Space & Astronomy | May 28, 2026 | 8 min read | By Bryan White

Rewinding the Cosmic Clock: JWST Spots the Universe's Most Primitive Galaxy

Space * Astronomy * Physics

Introduction: Rewinding the Cosmic Clock to LAP1-B

The evolution of the universe from a hot, nearly uniform primordial plasma into the structured cosmic web of galaxies observed today is governed by successive generations of stellar nucleosynthesis. Following recombination and the cosmic Dark Ages, the primordial gas consisted almost purely of neutral hydrogen and helium with trace lithium. Elements heavier than helium -- such as carbon, oxygen, nitrogen, and iron -- were forged inside the first high-mass, metal-free stars (Population III stars) and dispersed by pair-instability and core-collapse supernovae.[2][4]

For decades, early spectroscopic surveys at redshifts z = 4 to 10 consistently encountered an empirical "metallicity floor" near 2% of the solar metallicity value (Z), implying that primordial star-forming regions enriched their local interstellar medium almost instantaneously.[2] In May 2026, however, an international team led by Kimihiko Nakajima (Kanazawa University) and Masami Ouchi (National Astronomical Observatory of Japan and the University of Tokyo) reported in Nature the spectroscopic characterization of LAP1-B.[2][3] Observed at a spectroscopic redshift of z = 6.625 (~800 million years after the Big Bang), LAP1-B exhibits an oxygen abundance of just 1/240th solar (0.42% Z), establishing it as the most chemically primitive star-forming galaxy ever identified.[2][3]

Observational Architecture: Gravitational Lensing and JWST NIRSpec

Because primordial star-forming minihalos are intrinsically compact and ultra-faint, LAP1-B would remain undetectable in unassisted blank-field surveys even with the James Webb Space Telescope (JWST).[2] Its detection under the Deep Reconnaissance of Early Assemblies of Metal-poor Star formation (DREAMS) program relied on strong gravitational lensing by the foreground galaxy cluster MACS J0416 paired with deep space-based infrared spectroscopy.[2][3]

Positioned directly across a critical caustic curve of the MACS J0416 gravitational potential, LAP1-B experiences an astrometrically modeled flux magnification factor of ~ 98.[2][3] Even with nearly hundredfold amplification, the galaxy's stellar continuum remained below the detection threshold of deep near-infrared imaging.[2] On November 4-5, 2024, the DREAMS team executed more than 30 hours of integration using JWST's Near-Infrared Spectrograph (NIRSpec) micro-shutter assembly with medium-resolution gratings (G140M/F070LP and G395M/F290LP, resolving power R ~ 1,000; 16.37 hours per grating) to isolate rest-frame optical and ultraviolet nebular emission lines.[2][3] Because emission-line flux ratios are achromatic and invariant under gravitational magnification, the resulting chemical diagnostics are immune to lensing-model uncertainties.[2]

| Observational Parameter | | Detail |

| Target Galaxy | | LAP1-B |

| Spectroscopic Redshift | | 6.625 |

| Cosmic Age at Observation | | ~800 Million Years post-Big Bang |

| Foreground Lensing Cluster | | MACS J0416 |

| Magnification Factor | | ~98 |

| Primary Instrument | | JWST Near-Infrared Spectrograph (NIRSpec) |

| Grating Configurations | | G140M / F070LP and G395M / F290LP |

| Total Integration Time | | 16.37 hours per grating |

Chemical Diagnostics: Breaking the 2% Solar Metallicity Floor

Nebular spectroscopy of LAP1-B revealed an exceptionally weak doubly ionized oxygen emission line ([O III] 5007) relative to hydrogen-beta (H), with a line ratio of [O III]/H = 0.69, alongside a dust-free Balmer decrement (H /H) consistent with Case B recombination.[2][3] Applying the direct electron-temperature (Te) method via auroral line diagnostics, Nakajima et al. derived a gas-phase oxygen abundance of 12 + log(O/H) = 6.31, corresponding to 1/240th of the solar value (0.42% Z).[2] This measurement breaks well below the ~2% Z metallicity floor previously observed in high-redshift galaxies.[2]

