The Milky Way Panorama Credit: ESO / S. Brunier

# **Newsletter of A Cosmology Group** - October 2018

*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 mainstream framework of the Big Bang cosmology. The *ACG Newsletter* seeks to highlight published observational results which seem anomalous in terms of the ΛCDM model.

Critical examinations of the scientific methods and investigations used in cosmology are also the subject of the *Newsletter*, as long as these are supported by empirical data. Purely theoretical work and new cosmologies not yet supported by observations are deferred to future discussions at the next ACG Conference.

If you would like to suggest a paper for review, please send a direct reference to `redshift@cosmology.info`. Published work in a refereed journal and with open access (e.g. a preprint on `arXiv` or `HAL`) is preferred.

The *Newsletter* is published irregularly, editor's schedule permitting, and when interesting papers are available. ACG subscribers[1] receive notifications of *Newsletter* publications. You can subscribe to *ACG Notifications* either by sending a request to `redshift@cosmology.info`, by joining the ACG Forum 'Alt Cosmology' on *Yahoo! Groups* at `groups.yahoo.com/neo/groups/altcosmology/info#`, or by following `@CosmologyGroup` on Twitter.

## ACG Editorial

Galaxies are the focus of this Newsletter, including a few *strange* ones and many at large redshifts.

*Louis Marmet*, October 29, 2018
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## Reviewed Publications

Most of the text given here is quoted and adapted from the original articles.

"**An enigmatic population of luminous globular clusters in a galaxy lacking dark matter**"
P. van Dokkum, Y. Cohen, *et al.*, The Astrophysical Journal Letters, 856:L30 (7pp), April 1, 2018
2018: doi.org/10.3847/2041-8213/aab60b and arxiv:1803.10240

Another paper on the galaxy lacking dark matter reported by the same group (see ACG Newsletter, April 2018). NGC1052-DF2 is very different from other Ultra Diffuse Galaxies (and indeed all other known galaxies). First, the luminosity of its globular clusters is sharply peaked at $M_{V,606} \approx -9.1$. This is remarkable as the canonical value of $M_V \approx -7.5$ was thought to be universal. The second difference is that the galaxy has no (or very little) dark matter, which is inconsistent with the idea that the old, metal-poor globular cluster systems of galaxies are always closely connected to their dark matter halos.

[1]The ACG counts 56 subscribers to *ACG Notifications*, and 55 followers on *Alt Cosmology Yahoo! Group* and *Twitter*.

*However*: The low dark matter content is not valid if the galaxy is only at 13 Mpc from us instead of the 20 Mpc that is assumed by van Dokkum *et al.*: see "**A distance of 13 Mpc resolves the claimed anomalies of the galaxy lacking dark matter**" by I. Trujillo, M.A. Beasley *et al.* arXiv:1806.10141.

van Dokkum replies in this article: arxiv:1807.06025.

"**A massive, dead disk galaxy in the early Universe**"
S. Toft, J. Zabl, *et al.*, Nature, Vol. 546, pp. 510-513, June 22, 2017
2017: dx.doi.org/10.1038/nature22388 and arxiv:1706.07030

This massive dead disk galaxy challenges theories of galaxy evolution. MACS21291 spins very fast: "... this pattern of stellar rotation in a dead galaxy strongly contradicts prevalent astrophysical theory regarding the formation of elliptical-shaped galaxies shortly after the Big Bang 13.7 billion years ago." (See: nbi.ku.dk/english/news/news17 /unexpected-rotation-in-a-stone-dead-galaxy/)

The observed rotational velocity reaches a maximum of $|V_{max,obs}(1'')| = 341 \pm 115$ km/s, showing unambiguously, and independently of model assumptions, that the galaxy has a higher degree of rotational support than observed previously in any galaxy that has ceased star formation. The exponential profile and late type kinematics of MACS21291 appear in tension with the commonly accepted picture derived from lower-resolution data, that high-redshift quiescent galaxies are predominantly dispersion-dominated protobulges. However, there is a growing body of indirect evidence that quiescent galaxies may grow more disk-like and rotation-dominated with redshift.

"**A High Stellar Velocity Dispersion and ∼100 Globular Clusters for the Ultra Diffuse Galaxy Dragonfly 44**"
P. van Dokkum *et al.*, The Astrophysical Journal Letters, Vol. 828, No. 1, 2016
2016: iopscience.iop.org/article/10.3847/2041-8205/828/1/L6

From van Dokkum's group, this time a galaxy with $> 98\%$ dark matter! We present the stellar kinematics of Dragonfly 44, one of the largest Coma ultra-diffuse galaxies. Our results add to other recent evidence that many ultra-diffuse galaxies are "failed" galaxies, with the sizes, dark matter content, and globular cluster systems of much more luminous objects. [Our] estimate of [the] total dark halo mass of Dragonfly 44 [...] suggests a total mass of $\sim 10^{12}\ M_\odot$, similar to the mass of the Milky Way. The existence of nearly dark objects with this mass is unexpected, as galaxy formation is thought to be maximally efficient in this regime.

