The Milky Way Panorama Credit: ESO / S. Brunier

Newsletter of *A Cosmology Group* - December 2019

ACG Editorial

*W*elcome to the last *ACG Newsletter* of the year. In breaking with tradition this *Newsletter* is much longer to accommodate some news, images, messages, more *Reviewed Publications* and an essay. More to be enjoyed next to the fireplace on a cold winter night, or during the long warm days of summer next to the bush fires (sorry for our colleagues in the southern hemisphere).

*I*n the past months it has become impractical to use ACG's forum *Alt Cosmology Yahoo! Group*. Some messages were lost and others suffered a long delay before appearing on the forum. Since December 14^{th}, *Yahoo Groups* no longer hosts user content: all messages posted on 'Alternative Cosmology' and 'Alternative Cosmology: Science' have disappeared. (A copy was made before the messages were lost.)

These problems with *Yahoo Groups* have justified moving the discussion forum to a new website. The new host for ACG's discussion forum is ***Gaggle*** *Mail*. Registered members post to the forum by sending an e-mail to *a.cosmology@gaggle.email*. Old messages are available through the web interface. ACG members who only wish to receive infrequent notifications are on *cosmology@gaggle.email*, but they can't post messages. ***Gaggle*** *Mail* produces a report which has been useful in resolving e-mail delivery problems and identify at least 24 e-mail addresses which were no longer valid since 2004.

The name of the new host, 'Gaggle', reminds me of an image found in the book written by Hoyle, Burbidge and Narlikar. The image, which should be familiar to most of you, is reproduced for your enjoyment on the next page.

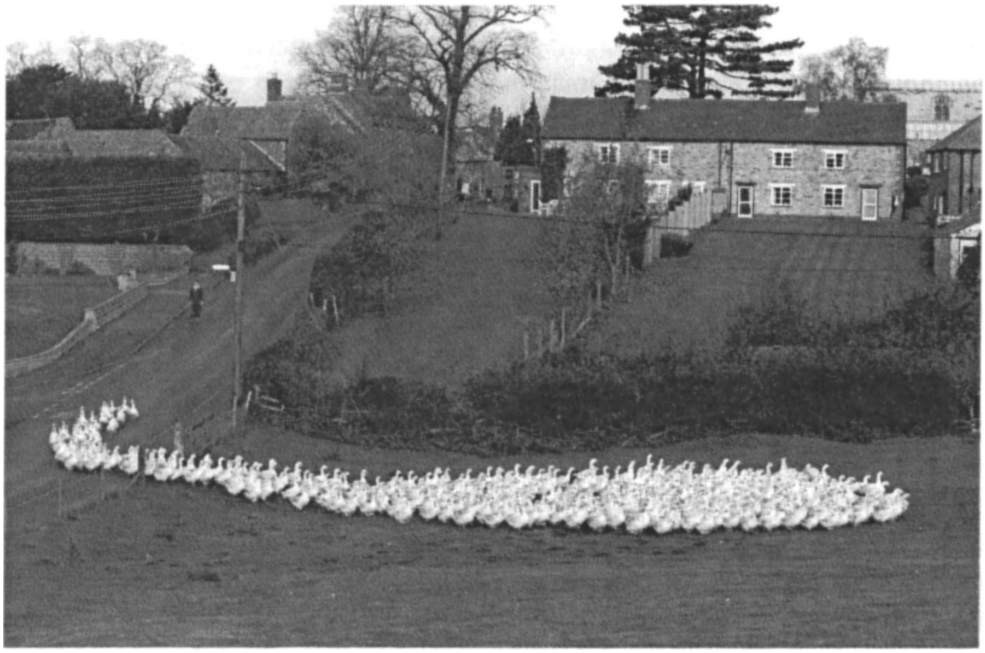
*O*n 2019-Nov-21 I sent this question to ACG members:

> A short Letter to Physics Today discusses how astrophysicists explained dark matter in the 1950s. At the time there was no need for exotic dark matter.
> "Galaxy collisions and ordinary dark matter" physicstoday.scitation.org/doi/10.1063/1.2743106
>
> Today it is believed that dark matter only exists in an exotic form: Which observations have disproved the 1950s model?
> ...

Domingos Soares replied on the next day - his answer was meant for the entire group:

> Hi Louis and ACG colleagues,
> I think the rationale goes like this: according to the Big Bang model, if one extrapolates the amount of baryonic matter needed for the primordial nucleosynthesis to present day, one gets 5% of the critical density in baryonic matter. BB requires approx. 30% of matter, thus 25% must be exotic and, of course, dark. But there is also a dark baryonic matter problem as well, which is often overlooked, that is, 4.5% of the baryonic matter is dark, only 0.5% is accounted for by the observations. In this regard, check the illustrations by Joel Primack that I quote in my article at http://lilith.fisica.ufmg.br/~dsoares/wish/primack-img.htm. The text is in Portuguese, but figures 1 to 4 are in English (fig. 4 is quite funny).
>
> Greetings from Belo Horizonte, MG, Brazil,
> Domingos

Thanks Domingos! It is clear that despite the lack of observations of dark matter, directly or indirectly, the astrophysical community will resist any significant change in the estimate for dark matter.