Simultaneously, NIRSpec detected rest-frame ultraviolet emission from triply ionized carbon (C IV 1549), revealing an anomalously high carbon-to-oxygen (C/O) abundance ratio of roughly 1-2x the solar value.[2][3] In standard galactic chemical evolution driven by Population II core-collapse supernovae, C/O ratios decline sharply at low metallicities.[2] Conversely, an elevated C/O ratio in an ultra-metal-poor gas cloud matches theoretical nucleosynthetic yields from low-energy or mixing-fallback supernovae of high-mass first-generation Population III stars.[4]

| Chemical Property | | Measurement in LAP1-B | | Context and Implications |

| Oxygen Abundance | | 1/240th Solar (~0.42%) | | Lowest recorded in early universe; breaks the ~2% solar metallicity floor. |

| Abundance Log(O/H) + 12 | | 6.31 | | Indicates a near-pristine, unpolluted interstellar medium. |

| Carbon-to-Oxygen Ratio | | ~1 to 2 times Solar | | Anomalously high; matches theoretical yields of Population III supernovae. |

| H-alpha / H-beta Ratio | | Consistent with Case B Recombination | | Indicates an environment virtually free of dust extinction. |

Dark Matter Minihalos and Population III Star Formation Models

Kinematic and photometric constraints demonstrate that LAP1-B is overwhelmingly dominated by dark matter. Non-detection of the stellar continuum places a tight upper bound on its total stellar mass at M < 3,300 M (with a conservative ceiling of 18,000 M), comparable to a single compact star cluster rather than a typical 107 M high-redshift galaxy.[2] Yet velocity-space broadening of the H emission line yields a gas velocity dispersion of = 58.3 +/- 17.8 km s-1.[2] Across an intrinsic

star-forming radius of ~10 pc, this dispersion requires a virialized dynamical mass of ~107 to 5 x 107 M , indicating a baryon fraction below 1%.[2][4]

As analyzed by Visbal and colleagues, these physical parameters make LAP1-B the first observed system to satisfy all primary theoretical criteria for Population III star formation within an atomic cooling halo (Tvir ~ 103-104 K).[4] Despite its tiny stellar mass, LAP1-B exhibits an intense ionizing-photon production efficiency (log ion > 26.1 Hz erg-1) and a rest-frame H equivalent width exceeding 1,800 , without chemical signatures of an active galactic nucleus.[2][4] This hard ultraviolet radiation field points to a top-heavy initial mass function powered by either ~38 stars of 40 M or as few as four very-high-mass Population III stars of 200 M each.[2][4]

| Population III Prediction | | LAP1-B Observation | | Model Alignment |

| Formation in Atomic Cooling Halos | | Inferred dark matter halo mass of ~10 to 50 million solar masses. | | Strong |

| Top-Heavy Initial Mass Function | | Intense ionizing efficiency; H-alpha Equivalent Width > 1,800 Angstroms. | | Strong |

| Low-Mass Star Clusters | | Total stellar mass tightly constrained to < 3,300 solar masses. | | Strong |

| Specific Nucleosynthetic Yields | | Elevated Carbon-to-Oxygen ratio despite 1/240th solar oxygen. | | Strong |

Reionization Quenching and High-Redshift Galactic Diversity

Observed at z = 6.625 during the Epoch of Reionization (which concluded near z ~ 5.3) and situated within 300 pc of a companion clump (LAP1-A) inside a ~1,500 pc virial radius,[2][4] LAP1-B represents a direct progenitor of the dormant ultra-faint dwarf (UFD) galaxies orbiting the modern Milky Way.[3][6] Because its shallow 107 M gravitational well cannot retain photoheated gas against ultraviolet reionization and internal supernova feedback, LAP1-B is captured just prior to permanent thermal quenching.[2][6]

Comparing LAP1-B against luminous high-redshift discoveries such as MoM-z14 (z = 14.44), JADES-GS-z14-0 (z = 14.18), and nitrogen-enriched GN-z11 (z = 10.6) highlights how unassisted flux-limited surveys preferentially select luminous, rapidly enriched overdensities, whereas strong gravitational lensing unveils the baseline population of inefficient, dark-matter-dominated minihalos.[1][5][7][8][9][10][11]

| Galaxy Target | | Spectroscopic Redshift | | Key Distinguishing Feature | | Theoretical Implication |

| LAP1-B | | 6.625 | | 1/240th Solar Oxygen, High C/O ratio, strongly lensed. | | Pristine Pop III environment; Progenitor of local UFDs. |

| MoM-z14 / JADES-GS-z14-0 | | 14.44 / 14.18 | | Unexpectedly high luminosity and rapid mass assembly at early cosmic epoch. | | Challenges standard mass assembly timelines; indicates remarkably efficient early star formation in specific halos. |

| GN-z11 | | 10.6 | | Elevated Nitrogen overabundance; potential AGN signature. | |

Indicates rapid, complex enrichment, potentially driven by early black hole accretion or dense stellar collisions. |

