The Milky Way Panorama Credit: ESO / S. Brunier

Newsletter of *A Cosmology Group* - October 2019

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 a Big Bang cosmology. The *ACG Newsletter* highlights observational results that are anomalous in terms of the ΛCDM model and provides a critical examination[1] of the methods and investigations used in cosmology.

The *Newsletter* is published irregularly, editor's schedule permitting, and when interesting papers are available. ACG subscribers[2] receive notifications of *Newsletter* publications. You can subscribe to *ACG Notifications* by sending a request to `redshift@cosmology.info`.

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. Summaries of new cosmologies are collected on A Cosmology Model or can be presented at the next ACG Conference.

ACG Editorial

This month: more Hubble tension: the universe could be as young as 12.8 Gy-old; poor understanding of galaxy formation; and a calculation that is off by 37 orders of magnitude.

Regards,

Louis Marmet, October 30, 2019
redshift@cosmology.info

Reviewed Publications[3]

- Redshift

"**A measurement of the Hubble constant from angular diameter distances to two gravitational lenses**" I. Jee *et al.*, Science Vol. 365, Issue 6458, pp. 1134-1138, 13 Sep 2019
doi: 10.1126/science.aat7371, and arXiv:1909.06712

We determine the angular diameter distances to two gravitational lenses, 810^{+160}_{-130} and 1230^{+180}_{-150} megaparsec, at redshifts $z = 0.295$ and 0.6304. Using these absolute distances to calibrate 740 previously measured relative distances to SNe, we measure the Hubble constant to be $H_0 = \underline{82.4}^{+8.4}_{-8.3}$ kilometers per second per megaparsec.

Pick your favourite value for H_0: $H_0 = \underline{75.6}$ km/s/Mpc in "A SHARP view of H0LiCOW: H_0 from three time-delay gravitational lens systems with adaptive optics imaging" arXiv:1907.02533, and $H_0 = \underline{75.7}$ km/s/Mpc in "Cosmology-independent local determination of H_0 in strong tension with CMB" arXiv:1906.11814.

[1] When the thesis is supported by empirical evidence.
[2] ACG has 51 subscribers to *ACG Notifications* and 62 followers on *Alt Cosmology* Yahoo! *Group*.
[3] Quoted text is adapted from the original articles: underlined text is my emphasis, *italicized text are my comments.*

- Nucleosynthesis

"**Identification of strontium in the merger of two neutron stars**"
D. Watson *et al.*, Nature volume 574, p. 497, 2019
doi: 10.1038/s41586-019-1676-3, and arXiv:1910.10510

Finally some spectroscopic confirmation of production of heavy elements. Understanding how these elements are formed is important for expanding or static cosmologies. Half of all the elements in the universe heavier than iron were created by rapid neutron capture. The theory for this astrophysical 'r-process' was worked out six decades ago and requires an enormous neutron flux to make the bulk of these elements. Where this happens is still debated.

The kilonova, AT2017gfo, emerging from the gravitational-wave-discovered neutron star merger, GW170817, was the first kilonova where detailed spectra were recorded. Observations of abundances in stars in dwarf galaxies suggest that large amounts of Sr are produced together with Ba in infrequent events, implying the existence of a site that produces both light and heavy r-process elements together in quantity. This is consistent with our spectral analysis of AT2017gfo.

- Large-Scale Structure

"**Constraints on bosonic dark matter from ultralow-field nuclear magnetic resonance**"
A. Garcon *et al.*, Science Advances, Vol. 5, no. 10, eaax4539, 2019
doi: 10.1126/sciadv.aax4539

Another null result for dark matter. The nature of dark matter, the invisible substance making up over 80% of the matter in the universe, is one of the most fundamental mysteries *(or perhaps the most fundamental mistake)* of modern physics. Ultralight bosons such as axions, axion-like particles, or dark photons could make up most of the dark matter. Couplings between such bosons and nuclear spins may enable their direct detection via nuclear magnetic resonance (NMR) spectroscopy.

As part of the cosmic axion spin precession experiment (CASPEr), an NMR-based dark-matter search, we use ultralow-field NMR to probe the axion-fermion "wind" coupling and dark-photon couplings to nuclear spins. No dark matter signal was detected above background, establishing new experimental bounds for dark matter bosons with masses ranging from 1.8×10^{-16} to 7.8×10^{-14} eV.