This is our view of the conformist approach to the standard (hot big bang) cosmology. We have resisted the temptation to name some of the leading geese.

Some of the leading geese are Nobel laureates - it is no surprise that cosmologists want to follow them! Copied from: F. Hoyle, G. Burbidge and J.V. Narlikar *"A Different Approach to Cosmology: from a Static Universe through the Big Bang towards Reality*," Cambridge University Press, Cambridge, p. 188 (2000)

$\mathcal{R}$eviewed papers this month: the Hubble constant is smaller than we thought, there is no acceleration of the expansion of the universe, there is an acceleration of the expansion, there is no acceleration of the expansion, we see magnetic fields but not dark matter, the assumption of a flat universe masks a cosmological crisis, and more evolved systems in a young universe.

A few exchanges on the discussion forum prompted me to write a short essay on the foundations of physics. It is presented at the end of this Newsletter. Your comments are welcome. My goal is to develop "specific criteria for a consistent cosmological model", c.f. a.cosmology.info/.

Happy holidays and a great year 2020!

Regards,

Louis Marmet, December 31, 2019
redshift@cosmology.info

Reviewed Publications[1]

- Redshift, Hubble constant, Expansion

"**A New Measurement of the Hubble Constant and Matter Content of the Universe Using Extragalactic Background Light γ-Ray Attenuation**"
A. Domínguez *et al.*, The Astrophysical Journal, Volume 885, Number 2, Nov. 8, 2019
doi: 10.3847/1538-4357/ab4a0e, and arXiv:1903.12097

The Hubble constant H_0 and matter density m of the Universe are measured using the latest γ-ray attenuation results from Fermi-LAT and Cherenkov telescopes. This methodology is based upon the fact that the extragalactic background light supplies opacity for very high energy photons via photon-photon interaction. The amount of γ-ray attenuation along the line of sight depends on the expansion rate and matter content of the Universe. This novel strategy results in a value of $H_0 = 68.0^{+4.2}_{4.1}$ km/s/Mpc and $m = 0.17^{+0.07}_{0.08}$. These estimates are independent and complementary to those based on the distance ladder, cosmic microwave background (CMB), clustering and weak plus strong lensing data. We also produce a joint likelihood analysis of our results from γ rays and these from more mature methodologies, excluding the CMB, yielding a combined value of $H_0 = 67.5^{+1.4}_{1.5}$ km/s/Mpc and $m = 0.30 \pm 0.03$. *The age of the universe is now at 14.5 Gyr...*

- Large-Scale Structure

"**Further evidence for a population of dark-matter-deficient dwarf galaxies**"
Q. Guo *et al.*, Nature Astronomy, doi:10.1038/s41550-019-0930-9 2019
doi: 10.1038/s41550-019-0930-9, and arXiv:1908.00046

In the standard cosmological model, dark matter drives the structure formation and constructs potential wells within which galaxies may form. The baryon fraction in dark halos can reach the universal value (15.7%) in massive clusters and decreases rapidly as the mass of the system decreases. In dwarf galaxies in the Local Group, dark matter dominates the mass content even within their optical-light half-radii ($r_e \sim 1$ kpc). However, recently it has been argued that not all dwarf galaxies are dominated by dark matter. Here we report 19 dwarf galaxies that could consist mainly of baryons up to radii well beyond r_e, at which point they are expected to be dominated by dark matter. Of these, 14 are isolated dwarf galaxies, free from the influence of nearby bright galaxies and high dense environments. This result provides observational evidence that could challenge the formation theory of low-mass galaxies within the framework of standard cosmology.

"**Evidence for anisotropy of cosmic acceleration**"
J. Colin, R. Mohayaee, M. Rameez, S. Sarkar, Astronomy and Astrophysics 631, L13, 2019
doi: 10.1051/0004-6361/201936373, and arXiv:1808.04597

There is no cosmic acceleration. The model-independent evidence for acceleration of the Hubble expansion rate from the largest public catalogue of Type Ia supernovae is only 1.4σ. This is in contrast to the claim that acceleration is established by SNe Ia at $> 6\sigma$ in the framework of the ΛCDM model. Moreover there is a significant (3.9σ) indication for a dipole in q_0 towards the CMB dipole – as is indeed expected if the apparent acceleration is an artefact of our being located in a local bulk flow which extends out far enough to include most of the supernovae studied. Given the observational evidence that there is no convergence to the CMB frame as far out as redshift $z \sim 0.1$ which includes half the known SNe Ia, this possibility must be taken seriously.

[1] Quoted text is adapted from the original articles: underlined text is my emphasis, *italicized text are my comments.*

Note that mistakes were made in the original SNe Ia analysis, but we can fix them!
In "**Is the expansion of the universe accelerating? All signs *still* point to yes**" (arXiv:1912.02191) *D. Rubin and J. Heitlauf reply:* Type Ia supernovae (SNe Ia) provided the first strong evidence that the expansion of the universe is accelerating. With SN samples now more than ten times larger than those used for the original discovery and joined by other cosmological probes, this discovery is on even firmer ground. Building on Rubin & Hayden (2016), we outline the errors made in the treatment of the data and inference on cosmological parameters. Reproducing the analysis with our proposed fixes, we find that the dipole parameters have little effect on the inferred cosmological parameters. We thus affirm the conclusion: the evidence for acceleration is secure.