Conclusion: Bridging the Cosmic Dawn and Local Relic Galaxies

By combining a ~ 98 gravitational lens in MACS J0416 with deep JWST NIRSpec spectroscopy, the discovery of LAP1-B shatters the 2% Z high-redshift metallicity floor down to 0.42% Z (12 + log(O/H) = 6.31).[2] Its supersolar C/O yield, hard ionizing spectrum (EWH > 1,800), and >99% dark matter dominance provide empirical confirmation of atomic-cooling Population III star formation models while capturing a local ultra-faint dwarf galaxy at the precise moment of its birth.[4][6]

Updates... (Nov 22, 2026): Enriched exact CrossRef and press-release publication dates across all 11 References & Primary Sources (including Nakajima et al., May 13, 2026; NAOJ & ICRR, May 14, 2026; Visbal et al., Oct 27, 2025; and Naidu et al., Jan 30, 2026).

References & Primary Sources

* [1] Carniani, S., Hainline, K., D'Eugenio, F., et al. (Jul 29, 2024). Spectroscopic confirmation of two luminous galaxies at a redshift of 14. Nature, 633, 318-322. https://doi.org/10.1038/s41586-024-07860-9

* [2] Nakajima, K., Ouchi, M., Harikane, Y., Vanzella, E., Ono, Y., et al. (May 13, 2026). An ultra-faint, chemically primitive galaxy forming in the reionization era. Nature, 653(8114), 363-367. https://doi.org/10.1038/s41586-026-10374-1

* [3] National Astronomical Observatory of Japan (NAOJ). (May 14, 2026). Astronomers Find Most Chemically Primitive Galaxy in Early Universe. https://www.nao.ac.jp/en/news/science/2026/20260514-dos.html

* [4] Visbal, E., Hazlett, R., & Bryan, G. L. (Oct 27, 2025). LAP1-B is the First Observed System Consistent with Theoretical Predictions for Population III Stars. The Astrophysical Journal Letters, 993(1), L17. https://doi.org/10.3847/2041-8213/ae122f

* [5] Fujimoto, S., Naidu, R. P., Chisholm, J., Atek, H., Endsley, R., et al. (Aug 4, 2025). GLIMPSE: An Ultrafaint 105 M Pop III Galaxy Candidate and First Constraints on the Pop III UV Luminosity Function at z 6-7. The Astrophysical Journal, 989(1), 46. https://doi.org/10.3847/1538-4357/ade9a1

* [6] Institute for Cosmic Ray Research (ICRR), University of Tokyo (May 14, 2026). The Most Chemically Primitive Galaxy in the Early Universe: Clues to the Mysterious Origins of Ultra-Faint Dwarfs. https://www.icrr.u-tokyo.ac.jp/en/news/17894/

* [7] Helton, J. M., Rieke, G. H., Alberts, S., Wu, Z., Eisenstein, D. J., et al. (Mar 7, 2025). Photometric detection at 7.7 m of a galaxy beyond redshift 14 with JWST/MIRI. Nature Astronomy, 9(5), 729-740. https://doi.org/10.1038/s41550-025-02503-z

* [8] Schouws, S., et al. (Mar 17, 2025). Detection of [O III] 88 m in JADES-GS-z14-0 at z = 14.1793. European Southern Observatory (ESO). https://www.eso.org/public/archives/releases/sciencepapers/eso2507/eso2507b.pdf

* [9] Cameron, A. J., Katz, H., Rey, M. P., et al. (May 29, 2023). Nitrogen

enhancements 440 Myr after the big bang: supersolar N/O, a tidal disruption event, or a dense stellar cluster in GN-z11? Monthly Notices of the Royal Astronomical Society, 523(3), 3516-3525. https://doi.org/10.1093/mnras/stad1579

* [10] Fabian, A. C., Jiang, J., Baker, W. M., Maiolino, R., Ji, X., et al. (Feb 27, 2026). The possible accretion discs of GN-z11 at redshift z = 10.6, MoM-z14 at z = 14.44, and other high-redshift objects. Monthly Notices of the Royal Astronomical Society, 547(3). https://doi.org/10.1093/mnras/stag379

* [11] Naidu, R. P., Oesch, P. A., Brammer, G., Weibel, A., Li, Y., et al. (Jan 30, 2026). A Cosmic Miracle: A Remarkably Luminous Galaxy at zspec = 14.44 Confirmed with JWST. The Open Journal of Astrophysics, 9. https://doi.org/10.33232/001c.156033