"**Flat rotation curves and low velocity dispersions in KMOS star-forming galaxies at $z \sim 1$**"
E.M. Di Teodoro, F. Fraternali and S. H. Miller, Astronomy and Astrophysics, 594, A77, 2016
2016: doi.org/10.1051/0004-6361/201628315 and arxiv:1602.04942

In the last decade the advent of Integral Field Spectroscopy has remarkably widened our possibilities of investigating the physical properties of galaxies in the high-redshift Universe. Kinematic studies revealed that the majority of star-forming galaxies in the stellar mass range $10^9 < M_\star/M_\odot < 10^{11}$ at $z > 1$ are disc-like systems. These starforming disky galaxies are rotationally supported with circular velocities of $100 - 300$ km/s already a few Gyr after the Big Bang. The predominance of disc-like kinematics over irregular or dispersion dominated kinematics seems to be in favor of a smooth mass growth of galaxies. However, the measured H$\alpha$ velocity dispersions in these systems are of the order of $50 - 100$ km/s, a factor 2-4 higher than the values found in local spiral galaxies, suggesting that discs at high redshift are morphologically and dynamically different from local ones. The general picture is that young discs were much more turbulent in the past and then they evolved towards a cooler dynamical state, with a $V/\sigma$ increasing with the cosmic time.

We find that: 1) the rotation curves of these $z \sim 1$ galaxies rise very steeply within few kiloparsecs and remain flat out to the outermost radius and 2) the H$\alpha$ velocity dispersions are low, ranging from 15 to 40 km/s, which leads to $V/\sigma = 3 - 10$. These characteristics are similar to those of disc galaxies in the local Universe. Finally, we also report no significant evolution of the stellar-mass Tully-Fisher relation. Our findings suggest that disc galaxies were already dynamically mature about 8 Gyr ago.

"**Massive Structures of Galaxies at High Redshifts in the Great Observatories Origins Deep Survey Fields**"

E. Kang, M. Im, Journal of The Korean Astronomical Society, Vol. 48, Issue 1, pp.21-55, Feb. 2015
2015: dx.doi.org/10.5303/JKAS.2015.48.1.21 and arxiv:1512.09282

If the Universe is dominated by cold dark matter and dark energy, it is expected that large scale structures form gradually, with galaxy clusters of mass $M \gtrsim 10^{14} M_{\odot}$ appearing at around 6 Gyrs after the Big Bang ($z \sim 1$). Here, we report the discovery of 59 massive structures of galaxies with masses greater than a few times $10^{13} M_{\odot}$ at redshifts between $z = 0.6$ and 4.5 in the Great Observatories Origins Deep Survey fields. We find that there are too many massive structures ($M > 7 \times 10^{13} M_{\odot}$) observed at $z > 2$ in comparison with the simulation predictions by a factor of a few, giving a probability of $< 1/2500$ of the observed data being consistent with the simulation. Our result suggests that massive structures have emerged early, but the reason for the discrepancy with the simulation is unclear. It could be due to the limitation of the simulation such as the lack of key, unrecognized ingredients (strong non-Gaussianity or other baryonic physics), or simply a difficulty in the halo mass estimation from observation, or a fundamental problem of the ΛCDM cosmology.

"**Galaxies as simple dynamical systems: observational data disfavor dark matter and stochastic star formation**"

P. Kroupa, Canadian Journal of Physics, 93(2): 169-202, 2015
2014: doi.org/10.1139/cjp-2014-0179 and arXiv:1406.4860

This long paper presents arguments challenging dark matter and stochastic star formation. The existence of dark matter particles is a key hypothesis in present-day cosmology and galactic dynamics. Given the large body of high-quality work within the standard model of cosmology, the validity of this hypothesis is challenged significantly by two independent arguments. (1) The *dual dwarf galaxy theorem* must be true, and (2) The action of dynamical friction due to expansive and massive dark matter halos must be evident in the galaxy population.

Briefly, PRIMORDIAL DWARF GALAXIES form within the dark matter halo and are dominated by dark matter. However, TIDAL DWARF GALAXIES form by interacting galaxies and contain very little exotic dark matter. The *dual dwarf galaxy theorem* states that both types of galaxies must exist in the universe.