"**The low density and magnetization of a massive galaxy halo exposed by a fast radio burst**"
J.X. Prochaska *et al.*, Science, Vol. 366, Issue 6462, p. 231, 2019
doi: 10.1126/science.aay0073, and arXiv:1909.11681

This work struggles to find more matter and magnetic fields than what is actually measured. Present-day galaxies are surrounded by cool and enriched halo gas extending for hundreds of kiloparsecs. This halo gas is thought to be the dominant reservoir of material available to fuel future star formation, but direct constraints on its mass and physical properties have been difficult to obtain. We report the detection of a fast radio burst (FRB 181112), localized with arcsecond precision, that passes through the halo of a foreground galaxy. Analysis of the burst shows that the halo gas has low net magnetization and turbulence. Our results imply predominantly diffuse gas in massive galactic halos, even those hosting active supermassive black holes, contrary to some previous results.

"**Radial Acceleration Relation in Rotationally Supported Galaxies**"
S.S. McGaugh, F. Lelli, J.M. Schombert, Phys. Rev. Lett. 117, 201101, 2016
doi: 10.1103/PhysRevLett.117.201101, and arXiv:1609.05917

This is an example of good systematic research that helps determining general relationships.

We report a correlation between the radial acceleration traced by rotation curves and that predicted by the observed distribution of baryons. The same relation is followed by 2693 points in 153 galaxies with very different morphologies, masses, sizes, and gas fractions. The correlation persists even when dark matter dominates. Consequently, the dark matter contribution is fully specified by that of the baryons.

This short article gives a brief description of the observation "Viewpoint: Connecting the Bright and Dark Sides of Galaxies" physics.aps.org/articles/v9/130:
McGaugh, Lelli, and Schombert have displayed a remarkably simple relation between the radial distribution of visible matter in disk galaxies and the radial dependence of the rotational velocity. [...] Why should the visible matter in the disk have such a tight correlation with the distribution of surrounding dark matter, over a wide range of disk masses and densities? [...] the new general relationship, which encompasses both mass and density, is harder to understand. Why should disks of different density at constant mass follow the same scaling relation as disks of different masses at constant density? And why is acceleration the relevant scaling parameter?

See also "One Law to Rule them All: The Radial Acceleration Relation of Galaxies" iopscience.iop.org/article/10.3847/1538-4357/836/2/152.

Physics World reports " 'Its an impressive demonstration of something, but I dont know what that something is,' admits James Binney, a theoretical physicist at the University of Oxford, who was not involved in the study." (physicsworld.com/a/correlation-between-galaxy-rotation-and-visible-matter-puzzles-astronomers/)
Observing that dark matter doesn't behave independently of baryonic matter may be the first step to show that dark matter doesn't exist.

"**Evidence for a Massive, Extended Circumgalactic Medium Around the Andromeda Galaxy**"
N. Lehner, J.C. Howk, B.P. Wakker, The Astrophysical Journal, Volume 804, Number 2, 2015
doi: 10.1088/0004-637X/804/2/79

We demonstrate the presence of an extended and massive circumgalactic medium (CGM) around Messier 31 using archival HST Cosmic Origins Spectrograph ultraviolet spectroscopy of 18 QSOs projected within two virial radii of M31. We present several arguments that the gas at these velocities observed in these directions originates from the M31 CGM rather than the Local Group or Milky Way CGM or Magellanic Stream.

We show that the M31 CGM gas is bound, multiphase, predominantly ionized, and is more highly ionized gas at larger R. We estimate using Si II, Si III, and Si IV, a CGM metal mass of $\gtrsim 2 \times 10^6$ $M_\odot$ and gas mass of $\gtrsim 3 \times 10^9 (Z_\odot/Z) M_\odot$ within $0.2R_{\rm vir}$, and possibly a factor of ~ 10 larger within $R_{\rm vir}$, implying substantial metal and gas masses in the CGM of M31.

One might wonder, with all this ionized gas that is hard to detect, if it could not account for dark matter in other galaxies?

