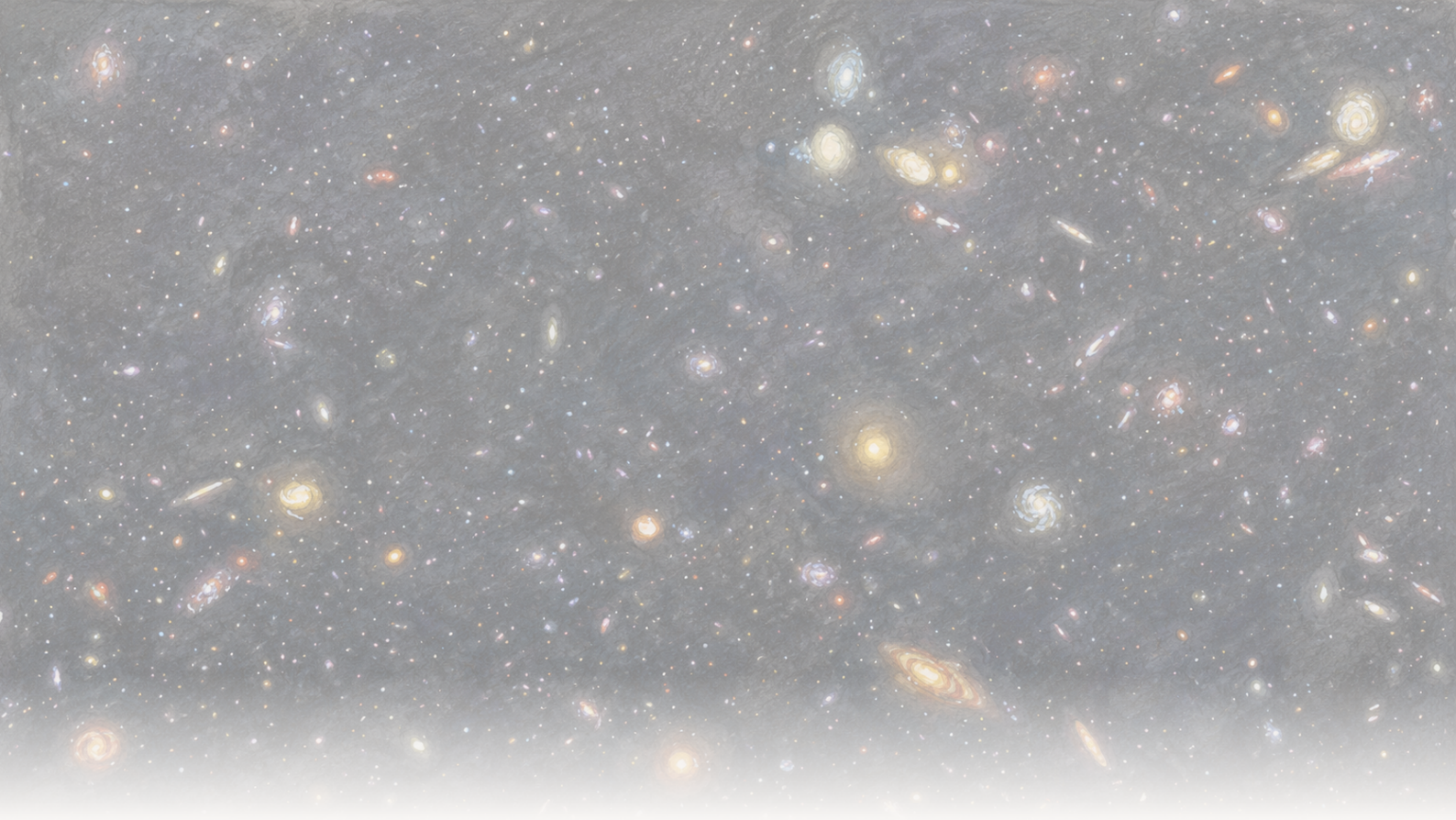


The Clean Paper

WHAT THE PAPER SAYS · WHAT IT DOESN'T · WHY IT MATTERS

Galaxy most distant hanga ammaatti ionizing light isaa leak godhaa qabame

Astronomers JWST fi Hubble fayyadamuun galaxy tokko cosmic reionization xumuramee ~250 million years booda escaping ionizing ultraviolet direct qabatan — leak gosa kanaa most distant. Headline escape fraction 50–100% real detection irratti hundaa'a garuu models irraa reconstructed, direct measured miti; quieter result leak direct hin argamne yeroo ta'u indirect tracer akkam fayyadamnu irratti first high-redshift test dha.