Sarkar et al. disagree. In "**A response to Rubin & Heitlauf: "Is the expansion of the universe accelerating? All signs *still* point to yes"**" (arXiv:1912.04257), *J. Colin, R. Mohayaee, M. Rameez, and S. Sarkar write:* We have shown that the acceleration of the Hubble expansion rate inferred from Type Ia supernovae is essentially a dipole with 3.9σ significance, approximately aligned with the CMB dipole, while its monopole component which may be interpreted as due to a Cosmological Constant (or more generally dark energy) is consistent with zero at 1.4σ. We emphasize that our procedure is justified and that the criticism of Rubin & Heitlauf (2019) serves only to highlight the rather "arbitrary corrections" that are made to the data in order to infer isotropic cosmic acceleration. This is a vivid illustration of the 'Cosmological Fitting Problem' faced by observers who live in an inhomogeneous universe but still use the maximally symmetric FLRW cosmolgy to interpret observations.

Supporting the no-acceleration argument, the following paper claims supernova dimming:
"**Universe opacity and Type Ia supernova dimming**"
V. Vavryčuk, Monthly Notices of the Royal Astronomical Society: Letters, Vol. 489, Issue 1, p. L63, Oct. 2019
doi: 10.1093/mnrasl/slz128

In this paper, I argue that except for a commonly accepted accelerating expansion of the Universe, a conceivable alternative for explaining supernova dimming is universe opacity caused by light extinction by intergalactic dust, even though it is commonly assumed that this effect is negligible. Using data of the Union2.1 SN Ia compilation, I find that the standard Λ cold dark matter (ΛCDM) model and the opaque universe model fit the SN Ia measurements at redshifts $z < 1.4$ comparably well. The optimum solution for the opaque universe model is characterized by the B-band intergalactic opacity $\lambda_B = 0.10 \pm 0.03$/Gpc and the Hubble constant $H_0 = 68.0 \pm 2.5$ km/s/Mpc. The intergalactic opacity is higher than that obtained from independent observations but still within acceptable limits.

This result emphasizes that the issue of the accelerating expansion of the Universe as the origin of the SN Ia dimming is not yet definitely resolved. Obviously, the opaque universe model as an alternative to the ΛCDM model is attractive, because it avoids puzzles and controversies associated with dark energy and the accelerating expansion.

"**Using Herschel and Planck observations to delineate the role of magnetic fields in molecular cloud structure**"
J.D. Soler, Astronomy & Astrophysics, Volume 629, September 2019
doi: 10.1051/0004-6361/201935779, and arXiv:1909.04862

We present a study of the relative orientation between the magnetic field projected onto the plane of sky ($B \perp$) on scales down to 0.4 pc, inferred from the polarized thermal emission of Galactic dust observed by Planck at 353 GHz, and the distribution of gas column density (NH) structures on scales down to 0.026 pc, derived from the observations by Herschel in submillimeter wavelengths, toward ten nearby ($d < 450$ pc) molecular clouds. The measured coupling between the NH distribution and the magnetic field suggests that the magnetic fields play a significant role in structuring the interstellar medium in and around molecular clouds. However, we found no evident correlation between the star formation rates, estimated from the counts of young stellar objects, and the relative orientation between NH and ($B \perp$) in these regions.

Magnetic fields contribute to bringing the material to form stars, but does not help their formation rates. A substitute for dark matter?

"**Untangling the Galaxy. I. Local Structure and Star Formation History of the Milky Way**"
M. Kounkel, K. Covey, The Astronomical Journal 158, Number 3, 2019
doi: 10.3847/1538-3881/ab339a, and arXiv:1907.07709

We identify a number of clusters, associations, and co-moving groups in the solar neighbourhood which appear to be filamentary or string-like, oriented in parallel to the Galactic plane, and some spanning hundreds of pc in length. Most of these string lack a central cluster, indicating that their filamentary structure is primordial, rather than the result of tidal stripping or dynamical processing. The youngest strings (< 100 Myr) are orthogonal to the Local Arm. The older ones appear to be remnants of several other arm-like structures that cannot be presently traced by dust and gas. The velocity dispersion measured from the ensemble of groups and strings increase with age, suggesting a timescale for dynamical heating of ~ 300 Myr. This timescale is also consistent with the age at which the population of strings begins to decline, while the population in more compact groups continues to increase, suggesting that dynamical processes are disrupting the weakly bound string populations, leaving only individual clusters to be identified at the oldest ages.

While it may be surprising that they can survive as quasi-coherent structures into the Gyr age, these strings do not show a significant evolution beyond slowly dissolving into the field, and the oldest strings are most likely the remnants of some of the most massive structures that have originally formed.

