Newsletter of *A Cosmology Group* - June 2024

ACG Editorial

In this Newsletter, papers on JWST observations that don't make sense in the ΛCDM paradigm and finally, a spectroscopically confirmed galaxy at $z > 14$...

Thanks to A. Mitra, M. Edwards, Y.-H. Sanejouand, M. Helland and all who contributed references to interesting papers.

Louis Marmet, June 4, 2024
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Reviewed Publications[1]

- Redshift, Hubble parameter, Expansion

"A shining cosmic dawn: spectroscopic confirmation of two luminous galaxies at z∼14" S. Carniani *et al.*, arXiv:2405.18485 (May 2024) "We present JADES JWST/NIRSpec spectroscopic confirmation of two luminous galaxies at redshifts of $z = 14.3$ and $z = 13.9$. The spectra reveal ultraviolet continua with prominent Lyman-α breaks but no detected emission lines. This discovery proves *(?)* that luminous galaxies were already in place 300 million years after the Big Bang and are more common than what was expected before JWST."

"Canonical Hubble-Tension-Resolving Early Dark Energy Cosmologies Are Inconsistent with the Lyman-α Forest" S. Goldstein, J.C. Hill, V. Iršič, and B.D. Sherwin, Phys. Rev. Lett. 131, 201001 (17 November 2023) https://journals.aps.org/prl/abstract/10.1103/PhysRevLett.131.201001 "Early dark energy, which briefly increases the cosmic expansion rate prior to recombination, is a leading scenario for resolving this "Hubble tension" while preserving a good fit to CMB data. However, this comes at the cost of changes in parameters that affect structure formation in the late-time universe."

"An effective description of Laniakea and its backreaction: Impact on Cosmology and the local determination of the Hubble constant" L. Giani *et al.*, arXiv:2311.00215 [Submitted on 1 Nov 2023] "We propose an effective model to describe the backreaction on cosmological observables induced by Laniakea, the gravitational supercluster hosting the Milky Way, which was defined using peculiar velocity data from Cosmicflows-4. The different expansion rates within the region, relative to the mean cosmological expansion, induce line-of-sight-dependent corrections in the computation of luminosity distances."

"Fitting of supernovae without dark energy" M. López-Corredoira and J.I. Calvo-Torel, Int. J. Mod. Phys. D, vol. 31, no. 15, p. 2250104, Aug. 2022, doi: 10.1142/S0218271822501048 and arXiv:2207.14688. "With data from Pantheon, we make fits to the corresponding Hubble–Lemaître diagram with various cosmological models. The data are well fitted by the standard model to include dark energy, but there is a degeneracy of solutions with several other variables. Within this degeneracy, models that give good fits to the data include: Einstein–de

[1]For all reviews, quoted text is adapted from the original, underlined text is my emphasis, and *italicized text are my comments.*

Sitter with gray extinction; linear Hubble–Lemaître law static Euclidean with gray extinction; Static Euclidean with tired light and gray extinction; Einstein–de Sitter with absolute magnitude evolution; Friedmann model with $\Omega_\Lambda = 0$ and partially non-cosmological tired-light redshifts/blueshift with attenuation/enhancement."

- Nucleosynthesis

"Discovery of Super-enriched Gas ∼1 Gyr after the Big Bang" J. Huyan *et al.* ApJL **954**, 1, L19 (2023) DOI 10.3847/2041-8213/aceefe "We report the discovery of a DLA at $z = 4.7372$ with an exceptionally high degree of chemical enrichment. Such a high level of enrichment a mere 1.2 Gyr after the Big Bang is surprising because of insufficient time for the required amount of star formation.[...] The metallicity of this absorber is higher than that of any other known DLA and is > 2 orders of magnitude above predictions of chemical evolution models and the NH I-weighted mean metallicity from previous studies at $z > 4.5$."

- Galaxy and Large-Scale Structure Formation

"A recently quenched galaxy 700 million years after the Big Bang" T.J. Looser *et al.*, Nature 629, 53–57 (2024). https://www.nature.com/articles/s41586-024-07227-0 "We report a (mini-)quenched galaxy at $z = 7.3$, when the Universe was only 700 Myr old. The JWST/NIRSpec spectrum is very blue but exhibits a Balmer break and no nebular emission lines. The galaxy experienced a short starburst followed by rapid quenching."

"GA-NIFS: JWST/NIRSpec IFU observations of HFLS3 reveal a dense galaxy group at $z \sim 6.3$" G.C. Jones *et al.*, arXiv:2308.16620 [Submitted on 31 Aug 2023] Accepted for publication in A&A "Massive, starbursting galaxies in the early Universe represent some of the most extreme objects in the study of galaxy evolution. One such source is HFLS3 ($z \sim 6.34$), which was originally identified as an extreme starburst galaxy with mild gravitational magnification. Here, we present new observations of HFLS3 with the JWST/NIRSpec IFU in both low and high spectral resolution, with high spatial resolution and sensitivity. This suggests that HFLS3 is not a single starburst galaxy, but instead is a merging system of star-forming galaxies in the Epoch of Reionisation."