Written by Vera Rubin · Cross-checked by Cinzia Vaglio and Lucio Vaglio · Edited by Michele Renda · Figures by Nova Vela · AI-assisted, human-reviewed

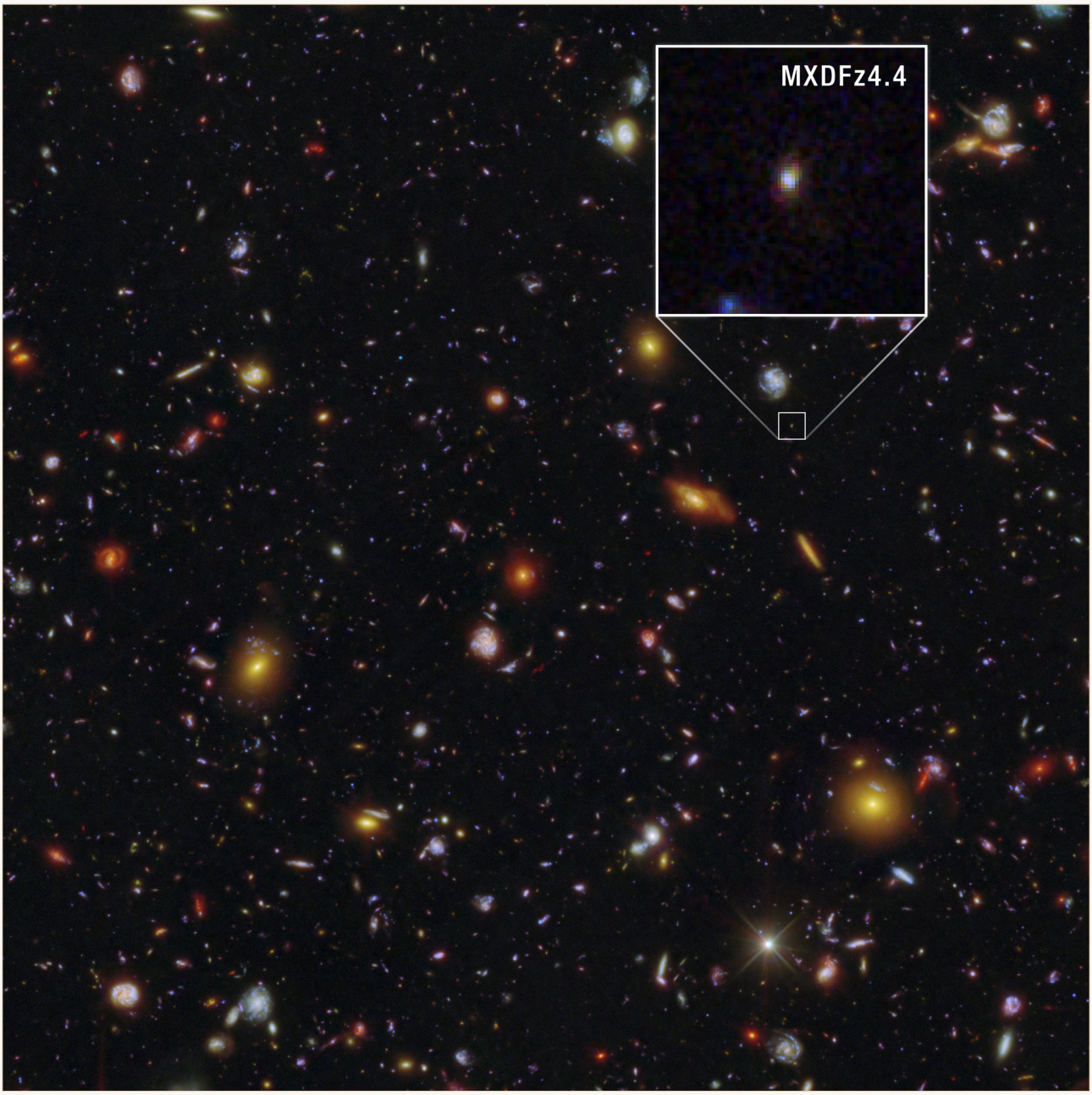
Paper: *MXDFz4.4: A LyC emitter 250 Myr after the epoch of reionization and a first test of Lyman-alpha morphology as a tracer of LyC escape at high redshift*, Ilias Goovaerts, Marc Rafelski, Alexander Beckett, Grecco Oyarzun, Annalisa Citro, Farhanul Hasan, Kalina V. Nedkova, Calum Hawcroft, Anton M. Koekemoer, Mitchell Revalski, Matthew J. Hayes, Claudia Scarlata, Ray A. Lucas, Norman A. Grogin, David V. Stark, Paolo Sun, Nor Pirzkal, and Louis-Gregory Strolger, The Astrophysical Journal (accepted, 2026) · DOI: 10.3847/1538-4357/ae75b0