The paper doesn't discuss dark matter nor magnetic fields, but these strings may have been formed by early magnetic fields. Why the young strings are perpendicular to the Local Arm is harder to explain.
A substitute for dark matter?

"**XV. Large-scale magnetic field reversals in the radio halo of NGC 4631**"
S.C. Mora-Partiarroyo *et al.*, Astronomy & Astrophysics 632, A11, December 2019
doi: 10.1051/0004-6361/201935961

The magnetic field in the halo is characterized by strong vertical components above and below the central region of the galaxy. The magnetic field in the disk is only clearly seen in the eastern side of NGC 4631, where it is parallel to the plane of the major axis of the galaxy. We detected for the first time a large-scale, smooth Faraday depth pattern in a halo of an external spiral galaxy, which implies the existence of a regular (coherent) magnetic field. A quasi-periodic pattern in Faraday depth with field reversals was found in the northern halo of the galaxy.

Since the magnetic field extends to the halo, it might play a role in shaping it. A substitute for dark matter? The theory of magnetism is well understood!

"We seem to have one of those rare occasions where a classical theory, about magnetic generators called dynamos, predicted the observations of NGC 4631 quite well. Our dynamo model produces spiraling magnetic fields in the halo that are a continuation of the normal spiral arms in the galaxy's disc," said Richard Henriksen, of Queen's University. (From m.phys.org/news/2019-11-image-giant-magnetic-ropes-galaxy.html)

- Old Systems

"**An over-massive black hole in a typical star-forming galaxy, 2 billion years after the Big Bang**"
B. Trakhtenbrot *et al.*, Science, Vol. 349, Issue 6244, p. 168, 2015
doi: 10.1126/science.aaa4506

Black hole out of kilter with theory

It is believed that black holes and their host galaxies coevolve, with the feedback from the black hole inducing star formation. Such a scenario requires certain timing and mass constraints for the black hole and the star-forming gas. Trakhtenbrot et al. looked at highred shift galaxies, when the universe was only about 2 billion years old. They found a black hole that developed to maturity much earlier than would be expected and was about 10% of

the total galactic mass – much more than expected. Moreover, star formation continued after it would have been expected to stop.

This black hole wss found in a 2 Gyr-old universe. In the following paper, much younger black holes have been found.

"**The REQUIEM Survey. I. A Search for Extended Ly Nebular Emission Around 31 $z > 5.7$ Quasars**"
E.P. Farina *et al.*, The Astrophysical Journal 887, Number 2, 2019
doi: 10.3847/1538-4357/ab5847, and arXiv:1911.08498

More and more supermassive black holes are found which existed just a few hundred million years after the Big Bang at the centre of galaxies. How they could have become so massive in such a short period of time is not well understood.

The discovery of quasars few hundred megayears after the Big Bang represents a major challenge to our understanding of black holes and galaxy formation and evolution. Their luminosity is produced by extreme gas accretion onto black holes, which already reached masses of $10^9 M_\odot$ by $z \sim 6$. Simultaneously, their host galaxies form hundreds of stars per year, using up gas in the process.

We here present results of our searches for extended Ly-Alpha halos around the first 31 targets observed as part of this program. As the first statistical and homogeneous investigation of the circum-galactic medium of massive galaxies at the end of the reionization epoch, the REQUIEM survey enables the study of the evolution of the cool gas surrounding quasars in the first 3 Gyr of the Universe. A comparison with the extended Ly-Alpha emission observed around bright ($M_{1450} < -25$ mag) quasars at intermediate redshift indicates little variations on the properties of the cool gas from $z \sim 6$ to $z \sim 3$ followed by a decline in the average surface brightness down to $z \sim 2$.

