Metal-enriched Neutral Gas Reservoir around a Strongly Lensed Low-mass Galaxy

This poster

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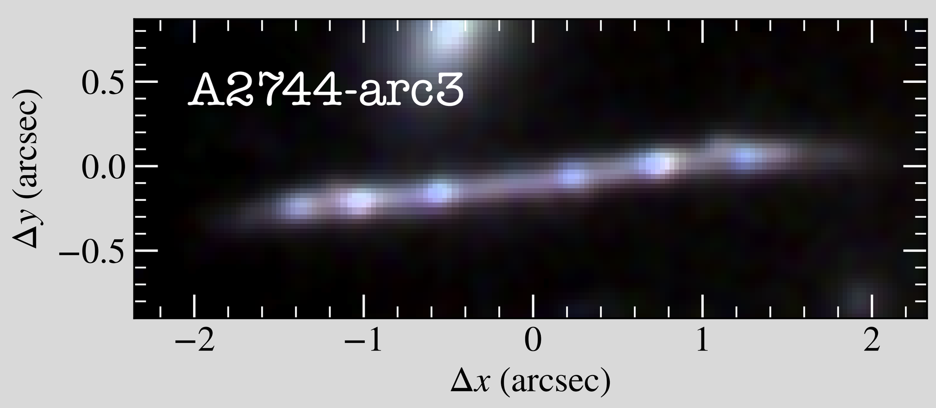
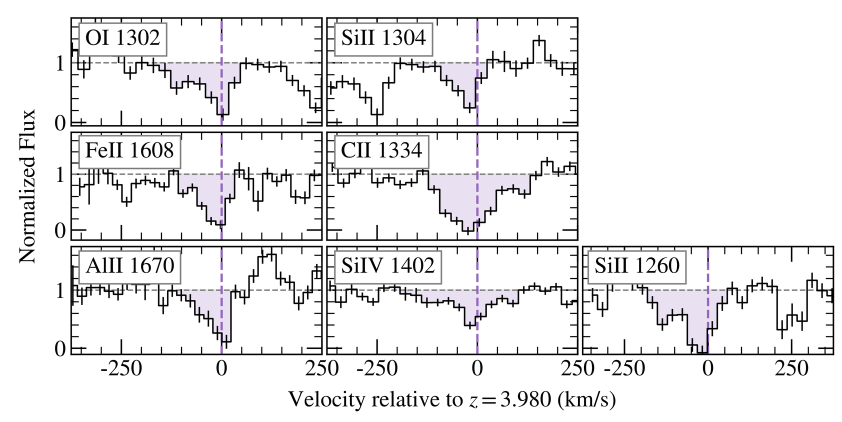
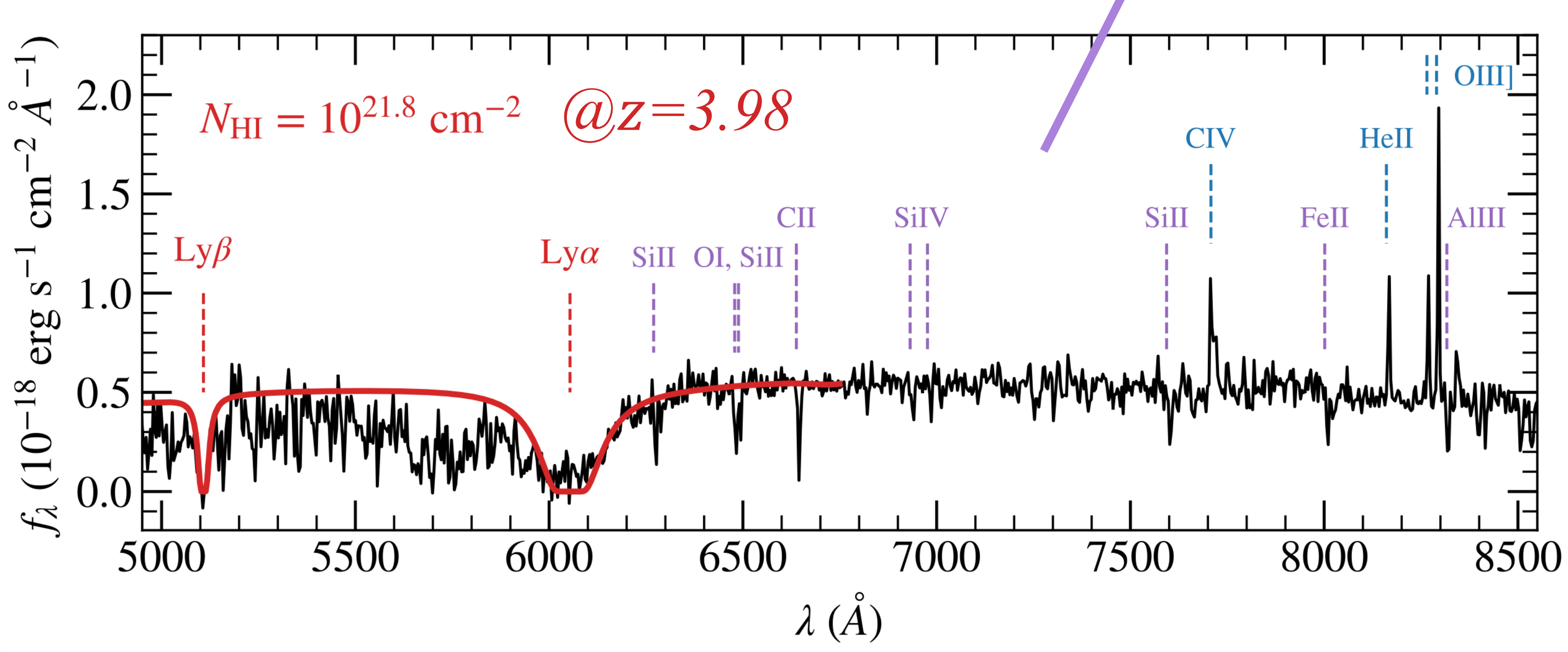