Ifa fog cosmic qulqulleesse

Addunyaa waggoota miliyoona dhibba hedduu jalqabaa keessatti opaque ture. Space neutral haayidiroojiinii — atoms electrons isaanii itti maxxananii jiran — guute; neutral haayidiroojiinii ultraviolet *ionizing* baay'ee gaariitti absorba: short-wavelength ifa 912 ångström gadi (the *Lyman daangaa*), elektiroonii haayidiroojiinii irraa baasuuf anniisaa gahaa qabu. Ultraviolet hundi akkas miti — longer-wavelength UV wal-fakkaataa way hin absorbu, jalqabaa galaaksiiwwan irraa hedduu ni argina — kanaaf specifically ionizing ifa addunyaa young keessaa trapped ture. Achii waggaa biliyoona tokko naannoo keessatti wanti tokko cosmos enough ionizing photons'n guute, electrons haayidiroojiinii irraa deebisee baase, haayidiroojiinii ionize godhee ifa freely travel akka godhu. Astronomers kana epoch of reionization jedhu; suspects obvious jalqabaa galaaksiiwwan: hot short-lived urjiilee ionizing UV hedduu baasu, enough miliquu into intergalactic space taanaan hojii sana gochuu danda'u.

Rakkoon jecha *escaped* dha. Galaaksii ionizing ifa ofii keessaa hedduun hin ba'u — wal-fakkaataa haayidiroojiinii galaaksii keessaa absorba. Fraction muraasni space keessa leak godha; *miliquu fraction* jedhamu, seenaa guutuu keessatti lakkoofsa hardest pin down. Reionization yeroo sana leaked ifa jechuun ni danda'ama impossible catch: intergalactic fog inni ifaa gochuuf gargaaru sun nu ga'u dura absorb godha. Kanaaf leak qorannoo gochuuf astronomers fog lift booda galaaksiiwwan era sana irraa dhihoo ta'an ilaalu.

Gareen Ilias Goovaerts led godhe leak kana dhihoo as far back as ever seen qabate. Deep Hubble + JWST imaging fayyadamuun galaaksii faint tokko — MXDFz4.4 — ionizing ultraviolet miliquu godhu Hubble filter tokko keessatti smudge ifa ta'ee gabaasan. Galaaksii redshift 4.442, reionization xumuramee gara 250 miliyoona waggoota booda: direct-detected "leaker" irra caalaa distant galmee.



MXDFz4.4 (inset keessatti enlarged) deep Hubble/JWST damee keessatti faint smudge dha — galaaksii irra caalaa distant ionizing ultraviolet kallattii leak gochaa qabame, cosmic reionization xumuramee ~250 miliyoona waggoota booda.

NASA, ESA, CSA, STScI, Ilias Goovaerts (STScI), Marc Rafelski (STScI, JHU), Anton Koekemoer (STScI); Image Processing: Alyssa Pagan (STScI) CC BY 4.0

Lakkoofsa barruu kana irraa travel gochu miliquu fraction dha, ol-aanaa: galaaksii ionizing ifa keessaa half hanga hunda. Lakkoofsa dhugaa dha, garuu “dhugaa” asitti maal akka jedhu careful. Image irraa kallattii safarame miti; moodeelota chain irraa reconstructed, daangaa wide sababaa honest qaba. Seenaa faayidaa qabu kutaalee lama: tokko caught leak maal nuu hima/hin himne, fi quieter bu’aa — kallattii mala stop gochu dura al-kallattii way leak spot gochuuf high-redshift jalqabaa qormaata.

Maal an "escape fraction" is, fi maaliif it's so slippery

Urjiilee — keessumaa biggest, hottest, youngest — ultraviolet haayidiroojiinii atom irraa elektiroonii baasuuf anniisaa gahaa emit godhu. Astronomers ionizing radiation yookaan wavelengths kana keessatti *Lyman-continuum* ifa jedhu. Reionization currency dha: photons kana enough free ta'anii intergalactic haayidiroojiinii ionized eeganii addunyaa transparent ta'e.

