The Milky Way Panorama Credit: ESO / S. Brunier

Newsletter of *A Cosmology Group* - February 2021

In this first Newsletter of 2021: Early-type galaxy fully formed and assembled, dwarf galaxies remain persistent challenge for ΛCDM, unknown origin of the diffuse Cosmic Optical Background, ten times more carbon in a nucleosynthesis simulation, and the Hubble tension between redshift-distance measurements and theoretical interpretation of the CMB.

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ACG - Leading Science into a New Cosmological Paradigm

Reviewed Publications[1]

- Redshift, Hubble parameter, Expansion

"**Discovery of a new extreme changing-state quasar with 4 mag variation, SDSS J125809.31+351943.0**"
S. Nagoshi, *et al.*, Publications of the Astronomical Society of Japan **73**, Issue 1, pp. 122-131, February 2021
doi: 10.1093/pasj/psaa108 and arXiv:2011.01127

We report the discovery of a quasar, SDSS J125809.31+351943.0 (J1258), which brightened in optical for 4 mag from 1983 to 2015, which is one of the largest quasar brightening events so far. [T]he J1258 brightening event can be interpreted as a scaled version of the variability in other Changing-State Quasars.
The quasar has increased its brightness by two magnitudes (factor of 6) in a recent period of eight years, somewhat surprising for an object that size. Challenged ΛCDM inference J deduced from: D, E, F, G.

"**Chandra Detection of Three X-ray Bright Quasars at** $z > 5$"
J.-T. Li, *et al.*, The Astrophysical Journal 906, No. 2, 135, 2021
doi: 10.3847/1538-4357/abc750 and arXiv:2011.02358

We report Chandra detection of three UV bright radio quiet quasars at $z \gtrsim 5$. It may have a short timescale variation (on a timescale of ∼600 s in the rest frame) which is however largely embedded in the statistical noise. We also compare the three quasars detected in this paper to other quasar samples. We find that J074749+115352 is extraordinarily X-ray bright. It's average α_{OX} and bolometric correction factor both significantly depart from some well defined scaling relations. We compare Γ of the three quasars to other samples at different redshifts, and do not find any significant redshift evolution based on the limited sample of $z > 5$ quasars with reliable measurements of the X-ray spectral properties.
A quasar with extreme properties at high redshift. Challenged ΛCDM inference J deduced from: D, E, F, G.

——— *The following five papers on the "Hubble Tension" show that the CMB measurements ($H_0 \simeq 68$ km/s/Mpc) can't be theoretically related to the redshift-distance Hubble Law ($H_0 \simeq 73.3$ km/s/Mpc).*

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

"**Measurements of the E-Mode Polarization and Temperature-E-Mode Correlation of the CMB from SPT-3G 2018 Data**"
D. Dutcher, L. Balkenhol, P.A.R. Ade, *et al.*, arXiv:2101.01684, 2021
arXiv:2101.01684

We present measurements of the E-mode (EE) polarization power spectrum and temperature-E-mode (TE) cross-power spectrum of the cosmic microwave background using data collected by SPT-3G. From SPT-3G data alone, we find $H_0 = 68.8 \pm 1.5$ km s^{-1} Mpc^{-1}. *Challenged ΛCDM inference H deduced from: D, F, G.*

"**The Atacama Cosmology Telescope: A Measurement of the Cosmic Microwave Background Power Spectra at 98 and 150 GHz**"
S.K. Choi, M. Hasselfield, S.-P. Patty Ho, *et al.*, Journal of Cosmology and Astroparticle Physics 12, 045, 2020
doi: 10.1088/1475-7516/2020/12/045 and arXiv:2007.07289

We present the temperature and polarization angular power spectra of the CMB measured by the Atacama Cosmology Telescope from 5400 deg^2 of the 2013-2016 survey, which covers >15000 deg^2 at 98 and 150 GHz. The best-fit model has a reduced χ^2 of 1.07 (PTE=0.07) with $H_0 = 67.9 \pm 1.5$ km/s/Mpc.
Challenged ΛCDM inference H deduced from: D, F, G.

