

Catching GS-9209 - A Massive Quiescent Galaxy Before Cosmic Noon with JWST

COSPAR UVIT-JWST WORKSHOP 2025



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A massive quiescent galaxy at redshift 4.658

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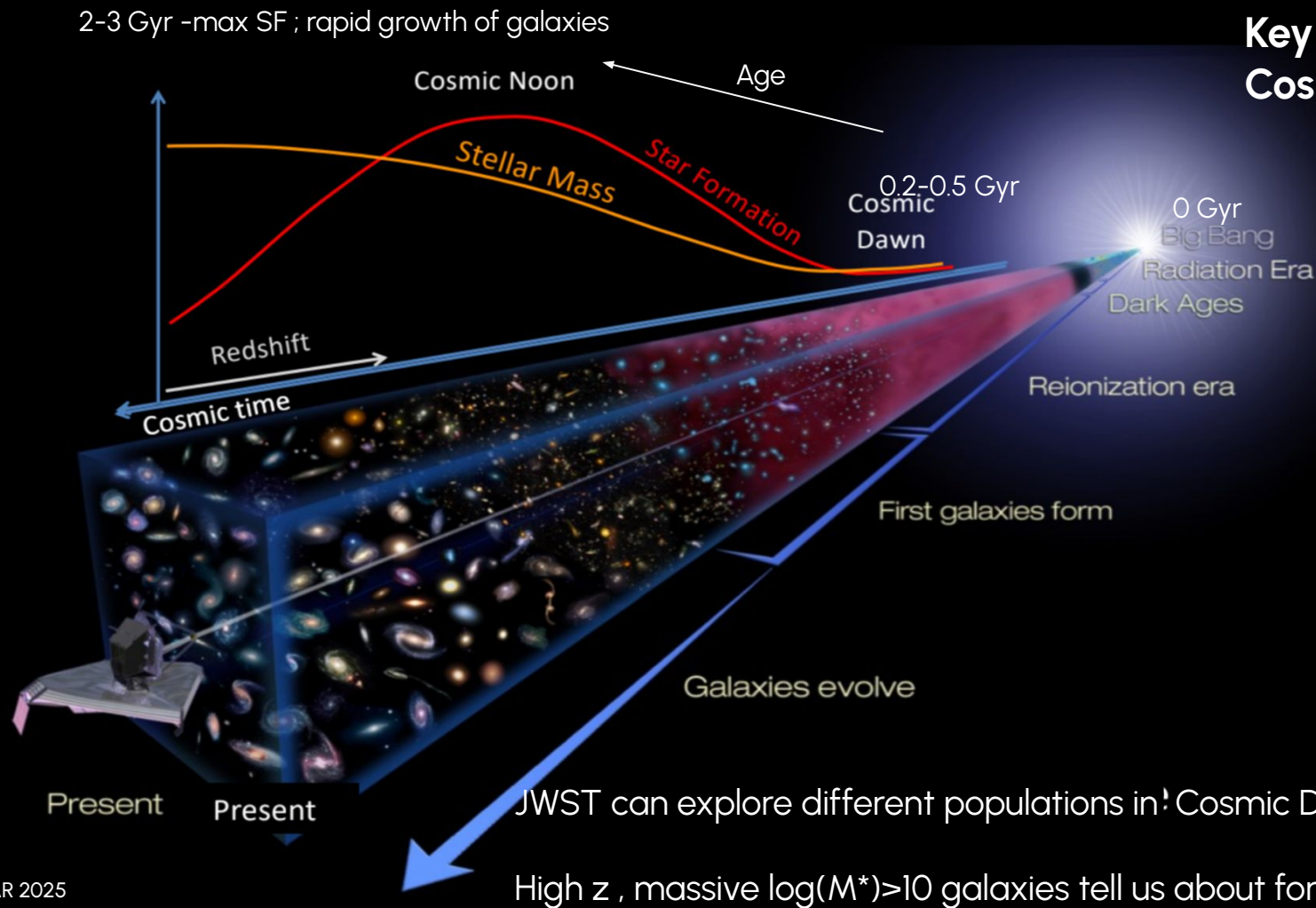
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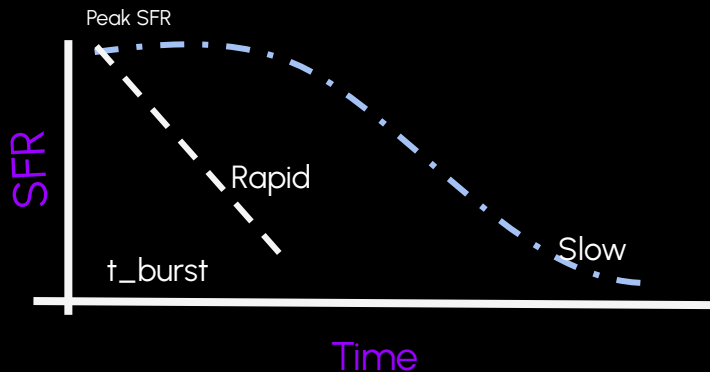
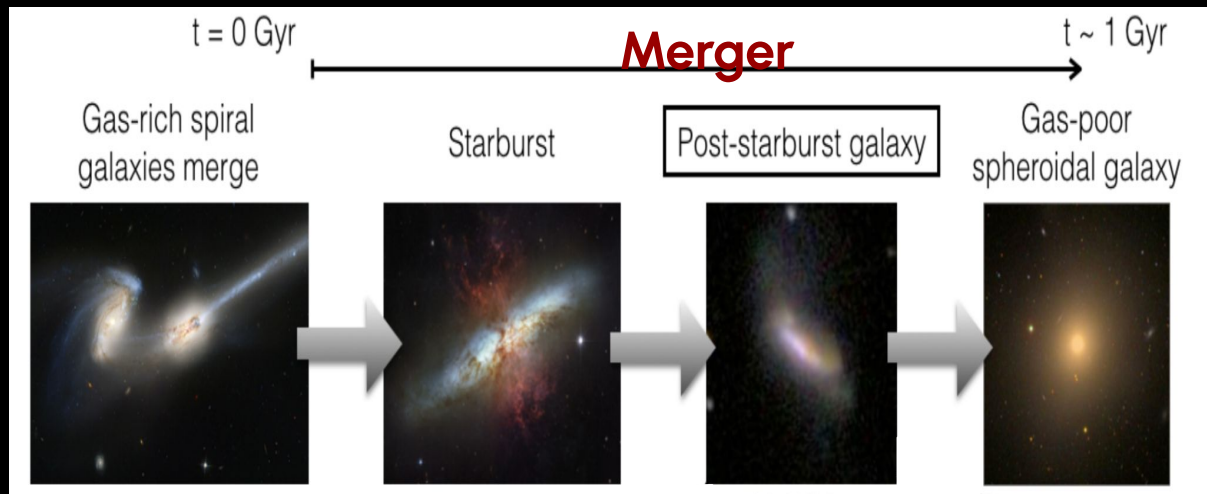
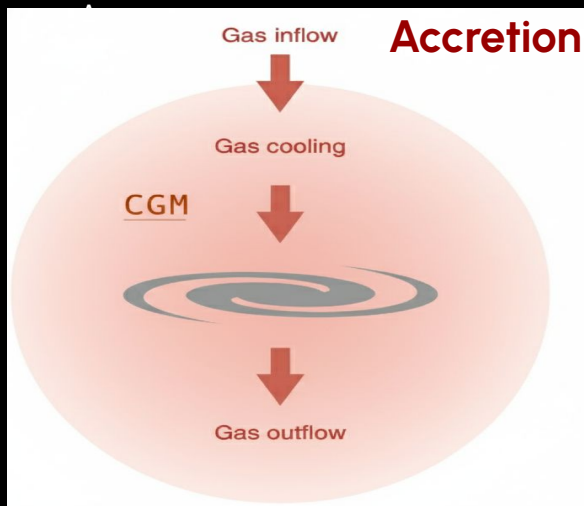
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The extremely rapid assembly of the earliest galaxies during the first billion years of cosmic history is a major challenge for our understanding of galaxy formation physics^{1–5}. The advent of the James Webb Space Telescope (JWST) has exacerbated this issue by confirming the existence of galaxies in substantial numbers as early as the first few hundred million years^{6–8}. Perhaps even more surprisingly, in some galaxies, this initial highly efficient star formation rapidly shuts down, or quenches, giving rise to massive quiescent galaxies as little as 1.5 billion years after the Big Bang^{9,10}. However, due to their faintness and red colour, it has proven extremely challenging to learn about these extreme quiescent galaxies, or to confirm whether any existed at earlier times. Here we report the spectroscopic confirmation of a massive quiescent galaxy, GS-9209, at redshift, $z = 4.658$, just 1.25 billion years after the Big Bang, using the JWST Near-Infrared Spectrograph (NIRSpec). From these data we infer a stellar mass of $M_* = 3.8 \pm 0.2 \times 10^{10} M_\odot$, which formed over a roughly 200 Myr period before this galaxy quenched its star-formation activity at $z = 6.5^{+0.2}_{-0.5}$, when the Universe was approximately 800 Myr old. This galaxy is both a likely descendent of the highest-redshift submillimetre galaxies and quasars, and a likely progenitor for the dense, ancient cores of the most massive local galaxies.