"Insights from Super-Metal-Rich Stars: Is the Milky Way bar young?" S. Nepal *et al.* arXiv:2311.16993 [Submitted on 28 Nov 2023] "Super-metal-rich (SMR) stars, currently in the solar neighbourhood, are expected to originate only in the inner Galaxy and have definitely migrated. We aim at studying a large sample of SMR stars to provide constraints on the epoch of the bar formation and its impact on the MW disc stellar populations. We investigate a sample of 169,701 stars with 6D phase space information and high-quality stellar parameters coming from the hybrid-CNN analysis of the Gaia-DR3 RVS stars. We interpret the steep decrease in number of SMR stars at around 3 Gyr as the end of the bar formation epoch. In this scenario, the peak of bar activity also coincides with a peak in the SF activity in the disc. We suggest the SF burst to have been triggered by the high bar activity, 3-4 Gyr ago. According to these results and interpretation, the MW bar could be young."

"A Near-infrared-faint, Far-infrared-luminous Dusty Galaxy at $z \sim 5$ in COSMOS-Web" J. McKinney *et al.*, The Astrophysical Journal **956** Number 2 DOI 10.3847/1538-4357/acf614 (10 Oct 2023) "A growing number of far-infrared (FIR) bright sources completely invisible in deep extragalactic optical surveys hint at an elusive population of $z > 4$ dusty, star-forming galaxies. AzTECC71, among the reddest galaxies in COSMOS-Web with F277W - F444W ~ 0.9, is undetected in NIRCam/F150W and F115W and fainter in F444W than other submillimeter galaxies identified in COSMOS-Web by 2–4 magnitudes. This galaxy is massive and infrared-luminous comparable to other optically undetected but FIR-bright dusty, star-forming galaxies at $z > 4$. If further FIR-selected galaxies that drop out of the F150W filter in COSMOS-Web have redshifts $z > 4$ like AzTECC71, then the volume density of such sources may be $\sim 3 - 10$x greater than previously estimated."
From https://www.space.com/james-webb-space-telescope-ghostly-galaxy-early-universe "Study author Jed McKinney of the University of Texas at Austin said in a statement. "It's potentially telling us there's a whole population of galaxies that have been hiding from us." "

"Cosmic Vine: A $z = 3.44$ Large-Scale Structure Hosting Massive Quiescent Galaxies" S. Jin *et al.* arXiv:2311.04867 [Submitted on 8 Nov 2023] "We report the discovery of a large-scale structure at $z = 3.44$ revealed by JWST data in the EGS field. This structure, dubbed "Cosmic Vine", consists of 20 galaxies with spectroscopic redshifts at $3.43 < z < 3.45$ and six galaxy overdensities with consistent photometric redshifts, making up a vine-like structure extending over a $\sim 4 \times 0.2$ pMpcˆ2 area. The two most massive galaxies of the Cosmic Vine are found to be quiescent with bulge-dominated morphologies. We found that the observed specific star formation rates of massive quiescent galaxies in $z > 3$ dense environments are two orders of magnitude lower than that of the BCGs in the TNG300 simulation. This discrepancy potentially poses a challenge to the models of massive cluster galaxy formation."

"UNCOVER: Illuminating the Early Universe—JWST/NIRSpec Confirmation of $z > 12$ Galaxies" B. Wang et al., ApJL, vol. 957, no. 2, p. L34 (Nov. 2023) doi: 10.3847/2041-8213/acfe07. "Observations of high-redshift galaxies provide a critical direct test to the theories of early galaxy formation, yet to date, only three have been spectroscopically confirmed at $z > 12$. Here we present JWST/NIRSpec observations of two galaxies: a robust detection at $z_{spec} = 12.3$, and a plausible candidate at $z_{spec} = 13.079$. Detailed stellar population modeling using JWST NIRCam and NIRSpec data corroborates the primeval characteristics of these galaxies: low mass ($\sim 10^8$ $M_\odot$), young, rapidly assembling, metal-poor, and star-forming. Interestingly, both galaxies are spatially resolved, having lensing-corrected rest-UV effective radii on the order of 300-400 pc, which are notably larger than other spectroscopically confirmed systems at similar redshifts."

A Milky Way-like barred spiral galaxy at a redshift of 3 L. Costantin, P.G. Pérez-González, Y. Guo, *et al.* Nature **623**, 499 (2023). https://doi.org/10.1038/s41586-023-06636-x "... simulations predict bars to be almost absent beyond $z = 1.5$ in the progenitors of Milky Way-like galaxies. Here we report observations of CEERS-2112, a barred spiral galaxy at redshift $z_{phot} \approx 3$."