Direct observations of low-mass, low-metallicity galaxies at z≥4 provide an indispensable opportunity for detailed inspection of the ionization radiation, gas flow, and metal enrichment in sources similar to those that reionized the universe. Combining the James Webb Space Telescope (JWST) and Very Large Telescope/MUSE we present detailed observations of a strongly lensed, low-mass ($\approx 10^{7.6}\ M_\odot$) galaxy at $z = 3.98$. our observations suggest that low-mass, low-metallicity galaxies, which dominate reionization, could be surrounded by a high covering fraction of the metal-enriched, neutral-gaseous clouds.

VLT/MUSE reveals an associated extremely strong DLA (ESDLA) with abundant metal absorbers

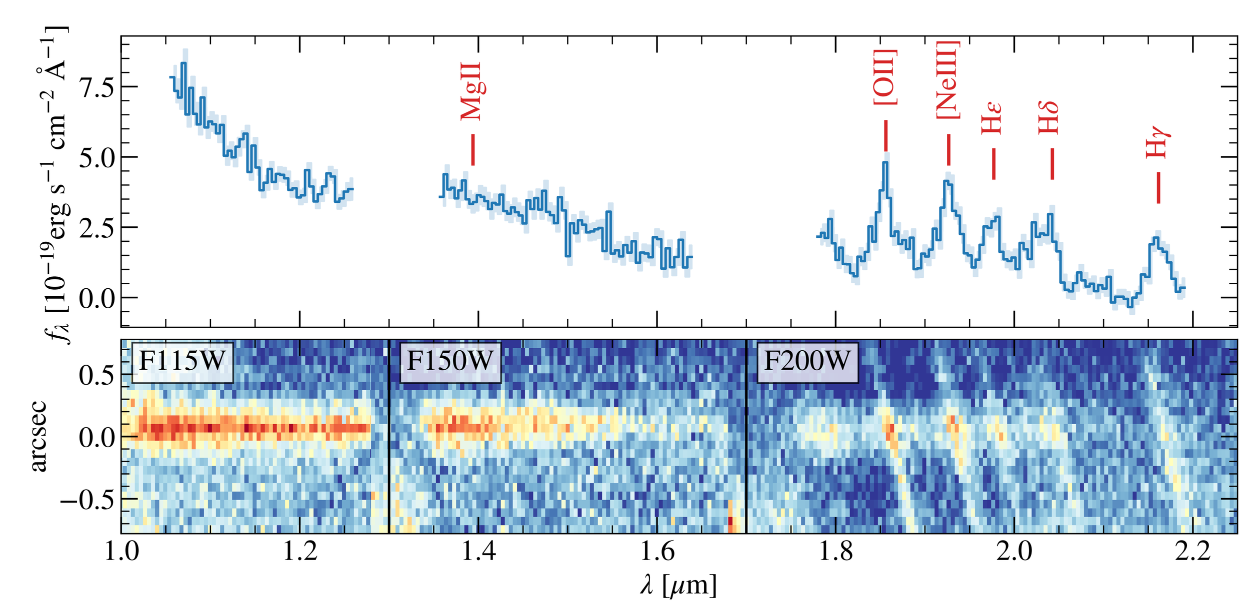
- Abubdant metal absorbers in the ESDLA with tentative P-Cygni profiles imply ongoing metal enrichment process by the young stellar feedback.
- Significant high-ionization nebular emission lines, C IV λ1548, 1550, He II λ1640, 0 III] λ1661, 1666 indicate hard ionizing radiation fields and the low-metallicity nature. Their line ratios favor the explanation of photoionization due to massive stars rather than AGNs (Gutkin et al. 2016).