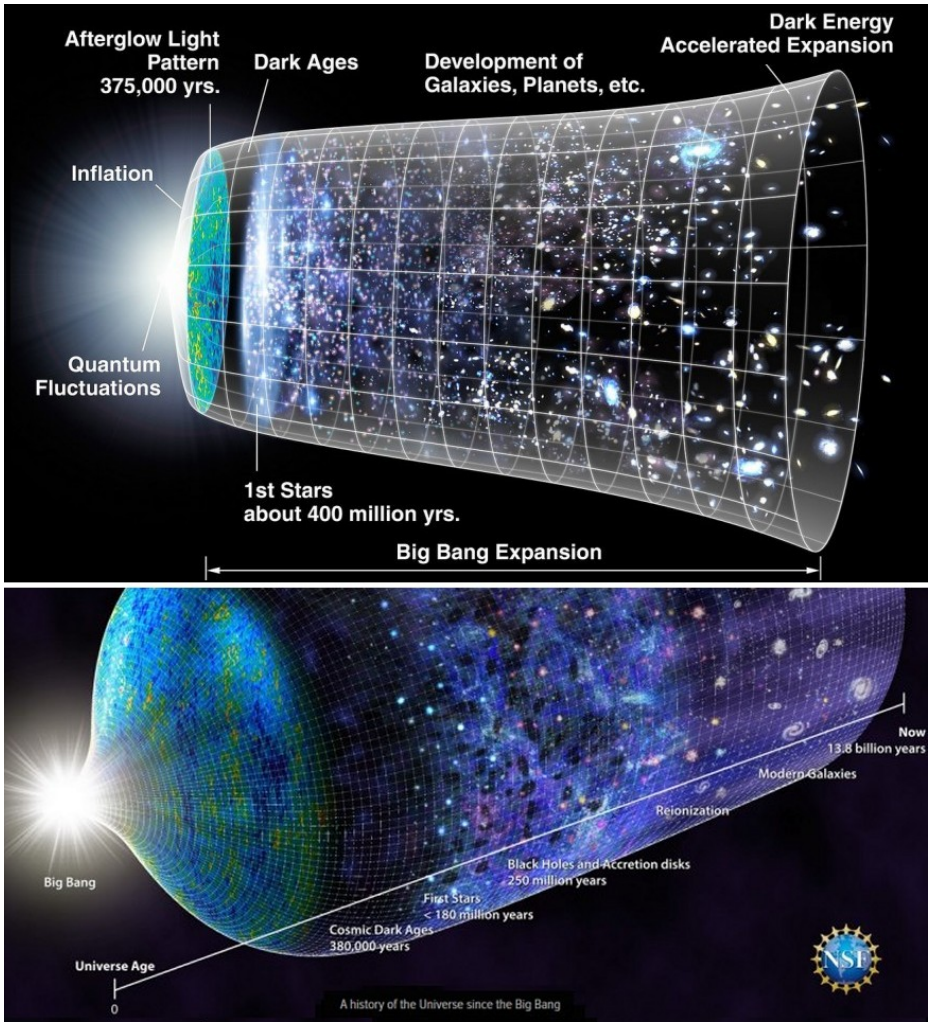
Another surprising finding is that these objects do not seem to evolve very much between $z \sim 6$ and $z \sim 3$. Yet, they must have evolved very rapidly during the first million years of their existence...

"**Stellar Velocity Dispersion of a Massive Quenching Galaxy at z = 4.01**"
M. Tanaka *et al.*, The Astrophysical Journal Letters 885, Number 2, L34, 2019
doi: 10.3847/2041-8213/ab4ff3, and arXiv:1909.10721

We present spectroscopic confirmation of a massive galaxy being quenched at $z = 4.01$, which is the most distant example known to date. Thanks to the high S/N of the spectrum, we are able to measure its stellar velocity dispersion, 268 ± 59 km/s. The size estimate based on the deep optical data is 0.76 ± 0.20 kpc with a stringent upper limit of 1.3 kpc, which is consistent with the typical size of massive quiescent galaxies from Kubo et al. (2018). Also, the galaxy is on the mass fundamental plane and the expected evolutionary path of the galaxy is consistent with the massive quiescent galaxies at lower redshifts.

The most striking finding of this work is that the stellar velocity dispersion of the massive galaxy at $z = 4.01$ is consistent with that of massive galaxies at lower redshifts. The observed no strong evolution in σ suggests that the mass in the core of massive galaxies does not evolve significantly, while most of the mass growth occurs in the outskirts of the galaxies, which also increases the size.

A well developed 'core' in this quenched (dead) massive galaxy, already formed 1.5 Gyr after the Big Bang.



Cosmologists change the past, as in Orwell's "1984"

On a web page dated 2006-Mar-16, a diagram of the history of the universe shows the first stars born 400 Myr after the Big Bang. Top image is from https://www.nasa.gov/vision/universe/starsgalaxies/wmap_pol.html
On 2018-Feb-28 the history of the universe has its first stars born < 180 Myr after the Big Bang. Lower image is from https://gizmodo.com/landmark-cosmic-observation-provides-tantalizing-hints-1823392625

""Big Three Dragons": a z = 7.15 Lyman BreakGalaxy Detected in [OIII] 88 μm, [CII] 158 μm, and Dust Continuum with ALMA"
T. Hashimoto *et al.*, Publications of the Astronomical Society of Japan, Volume 71, Issue 4, 71, August 2019
doi: 10.1093/pasj/psz049, and arXiv:1806.00486

We present new ALMA observations and physical properties of a Lyman Break Galaxy at $z = 7.15$. Our target, B14-65666, has a bright ultra-violet (UV) absolute magnitude, $M_{UV} \simeq -22.4$, and has been spectroscopically identified in Lyα. We successfully detect spatially resolved [CII], [OIII], and dust continuum emission in two bands, making B14-65666 the first object at $z > 6$ with a complete set of these three features[2]. Owing to our high spatial resolution data, we show that the [OIII] and [CII] emission can be spatially decomposed into two clumps associated with the two rest-frame UV clumps whose spectra are kinematically separated by $\simeq 200$ km/s. Based on these results, we argue that B14-65666 is a starburst galaxy induced by a major-merger. The merger interpretation is also supported by the large specific star-formation rate inferred from our SED fitting. Probably,

[2] "Big Three Dragons" is a hand in a Mahjong game with triplets or quads of all three dragons.

a strong UV radiation field caused by intense star formation contributes to its high dust temperature and the [OIII]-to-[CII] luminosity ratio.