Key Epochs in Cosmic History



Two Pathways in Λ CDM Framework

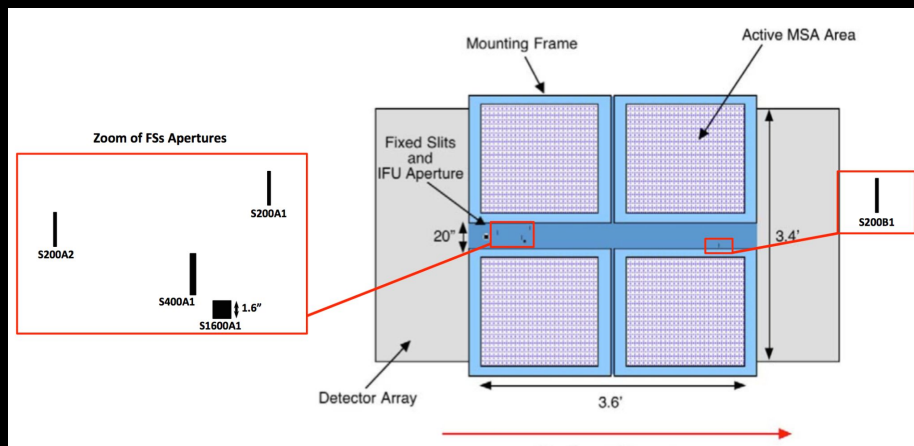


SFH differ depending on formation pathway.