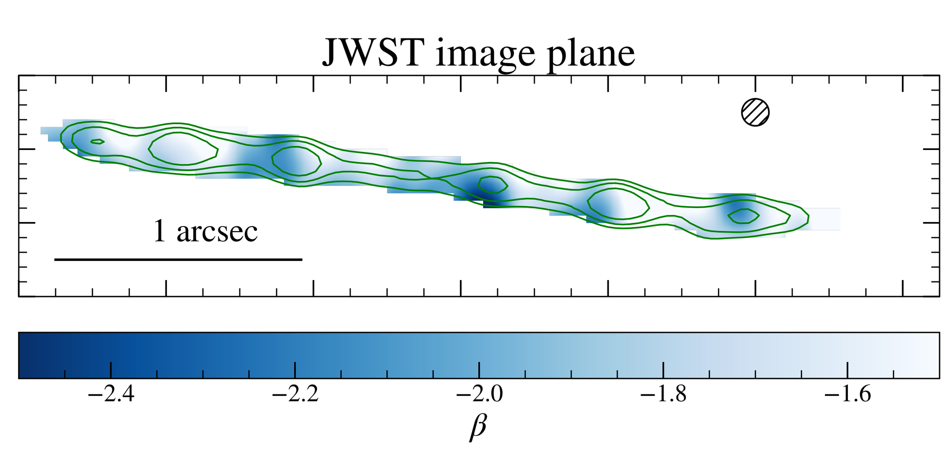


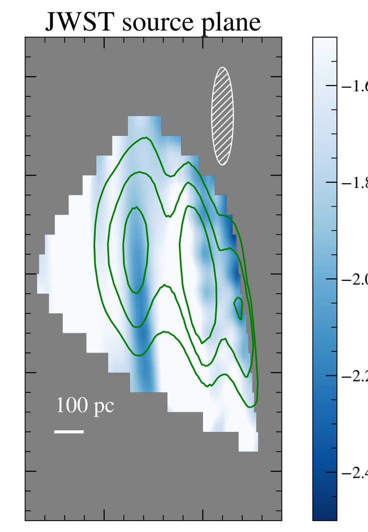
JWST/NIRISS slitlesextremes grism indicates a metal-poor HII region with ionization states