This is the earliest example of merging galaxies ever found so far. The concern here is that $z = 7.15$ corresponds to only ~ 750 Myr after the Big Bang. How can two galaxies be involved in a merger so early?
(The second-earliest known merging galaxies are at $z = 5.655$; see D.A. Riechers *et al.*, "Rise of the Titans: A Dusty, Hyper-luminous "870 μm Riser" Galaxy at $z \sim 6$," ApJ 850 1, 2017 doi: 10.3847/1538-4357/aa8ccf*).*

- Cosmology

"**Planck evidence for a closed Universe and a possible crisis for cosmology**" *... another crisis!*
E. Di Valentino, A. Melchiorri, J. Silk, Nature Astronomy Nov. 4, 2019
doi: 10.1038/s41550-019-0906-9, and arXiv:1911.02087

The recent Planck Legacy 2018 release has confirmed the presence of an enhanced lensing amplitude in cosmic microwave background power spectra compared with that predicted in the standard Λ cold dark matter model. A closed Universe can provide a physical explanation for this effect, with the Planck cosmic microwave background spectra now preferring a positive curvature at more than the 99% confidence level. Here, we further investigate the evidence for a closed Universe from Planck, showing that positive curvature naturally explains the anomalous lensing amplitude, and demonstrating that it also removes a well-known tension in the Planck dataset concerning the values of cosmological parameters derived at different angular scales. We show that since the Planck power spectra prefer a closed Universe, discordances higher than generally estimated arise for most of the local cosmological observables, including baryon acoustic oscillations. The assumption of a flat Universe could therefore mask a cosmological crisis where disparate observed properties of the Universe appear to be mutually inconsistent. Future measurements are needed to clarify whether the observed discordances are due to undetected systematics, or to new physics or simply are a statistical fluctuation.

An Essay on the Foundations of Physics

Although it is difficult to agree on a precise definition of the scientific method (how we do science), the distinction between science and mathematics (what is science) should always be clear in the scientist's mind. In a recent video, Sabine Hossenfelder dissociates the physical theory from the measurement that defines it.

In her words: "*If you want to claim that the Higgs boson does not exist, you have to demonstrate that the theory which contains the mathematical structure called 'Higgs boson' does not fit the data. Whether or not Higg bosons ever arrived in a detector is totally irrelevant.*" (https://youtu.be/ ka9KGqr5Wtw?t=194) Her statement ignores that the basis of a physical concept is always an experiment, not a mathematical structure! This essay describes physics as a distinct activity which is not dependent on mathematics.

In their argumentation, mathematicians, logicians, philosophers and even physicists often forget about the foundations on which physics is based and place mathematical modeling above experimentation. Despite being a formal language and a very powerful tool, mathematics does not fundamentally define any physical concept.

The Device as a Physical Concept

The only way to describe the real world is to pay attention to observations. These observations are necessarily obtained from measuring devices which range in complexity from the simple ruler to large particle accelerators and the human eye. What is often forgotten is that not only does a measuring device produce observations, it also concretizes the questions asked by the scientist. As a result, *a measuring device defines a physical concept.* The cartoons below show a few examples of this.

In Fig. 1 Panel A, the position of the needle symbolizes an observation. Physicists agree that such a device defines the concept of "distance": if the balls are moved, a different observation is obtained. Two different observations of the distance are depicted in examples A1 and A2.

Physicists agree that the device of Panel B defines the concept of "elastic force": if the right-hand side ball is moved, the coil spring is stretched and a different observation is obtained. Two different observations of the elastic force are depicted in examples B1 and B2. Note that the device is constructed in such a way that for balls aligned with the balls in A1 and A2 the same observations are obtained.