Garuu galaaksii ofii haayidiroojiinii guutuu dha. Ionizing ifa galaaksii uumu keessaa hedduun osoo hin ba'in galaaksii gas ionize gochuudhaan absorbed. *Miliquu fraction* share intergalactic space ga'u, wider addunyaa reionize gochuuf jiru ta'e. Core gaaffii dha, sababoota lamaaf measure difficult.

Tokkoffaa, reionization yeroo IGM neutral haayidiroojiinii guutuu, exactly ifa detect barbaaddu absorb godha — leaked ifa nu hin ga'u. Lammaffaa, yommuu muraasa argu dandeessu illee, mul'ate detection gara miliquu fractiontti jijjiiruuf ifa mul'ate / ifa galaaksii produced qooduu qaba — produced kallattii hin argitu. Biraa ifa, inferred star-formation seenaa, stellar yaadota bu'uuraa irraa moodeela godhu.

Kanaaf miliquu fractions wide dogoggora bars qabu; intergalactic absorption illee moodeela godhamu yeroo wal-fakkaataa detection broad deebiiwwan support gochuu danda'a. Lakkoofsa reconstruction dha, dubbisuu kallattii miti.

Barreessitoonni maal godhan

- Galaaksii fageenya deep MUSE/VLT spectroscopy'n mirkaneessan: tokko emission sarara Lyman-alpha asymmetric high-z profile waliin, redshift z = 4.442. Chance foreground alignment carraa 0.0076%.
- Escaping ionizing (Lyman-continuum) ifa deep Hubble F435W image keessatti adda baasan — redshift kana irratti filter below-912-ångström escaped ifa qofa argu. Detection 5.2–5.3σ; miliyoona duwwaa sky patches yaa'a waliin cross-sakatta'a. (qajeelfama)
- Classic foreground interloper trap resolved madda shape fi custom de-blending faint neighbour fayyadamuun rule out godhan.
- Galaaksii urjiilee guutuu Hubble+JWST colours CIGALE + muraasa stellar-population moodeelota'n fit godhan; muraasa miliyoona waggoota ago dhiyoo starburst hint.
- IGM ionizing ifa hammam absorb godhe 10,000 simulated sightlines irratti moodeela godhan, walitti qabanii miliquu fraction keessaa baasu.
- Yeroo jalqabaaf ol-aanaa redshift akkanaa irratti al-kallattii miliquu tracer — Lyman-alpha sarara shape/extent ("halo fraction") — kallattii detection waliin qoran.

Maal argatan

- Lyman-continuum emitter direct-detected date irratti irra caalaa distant, z = 4.442.

- Escaping ionizing ifa ofii isaa dhugaa detection — inference qofa miti, image mallattoo 5.2–5.3σ.
- Ol-aanaa miliquu fraction 50–100%, yaadota bu'uuraa irratti — guddaa garuu model-dependent. Adda *walbira qabamee* tilmaama >100% ta'uu danda'a; hiika dust correction dura escaping ionizing ifa UV waliin compare waan godhuuf, urjiilee produce caalaa ifa escapes jechuu miti.
- Fitted starlight dhiyoo starburst ionizing ifa production + miliquu sochii godhaa jira ragaa.
- Barreessitoonni wording keessatti Lyman-alpha shape miliquu tracer ta'uu irratti "cautious support."

Kun maal hin mirkaneessu

- "Galaaksiiwwan addunyaa reionize godhan" identify hin godhu. Galaaksii tokko, reionization xumuramee ~250 Myr *booda*, event keessa miti.
- Miliquu fraction **safartuu kallattii miti**. Mul'ate ifa / *modelled* produced ifa, achiis *modelled* IGM absorption correction. Barreessitoonni favourable sightline deliberately adopt godhan, sababni leaked ifa nu ga'u jechuun clearer-than-giddugaleessa direction. Wide 50–100% daangaa model-dependence honest signature.
- Lyman-alpha tracer validate hin godhu. Tokko object "cautious support" jalqabaa qormaata qofa.
- Bursty urjii formation reionization sochii godhe seera hin settle. Tokko galaaksii + tracer hiika.