When a test is performed, the two types of dwarf galaxies cannot be distinguished dynamically, and thus the Standard Model of Cosmology (SMoC) is falsified. A second test involves velocity dispersion measurements of pressure-supported dwarf galaxies. It turns out that these galaxies are indistinguishable in terms of their radiusmass relation and that the SMoC is also falsified by these observations.

Other tests are presented based on dynamical friction and star formation. The paper gives an extensive source of references.

"**The Most Luminous z ∼9-10 Galaxy Candidates Yet Found: The Luminosity Function, Cosmic Star-Formation Rate, and the First Mass Density Estimate at 500 MYR**"

P. A. Oesch *et al.*, Astrophysical Journal 786, 108, 2014
2014: iopscience.iop.org/0004-637X/786/2/108 and arxiv:1309.2280

"Four surprisingly bright galaxy candidates at $z \sim 9 - 10$ were discovered, doubling the number of $z \sim 10$ galaxy candidates that are known, just $\sim$ 500 Myr after the Big Bang. The abundance of such luminous candidates suggests higher number density of bright sources than previously expected." These observations come from many data sets: the HST CANDELS WFC3, the IR GOODS-N, the very deep Spitzer/IRAC 4.5 m and the GOODS-S. The redshift is not evaluated from spectroscopic observations. The reliability of the redshift based on colour is yet to be determined.

Since the data does not make sense to the authors, they repeatedly write about the surprising and unusual aspects of this discovery:

- "... the detection of such bright $z \sim 9-10$ galaxy candidates in the GOODS-N dataset is surprising given previous constraints on UV LFs at $z > 8$." §3.3
- "... the unusual brightness of our GOODS-N sources led us to give particular attention to this aspect." §3.3.3
- "While it is quite unlikely that we have identified sources with very unusual SEDs, the possibility remains, though finding four such undocumented sources seems a remote possibility." §3.3.4
- "While it would be surprising (though very interesting) to see significant AGN activity just a few hundred million years after the formation of the first stars, without spectroscopic observations, it is of course nearly impossible to reliably assess such a contribution." §3.4
- "The detection of four very bright $z > 9$ galaxy candidates in GOODS-N is quite surprising given the dearth of candidates in the very similar GOODS-S data..." §4
- "...the most plausible outcome is that these galaxy candidates are really at $z \sim 9-10$. Yet we cannot rule out that they constitute very unusual objects at lower redshift." §6
- "...the detection of four such bright sources is surprising given the expected number of only 1 source at H160 < 27 mag in the full search area." §6
- "Spectroscopic redshift measurements could show if these surprisingly luminous candidates are really at high redshift as all the photometric tests suggest." §6

"**A galaxy rapidly forming stars 700 million years after the Big Bang at redshift 7.51**"
S.L. Finkelstein *et al.*, Nature 502, 524527, 24 October 2013
2013: nature.com/articles/nature12657, also on arxiv:1310.6031

The paper describes a redshift measurement of galaxy z8_GND_5296 identified in the Cosmic Assembly Near-infrared Deep Extragalactic Legacy Survey (CANDELS), which uses the infrared spectrometer on one of the Keck telescopes. The redshift is measured to be z = 7.508, an accurate determination based on Lyman-$\alpha$ emission from hydrogen gas.

"This new observation of a galaxy that formed about 700 million years after the Big Bang is significant because astronomers have only measured accurate distances for five of them. This galaxy marks the sixth, and it is the farthest of them all." Galaxy z8_GND_5296 is relatively rich in "metals" (elements heavier than helium). These elements are produced by stars rather than the Big Bang, which indicates a very rapid cycle of star birth and death only 700 million years after the Big Bang.

While there are dozens of galaxies with redshifts greater than 7 (determined indirectly by the apparent color of the galaxy), the redshifts cannot be checked spectroscopically for most because something appears to be preventing much of the Lyman alpha light from reaching us. At this time there are too few galaxies observed to confirm the hypothesis that intergalactic gas scatters the light.

The Nature paper reports "a deep near-infrared spectroscopic survey of 43 photometrically-selected galaxies with $z > 6.5$. We detect a near-infrared emission line from only a single galaxy, confirming that some process is making Lyman-$\alpha$ difficult to detect [...] placing this galaxy at a redshift $z = 7.51$, an epoch 700 million years after the Big Bang. This galaxys colours are consistent with significant metal content, implying that galaxies become enriched rapidly. We calculate a surprisingly high star-formation rate [...] which is more than a factor of 100 greater than that seen in the Milky Way. Such a galaxy is unexpected in a survey of our size, suggesting that the early Universe may harbour a larger number of intense sites of star formation than expected."