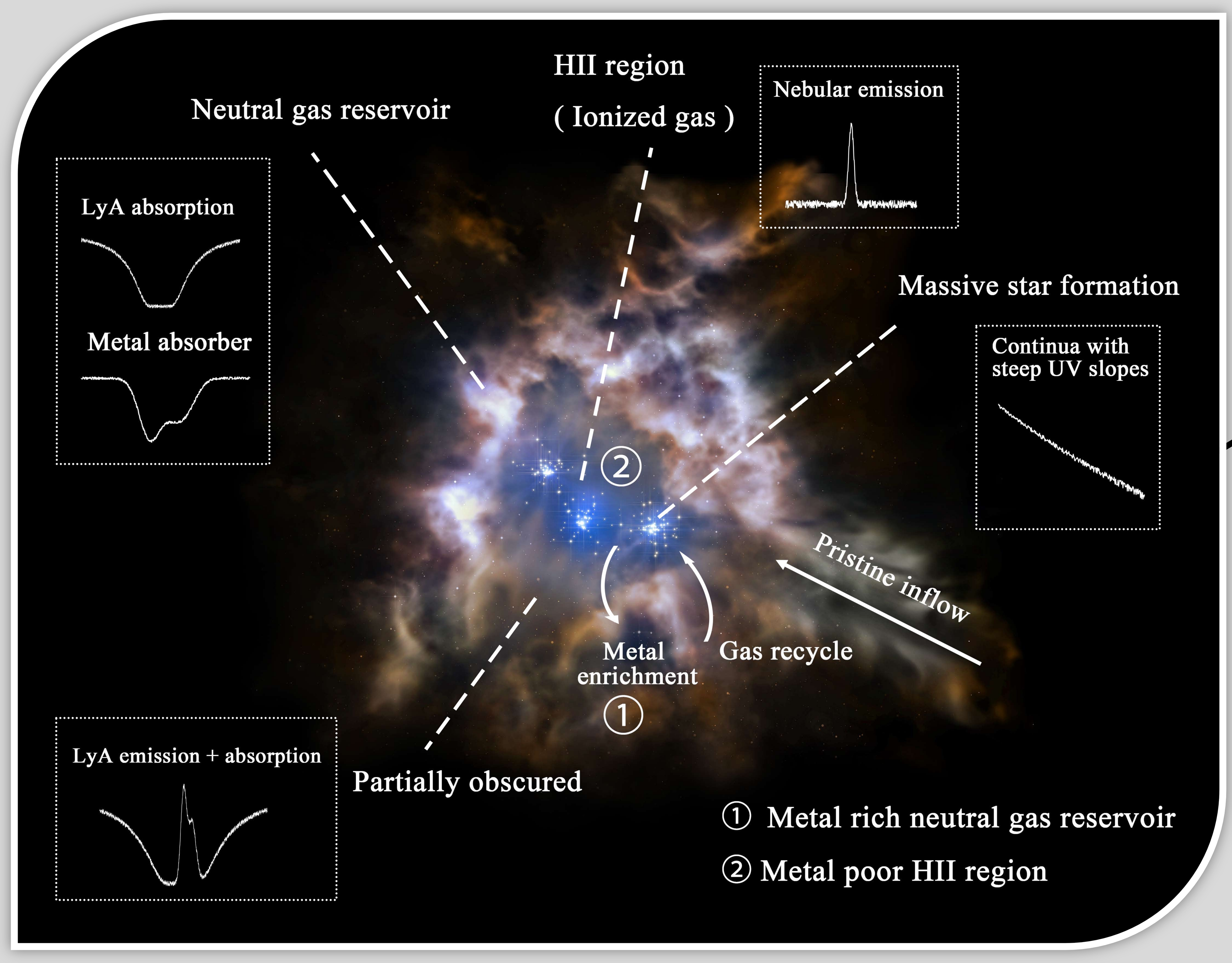
- Strong Balmer and [OII], [NeIII] emission lines serve as an indicator of the metal-poor HII region: $12 + \log(\mathrm{O/H}) \approx 7.75 \pm 0.05$, i.e. $Z \approx 0.12 Z_\odot$ based on the empirical metallicity calibrations (Bian et al. 2018).



- The UV slope β ($f_\lambda \propto \lambda^\beta$) reaches -2.5 around those small stellar clumps on the physical scale down to <100pc in the source-plane. This further confirms the extreme ionizing conditions, making A2744-arc3 a textbook example to get an unparalleled view of low-mass galaxies at the epoch of reionizaiton.







The schematic toy model of A2744-arc3 as a low-mass, low-metallicity galaxy with high-metallicity neutral gas reservoir.

- The hard ionization field from compact and bursty star-forming regions forms hot, thin, and highly ionized HII regions around them, where strong narrow nebular emission lines are produced
- The CGM geometry determines the shape of Lyα emission/absorption we observed: damped Lyα / partially obscured / Lyα emission with underlying absorption.
- Feedback from central star formation, such as stellar winds, could metal enrich the neutral gas, leading to strong metal absorbers with P-Cygni profiles. The recycled neutral gas can further efficiently fuel the next-generation star formation.

Our Paper

Lin et al. 2023, The ApJL, 944, 59.
10.3847/2041-8213/aca1c4
10.48550/arXiv.2209.03376

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