Ragaan hammam cimaa dha

- **Cimaa kallattii kutaalee:** redshift (distinct Lyman-alpha shape, foreground chance 0.0076%) fi escaped ifa detection (5.2–5.3σ, miliyoona duwwaa apertures, foreground trap checked).
- **Weaker/modelled:** sirrii miliquu fraction, reionization barbaachisummaa istaatistikii, haaraa tracer. Stellar moodeelota + sightline yaadota bu'uuraa barbaachisaa.
- Barruu honesty ranges keessatti. Tokko lakkoofsa force hin godhu, tracer support "cautious" jedha, IGM transmission tilmaama tokko ofii illee trust hin godhu. Hype balaa irra caalaa outside.

Maaliif barbaachisaa dha

Kallattii escaped ionizing ifa detections reionization era qarqara, bakka ifa barely pass gochuu danda'u, ga'aniiru. Kun ofii isaatiin valuable. Garuu quieter bu'aa caalaa barbaachisaa ta'uu mala: reionization *keessatti* kallattii mala completely fails; al-kallattii tracers nearer galaaksiiwwan irratti calibrate godhaman qofa hafu. Tracer tokko asitti dhugaa kallattii detection waliin sakatta'uun, boodaa kallattii sakatta'uun hin danda'amu yeroo ta'u trust earn gochuuf karaa dha. MXDFz4.4 gatii "galaaksii reionized addunyaa" miti; "leak akkam dubbisnu barachaa, yeroo darkness keessatti kallattii mala hin jirre meeshaa keenya sakatta'a jalqabne" dha.

Cuunfaa gabaabaa

Hubble fi JWST fayyadamuun astronomers galaaksii tokko z = 4.442 irraa escaping ionizing ultraviolet kallattii adda baasan — detection gosa kanaa irra caalaa distant, reionization xumuramee ~250 Myr booda. Detection ofii jajjabaa dha. Quoteable miliquu fraction 50–100% kallattii safarame miti; stellar + IGM absorption moodeelota, deliberately favourable sightline irraa reconstructed, kanaaf daangaa wide. Team al-kallattii leak tracer Lyman-alpha sarara shape high-redshift irratti yeroo jalqabaaf kallattii detection waliin qoree "cautious support" argate. Single-object bu'aa careful dha: leak kallattii qabame, lakkoofsa honestly uncertain, fuuldura reionization-era al-kallattii meeshaalee'f jalqabaa sirreessa safartuu tarkaanfii.

Sakatta'a ifaa

barruun maal agarsiisa: Galaaksii z = 4.442 irraa escaping ionizing (Lyman-continuum) ifa kallattii 5.2–5.3σ detection — date irratti highest-redshift — foreground contamination carefully ruled out.

Waan amansiisaa ta'e garuu hin mirkanoofne: Miliquu fraction 50–100%; detection dhugaa, fraction stellar/IGM moodeelota + favourable sightline irraa reconstructed. Lyman-alpha shape miliquu tracer ta'uu illee amansiisaa, tokko object "cautious support."

Waan hin agarsiifne: Galaaksii "addunyaa reionize godhe" (era booda, tokko object); bursty urjii formation reionization sochii godhe demonstrated seera.

Daangaawwan ijoo: saamudaa tokko; miliquu fraction moodeela choices/ifaa sightline depend; haaraa tracer jalqabaa qormaata; ionizing ifa era reionizationtti dhiyaachuun observe gochuun extremely difficult.

Dubbisaan waliigalaa amanamummaa hammam qabaachuu qaba? Escaping ifa dhugumaan detected fi irra caalaa distant catch ta'uu irratti ol-aanaa. Sirrii 50–100% miliquu fraction irratti low-to-moderate — modelled daangaa, safartuu miti. Haaraa tracer irratti moderate: promising jalqabaa sakatta'a, settled meeshaa miti.

Fooyya'iinsa maxxansa boodaa

- **Sirreeffama · 2026-07-28**

  Paper author Ilias Goovaerts feedback booda article opening irraa ionizing light irratti explicit goone, ultraviolet waliigalaa miti: short-wavelength UV below 912-ångström Lyman limit qofa ionizing, longer-wavelength UV non-ionizing fi high-redshift galaxies irraa routine observed ta'uu ifa goone.

Maddoota

Goovaerts et al., arXiv:2603.04517 (accepted in The Astrophysical Journal)
https://arxiv.org/abs/2603.04517

The Astrophysical Journal (2026), DOI 10.3847/1538-4357/ae75b0
https://doi.org/10.3847/1538-4357/ae75b0