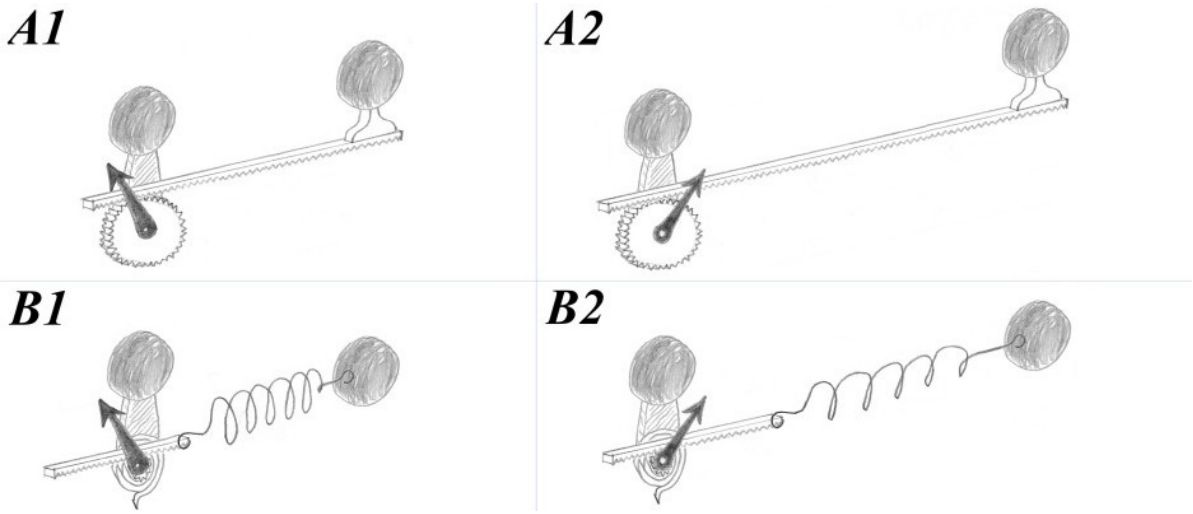


Figure 1. (A) A needle indicator is attached to a pinion in the familiar rack-and-pinion configuration. The pinion rotates about an axis attached to a vertical plate which supports a ball (left). Another ball is attached to the far end of the rack (right). **(B)** A needle indicator is attached to a small pinion which is held by a spiral spring. The other end of the spring is attached to a vertical plate and a ball. A short rack drives the pinion. The right-hand end of the rack is attached to a large coil spring which is in turn attached to another ball.

The device of Panels C defines the "electrostatic force". Two different observations of 'electrostatic force' are depicted in C1 and C2. Note that the device is constructed in such a way that for balloons aligned with the balls in examples A1 and A2, the same observations are obtained.

These few primitive examples show how the measuring device define a physical concept.

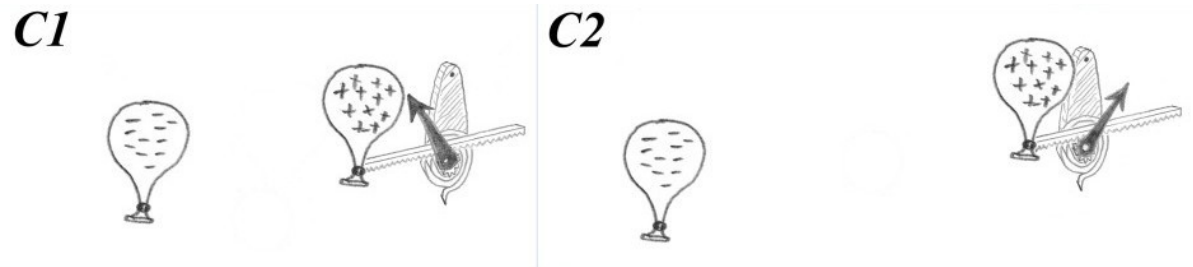


Figure 2. (C) The rack-and-pinion indicator is attached to a positively charged balloon on the right. The balloon on the left has a negative charge. Charged balloons are produced with the usual method involving cats.

Physical concepts without mathematics

The curiosity driven scientist will immediately ask the question: *if the objects are kept aligned for all measuring devices, will the observations agree for object separations which are not those of examples 1 or 2?*

Based on observations A1, A2, B1 and B2, a hypothesis can be made: "When the objects of devices A and B are aligned, the observations from A and B are the same for any distance." Moving the objects shows that the hypothesis holds. Thus distance and elastic force have a common characteristic. This is Hooke's law of elasticity.

Based on observations A1, A2, C1 and C2, another hypothesis can be made: "When the objects of devices A and C are aligned, the observations from A and C are the same for any distance." Here the hypothesis *fails* when the objects are moved to other positions. The electrostatic force between two objects does not behave in the same way as their distance.

This is to show how physical concepts such as distance, elastic force and electrostatic force are compared without any reference to a mathematical structure (such as a linear or an inverse quadratic function).

Physics and Mathematics

Every physical concept used in physics, such as distance, time, velocity, mass, force, etc. must be defined by a measuring device. Any other concept not related to a measuring device is disconnected from the real world, does not produce observations and cannot be subjected to the scientific method. Physics operates based on observations, concepts, hypotheses and experimental tests - four elements recognizable in the scientific method.

It is important to keep in mind the distinction between physics and mathematics as it impacts on which statements have a physical meaning.

→ Experimental tests and observations support (or falsify) a correspondence with other observations. Claims such as "equations lead to correct predictions" and "observations falsify equations" result from a poor understanding of science. Predictions are consistent with observations, independently of the language used to describe them. In the example with panels A-C above, it is the physical concept that was falsified, not a mathematical equation.

To be sure, mathematics is a very powerful language that describes physical concepts and observations. The text on p. 9 above can fit on this single line:

"Distance is d; Hooke's law $F_H = kd$; the electrostatic force $F_E \sim l - d$ is falsified (k and l are some constants)."

However, the power of mathematics cannot generate any new physical concept, even if the equations are "simple" or "beautiful". (Hossenfelder gets this one right: https://youtu.be/99hVAu1k6G8?t=2477.)

→ The concept of "infinity" is purely mathematical: no device can generate an observation of 'Infinity'; there is no physical concept associated with it.

→ A device does not reveal the "truth" about distance, force or any other physical observable. The only truth is our metaphysical confidence that our logic can be used to argue about truth and the foundations of physics. Believing in the scientific method is a metaphysical choice made by the scientist, *a choice that is not supported by science!* Since we can't build a device with an indicator that will show true or false, 'Truth' is not a physical concept. While no observation has a reality of its own, physical concepts and theories express relationships which describe the real world.

