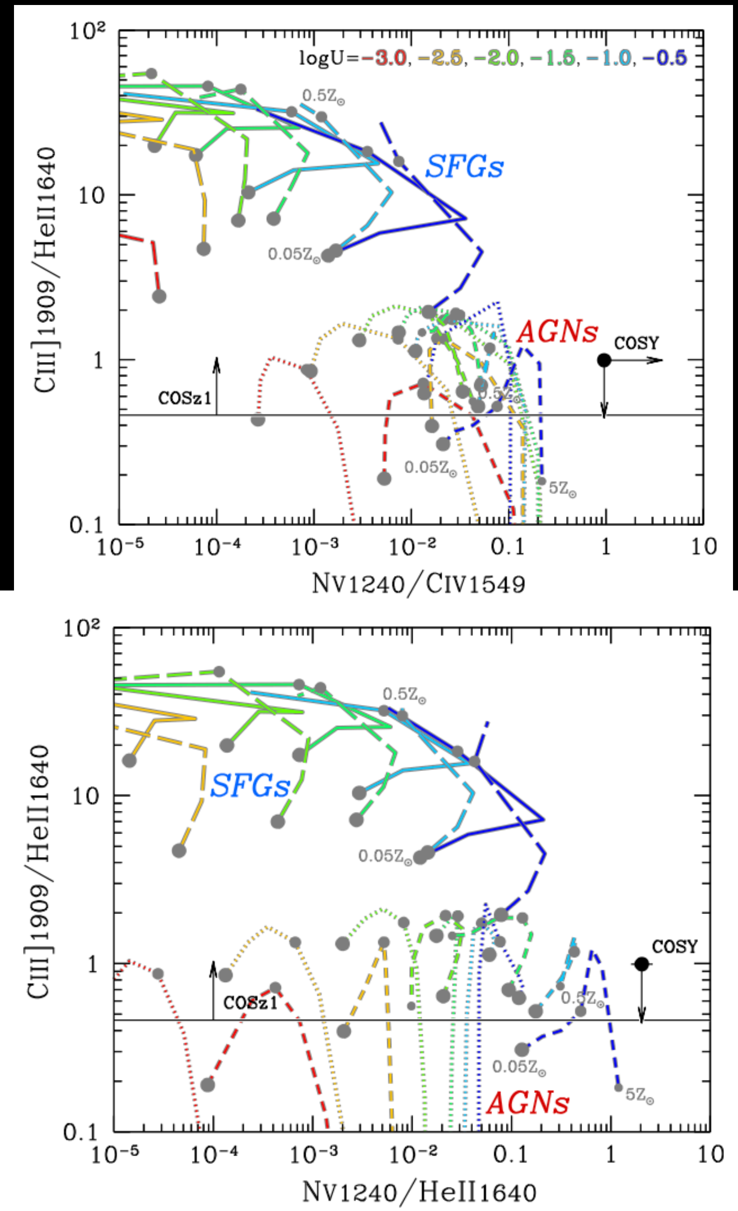
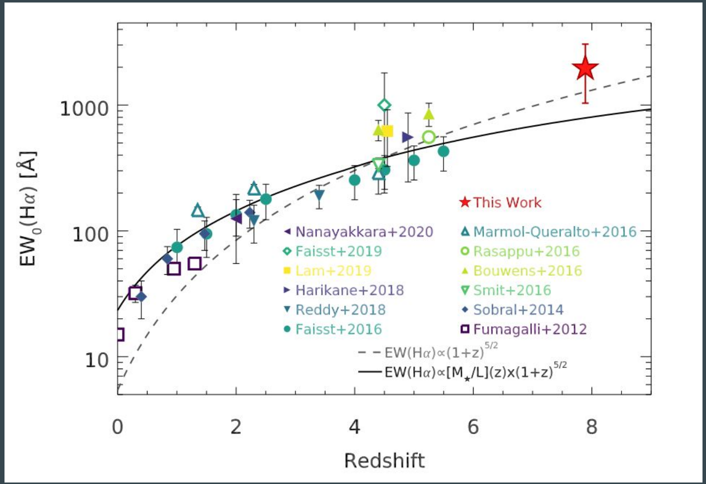


Figure 7. Line ratio diagrams from photoionization models. Metallicity ranges from $Z = 0.05$ to 1 (5) $Z_\odot$ for galaxy (AGN) models for an ionization parameter $\log(U)$ from -3.0 (red) to -0.5 (blue) as shown in the legend. Solid and long dashed lines are for single and binary stellar population models in star-forming galaxies (SFGs), respectively. Dashed and dotted curves present AGN models with power-law indices $\alpha = -1.2$ (hard) and -2.0 (soft), respectively.

High Equivalent Width of Hα+[N II] Emission in z ~ 8 Lyman-break Galaxies from IRAC 5.8μm Observations: Evidence for Efficient Lyman-continuum Photon production in the Epoch of Re-ionization

Mauro Stefanon, et al. (2022)



Comparison of the new EW0 (Hα) measurement with previous determinations at lower redshifts from the literature suggests that the trend of increasing EW0 (Hα) with redshift can be extended up to z ~ 8.

The large value of ξ_{ion} they find suggests that escape fractions are sufficient for star-forming galaxies to fully ionize the neutral H at z ~ 8.

The small value of f_{esc} is consistent with what is seen at lower redshifts z ~ 2−6 in star-forming galaxies, reinforcing the likelihood that galaxies alone are responsible for reionization.