Some Fingerprint of formation should remain within high z massive galaxies.

GS-9209

- ❑ Caputi et al. (2004) used GOODS Hubble's Advanced Camera for Survey B, V, I775 ; VLT-ISAAC J, H and Ks band imaging - estimated photometric redshift for 198 Extreme Red Galaxies.
- ❑ Identified 12 sources having $z_{\text{phot}} > 4$; $\log(M^*) > 10$. GS-9209 is one of them.
- ❑ JWST initial cycles targeted Potential high redshift quiescent candidates with NIRSpec for Spectra.



NIRSpec Fixed Slit apertures

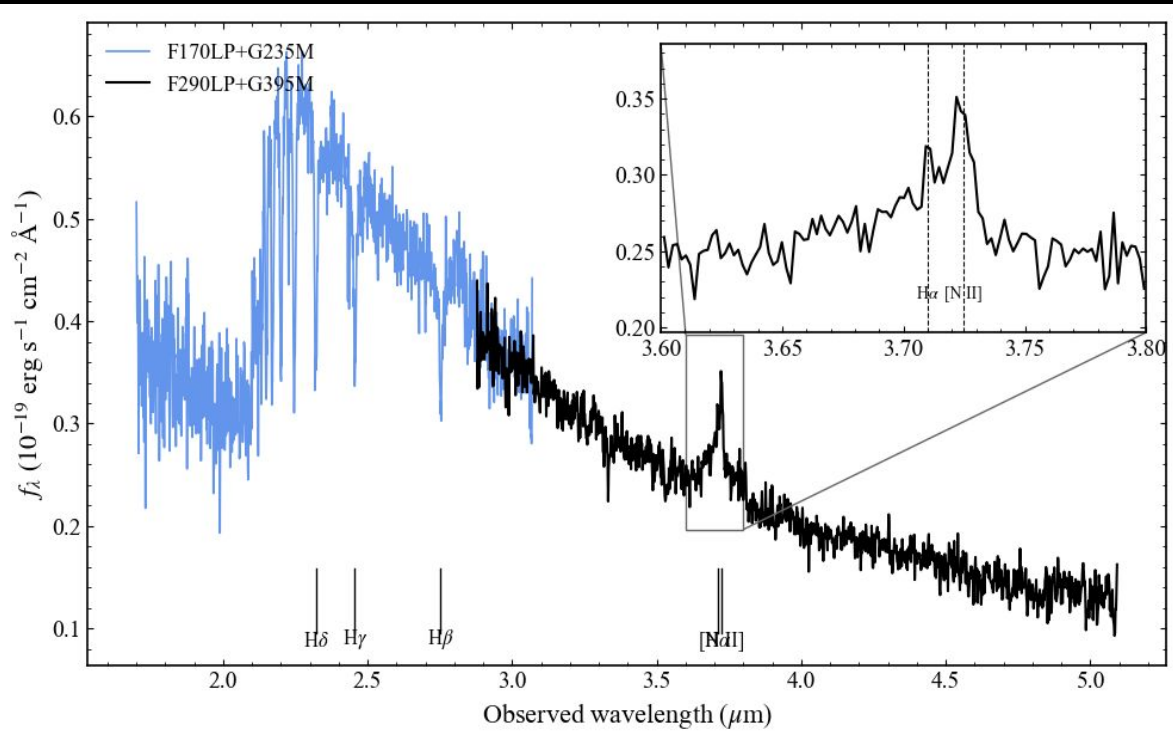
JWST PID 2285 Observation Details:
Slit : S200A1

Disperser-filter Info :

G235M/FI70LP 1.66–3.07 μm
30 group/integration, 2h exposure

G395M/F290LP 2.27–5.10 μm
20 group/integration , 3h exposure

5 integrations in every grating



Results:

Identified Hydrogen absorption lines

Rest frame $H\alpha = 0.6563 \mu\text{m}$, $H\beta = 0.4861 \mu\text{m}$, $H\gamma = 0.4341 \mu\text{m}$, $H\delta = 0.4102 \mu\text{m}$.

- This galaxy is at $z \sim 4.65$ - age of universe was 1.5 billion years.
- A type stars (7500-10,000K surface T_{eff}) usually have balmer lines. Must gone through a starburst phase within few 100 Myr. Little star formation remain as H- α emission line is small.

NII/Ha lines are well resolvable.

In 3.6-3.8 μm region fitted lines. Found $\log(\text{NII}/\text{Ha})$ value ~ -0.1 Some hard ionizing source other than SF must be present.