→ Concerning the question about the beginning of the universe, the two options for the logician are the same as those for the physicist:

(1) the universe has a beginning, or
(2) the universe does not have a beginning.

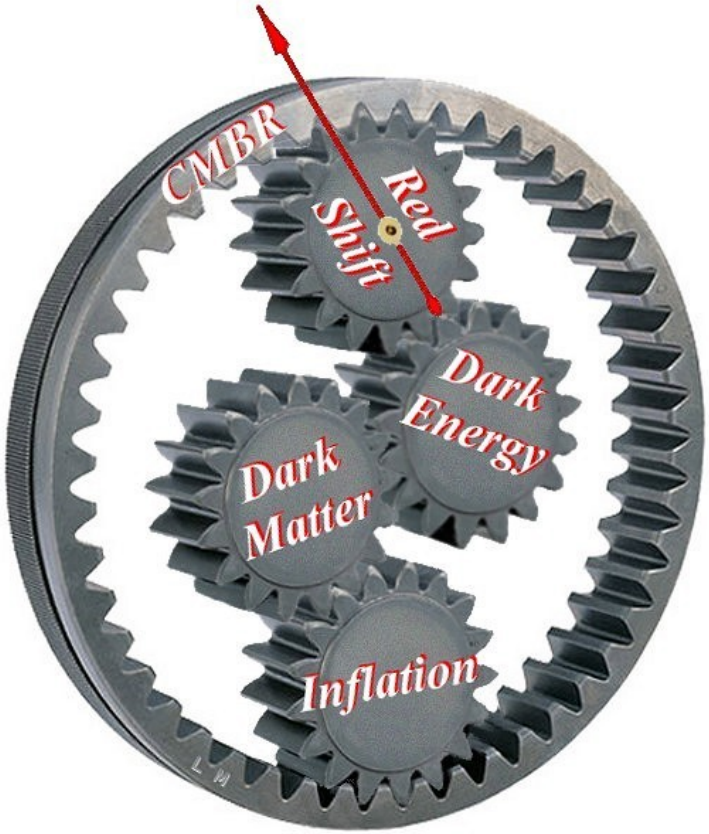
However, since science does not give a 'truth value' to a proposition about the real world (see above) the negative of that proposition cannot be assigned a 'truth value' either.

Option (1) is rejected by physics because it implies creation of energy (which is contrary to energy conservation laws). As tempting as it is, this *does not mean* that physics can accept the negative of that proposition! Option (2) is not a scientific proposition because 'no beginning' implies infinite time. Therefore, our current scientific knowledge does not even allow the scientist to assume that any of these two propositions is 'true'.

→ Theories have limits of applicability, not because of some arbitrary weakness but because beyond those limits the experiment breaks the device. (E.g. the spring of 'Hooke's law' eventually breaks.) Without a working device there is no observation and therefore no science. Near a black hole for example, the gravitational field gradient will break any physical device we throw at it. Inside that 'break-down radius' no physical concept can exist. Schwarzschild can calculate a relativistic solution, Hawking can say there is no event horizon, but this is all irrelevant to physics since the entire 'black hole' is inside the 'break-down radius' and so the concept is not scientific.

→ If a proposed cosmology is purely mathematical (e.g. "the universe is an infinite 10-D space"), it has no physical meaning and cannot be studied by science.

Λ-CDM theory



Symbolic measurement device representing the ill-constructed Λ-CDM model. Concordance Cosmology appears consistent, but the mechanically inclined will immediately notice that the gears cannot even rotate! The redshift indicator is highlighted on purpose: this entire device depends on the interpretation of redshift measurements.

All that considered, the Λ-CDM theory is not viable. Not only the theory is not consistent with many observations, but it is not scientifically build. '*Big Bang singularity*', '*inflation*', '*a state so hot that the laws of physics are different*', '*dark matter*' and '*dark energy*' are not physical concepts. Λ-CDM is pure mathematical speculation which has no chance of being even remotely correct since it is not based on physical concepts. This explains why everything about the theory keeps being revised: the age and shape of the universe, the distribution of matter, the accelerated expansion, the predictions of the CMBR temperature, the quantity of Lithium, etc.

Hopefully, these considerations will help develop "specific criteria for a consistent cosmological model" listed on a.cosmology.info/.

Louis Marmet

Many thanks to Doug Marett, Olli Santavuori, Pierre Berrigan, Eric Lerner, Dawid Bunikowski, Bjørn Ekeberg, Hartmut Traunmüller, David Bernier and my mentors of years ago for the discussions which led to the development of these ideas.

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 a Big Bang cosmology. The *ACG Newsletter* highlights observational results that are anomalous in terms of the ΛCDM model and provides a critical examination[3] 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[4] receive notifications of *Newsletter* publications. You can subscribe to *ACG Notifications* or join the ACG Forum 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.

[3] When the thesis is supported by empirical evidence.
[4] ACG has 53 subscribers to *ACG Notifications* and 38 followers on *A Cosmology Group* on the Gaggle Mail forum.