"**The current status of galaxy formation**"
J. Silk, G.A. Mamon, Research in Astron. Astrophys. 12, No. 8, 917946, 2012
doi: 10.1088/1674-4527/12/8/004

An older article on galaxy formation. There is a constant struggle to get the theory to work with both low-redshift and high-redshift galaxies.
Metallicity dependent star formation alleviates the high redshift problem, reducing the stellar mass that is in place early and enhancing the specific star formation rates (SSFR) as needed. However, it is a disaster at low z because the change in metallicity and the gas fraction anti-correlate, hence leading to too little evolution in the SSFR...
Attempts to patch up the problem at low redshift, to avoid an excess of massive galaxies, exacerbate the inadequacy of the predicted numbers of massive galaxies at high redshift...
Outflows may reproduce the observed cores if the star formation efficiency is high at early epochs, but such models fail to result in the strong evolution observed at low redshift...
Semi-analytical Models (SAMs) have been remarkably successful in constructing mock catalogs of galaxies at different epochs and are used in motivating and in interpreting the large surveys of galaxies. [...] However, a major difficulty confronted by all SAMs is that the evolution of the galaxy luminosity function contradicts the data, ei-

ther at high or at low redshift...
There is a well-known difficulty in matching both the galaxy luminosity function and Tully-Fisher scaling relation, even at $z = 0$. Reconciliation of the Tully-Fisher zero point with the galaxy luminosity function requires too high an efficiency of star formation. In fact, the problem is even worse: the models of massive spirals tuned to fit the Tully-Fisher relation are too concentrated. The luminosity function problem is most likely related to another unexplained property of high z galaxies. The SSFR evolution at high z is very different from that at low z...

- Old Systems

"**Early cosmological evolution of primordial electromagnetic fields**"
T. Kobayashi, M.S. Sloth, Phys. Rev. D 100, 023524, 2019
doi: 10.1103/PhysRevD.100.023524, and arXiv:1903.02561

The origin of the magnetic fields in our universe is a mystery. *(So they say! There are plasmas everywhere, even in intergalactic space. When pushed by stellar winds and pulled by gravity, they form currents which generate magnetic fields. Where is the mystery?)* Here we show that primordial magnetic fields do not exhibit radiation-like redshifting in the presence of stronger electric fields, as a consequence of Faraday's law of induction. In particular for the standard Maxwell theory, magnetic fields on super-horizon scales can redshift as $B^2 \propto a^{-6}H^{-2}$, instead of the usually assumed a^{-4}. Taking into account this effect for in stationary magnetogenesis can correct previous estimates of the magnetic field strength by up to 37 orders of magnitude.

The mystery is that nobody has noticed that estimates were off by 37 orders of magnitude *before!*

"**Dusty starburst galaxies in the early Universe as revealed by gravitational lensing**"
J.D. Vieira *et al.*, Nature 495, p. 344, 2013
doi: 10.1038/nature12001, and arXiv:1303.2723

In the past decade, our understanding of galaxy evolution has been revolutionized by the discovery that luminous, dusty, starburst galaxies were 1,000 times more abundant in the early Universe than at present. It has, however, been difficult to measure the complete redshift distribution of these objects, especially at the highest redshifts ($z > 4$). Here we report a redshift survey at a wavelength of three millimeters, targeting carbon monoxide line emission from the star-forming molecular gas in the direction of extraordinarily bright millimetre wave-selected sources. At least 10 of the sources are found to lie at $z > 4$, indicating that the fraction of dusty starburst galaxies at high redshifts is greater than previously thought. Models of lens geometries in the sample indicate that the background objects are ultra-luminous infrared galaxies, powered by extreme bursts of star formation.

"**SUBARU High-z Exploration of Low-Luminosity Quasars (SHELLQs). I. Discovery of 15 Quasars and Bright Galaxies at** $5.7 < z < 6.9$"
Y. Matsuoka *et al.*, The Astrophysical Journal 828, Number 1, 2016
doi: 10.3847/0004-637X/828/1/26

The era from the birth of the first stars to cosmic reionization is one of the key subjects in astronomy and astrophysics today. While the formation of the first stars is observationally out of reach at present, the epoch of reionization is being explored with several different approaches. The main source of the ultraviolet photons that caused the reionization of the universe is still under debate. It has been argued that star-forming galaxies observed in deep surveys are not able to produce a sufficient number of photons to sustain reionization, while the revised Planck results with later reionization than previously thought may alleviate this problem.

Active galactic nuclei (AGNs) have been studied as a possible additional source of ionizing photons, but the results are still controversial, largely due to the lack of knowledge about the numbers of faint quasars and AGNs residing in the reionization era.