"Dissecting the Thermal SZ Power Spectrum by Halo Mass and Redshift in SPT-SZ Data and Simulations" J. Hernandez *et al.* arXiv:2309.12475 [Submitted on 21 Sep 2023] "We explore the relationship between the thermal Sunyaev-Zel'dovich (tSZ) power spectrum amplitude and the halo mass and redshift of galaxy clusters in South Pole Telescope (SPT) data, in comparison with three N-body simulations combined with semi-analytical gas models of the intra-cluster medium. Discrepancies exist and the data notably exhibits a steep mass-dependence which all of the simulations fail to reproduce. This suggests the need for additional mass- and redshift-dependent adjustments to the gas models of each simulation, or the potential presence of contamination in the data at halo masses below the detection threshold of SPT-SZ. Furthermore, the data does not demonstrate significant redshift evolution in the per-cluster tSZ power spectrum contribution, in contrast to self-similar model predictions."

"Relight the Candle: What happens to High Redshift Massive Quenched Galaxies" Rhea-Silvia Remus, Lucas C. Kimmig, arXiv:2310.16089 "A puzzling population of extremely massive quiescent galaxies at redshifts beyond $z = 3$ has recently been revealed by JWST and ALMA, some of them with stellar ages that show their quenching times to be as high as $z = 6$, while their stellar masses are already above $5 \times 10^{10} M_{sun}$. These extremely massive yet quenched galaxies challenge our understanding of galaxy formation at the earliest stages. Furthermore, we demonstrate that the massive quenched galaxies do not reside in the most massive nodes of the cosmic web, but rather live in side-nodes of approximately Milky-Way halo mass. Even at $z = 0$, only about 10% end up in small-mass galaxy clusters, while most of the quenched galaxies at $z = 3.4$ end up in group-mass halos, with about 20% actually not even reaching 1e13Msun in halo mass."

- Cosmology

"An almost dark galaxy with the mass of the Small Magellanic Cloud" M. Montes *et al.*, A&A **681** (January 2024) A15 https://www.aanda.org/articles/aa/full_html/2024/01/aa47667-23/aa47667-23.html "Almost dark galaxies are objects that have eluded detection by traditional surveys such as the Sloan Digital Sky Survey (SDSS). The low surface brightness of these galaxies, and hence their low surface stellar mass density (a few solar

masses per pc^2 or less), suggest that the energy density released by baryonic feedback mechanisms is inefficient in modifying the distribution of the dark matter halos they inhabit. For this reason, almost dark galaxies are particularly promising for probing the microphysical nature of dark matter. In this paper, we present the serendipitous discovery of Nube, an almost dark galaxy. Nube is the most massive and extended object of its kind discovered so far. The galaxy is ten times fainter and has an effective radius three times larger than typical ultradiffuse galaxies with similar stellar masses. Current cosmological simulations within the cold dark matter scenario, including baryonic feedback, do not reproduce the structural properties of Nube. However, its highly extended and flattened structure is consistent with a scenario where the dark matter particles are ultralight axions."

"The FLAMINGO project: revisiting the S8 tension and the role of baryonic physics" I.G. McCarthy *et al.* arXiv:2309.07959 [Submitted on 14 Sep 2023] "A number of recent studies have found evidence for a tension between observations of large-scale structure (LSS) and the predictions of the standard model of cosmology with the cosmological parameters fit to the cosmic microwave background (CMB). The origin of this 'S8 tension' remains unclear, but possibilities include new physics beyond the standard model, unaccounted for systematic errors in the observational measurements and/or uncertainties in the role that baryons play. Here we carefully examine the latter possibility using the new FLAMINGO suite of large-volume cosmological hydrodynamical simulations. Despite the wide range of astrophysical behaviours simulated, we find that baryonic effects are not sufficiently large to remove the S8 tension. These results suggest that some mechanism is required to slow the growth of fluctuations at late times and/or on non-linear scales, but that it is unlikely that baryon physics is driving this modification."
"Largest-ever Computer Simulation of the Universe", Sky and Telescope, https://skyandtelescope.org/ astronomy-news/largest-ever-computer-simulation-of-the-universe/

"The Scale of Homogeneity in the $R_h = ct$ Universe" F. Melia, MNRAS **525** Issue 3 (Nov. 2023) p. 3248, https://doi.org/10.1093/mnras/stad2496 "Studies of the Universe's transition to smoothness in the context of LCDM have all pointed to a transition radius no larger than ∼300 Mpc. These are based on a broad array of tracers for the matter power spectrum, including galaxies, clusters, quasars, the Ly-alpha forest and anisotropies in the cosmic microwave background. It is therefore surprising, if not anomalous, to find many structures extending out over scales as large as ∼2 Gpc, roughly an order of magnitude greater than expected. Such a disparity suggests that new physics may be contributing to the formation of large-scale structure, warranting a consideration of the alternative FLRW cosmology known as the $R_h = ct$ universe. This model has successfully eliminated many other problems in LCDM."

A Cosmology Group

A Cosmology Group draws its mandate from the *Open Letter to the Scientific Community* to engage scientists in an open exchange of ideas beyond the framework of Standard Cosmology through a critical examination[2] of the methods and investigations of cosmology. The *ACG Newsletter* highlights observational results that are anomalous in terms of the Big Bang paradigm.

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[2] When the thesis is supported by empirical evidence.
[3] ACG currently has 34 followers.