"**The Hubble Constant from Infrared Surface Brightness Fluctuation Distances**"
J.P. Blakeslee, J.B. Jensen, C.-P. Ma, P.A. Milne, J.E. Greene, arXiv:2101.02221, 2021
arXiv:2101.02221

We present a measurement of the Hubble constant H_0 from surface brightness fluctuation (SBF) distances for 63 bright, mainly early-type galaxies out to 100 Mpc observed with the Wide Field Camera 3 Infrared Channel (WFC3/IR) on the Hubble Space Telescope (HST). The distances reach the Hubble flow, with the majority of galaxies being in the 50-80 Mpc range. From a weighted average of the Cepheid and Tip of the Red Giant Branch calibrations, we derive $H_0 = 73.3 \pm 0.7 \pm 2.4$ km/s/Mpc, where the errors reflect the statistical and systematic uncertainties. *Challenged ΛCDM inference F.*

"**Cosmic Distances Calibrated to 1% Precision with Gaia EDR3 Parallaxes and Hubble Space Telescope Photometry of 75 Milky Way Cepheids Confirm Tension with LambdaCDM**"
A.G. Riess, S. Casertano, W. Yuan, *et al.*, arXiv:2012.08534, 2020
arXiv:2012.08534

We use new Gaia EDR3 parallaxes, vastly improved since DR2, and the Period-Luminosity (PL) relation of 75 Milky Way Cepheids Cepheids to simultaneously calibrate the extragalactic distance ladder and to refine the determination of the Gaia EDR3 parallax offset. Applied to the calibration of SNe Ia, it results in a measurement of the Hubble constant of 73.0±1.4 km/sec/Mpc. In combination with the best complementary sources of Cepheid calibration, we reach 1.8% precision and find $H_0 = 73.2 \pm 1.3$ km/sec/Mpc. *Challenged ΛCDM inference F.*

"**H0LiCOW - XIII. A 2.4 per cent measurement of H_0 from lensed quasars: 5.3σ tension between early- and late-Universe probes**"
K.C. Wong, S.H. Suyu, G.C.-F. Chen, *et al.*, MNRAS 498, Issue 1, pp. 1420-1439, October 2020
doi: 10.1093/mnras/stz3094

We present a measurement of the Hubble constant (H_0) and other cosmological parameters from a joint analysis of six gravitationally lensed quasars with measured time delays. We find $H_0 = 73.3^{+1.7}_{-1.8}$ km s^{-1} Mpc^{-1}.
Challenged ΛCDM inference F.

- Nucleosynthesis

"**Enhanced triple-α reaction reduces proton-rich nucleosynthesis in supernovae**"
S. Jin, L.F. Roberts, S.M. Austin, H. Schatz, Nature 588, pp. 57-60, 2020
doi: 10.1038/s41586-020-2948-7

There is more to be learned about nucleosynthesis. This is a theoretical simulation, but interesting nonetheless. At sufficiently high nucleon densities, proton- and neutron-scattering processes may alter the effective width of the Hoyle state. [...] Here we report that in proton-rich core-collapse supernova outflows, these [...] processes enhance the triple-α reaction rate by up to an order of magnitude. The larger reaction rate suppresses the production of heavy proton-rich isotopes that are formed by the νp process (ν = neutrino, and p = proton) in the innermost ejected material of supernovae. Previous work on the rate enhancement mechanism did not anticipate the importance of this enhancement for proton-rich nucleosynthesis. [...] The resulting suppression of heavy-element nucleosynthesis for realistic conditions casts doubt on the νp process being the explanation for the anomalously high abundances of ^{92,94}Mo and ^{96,98}Ru isotopes in the Solar System and for the signatures of early Universe element synthesis in the Ga-Cd range found in the spectra of ancient metal-poor stars.
See also: phys.org/news/2020-12-supernova-elemental-mystery.html.
Challenged ΛCDM inference I deduced from: D, F, G.

- Galaxy and Large-Scale Structure Formation

"**New Horizons Observations of the Cosmic Optical Background**"
T.R. Lauer, *et al.*, ApJ 906, 77, 2021
doi: 10.3847/1538-4357/abc881 and arXiv:2011.03052

We used existing data from the New Horizons LORRI camera to measure the optical-band sky brightness within seven high galactic latitude fields. The average raw level measured while New Horizons was 42 to 45 AU from the Sun is $\sim 10\times$ darker than the darkest sky accessible to the *Hubble Space Telescope*, highlighting the utility of New Horizons for detecting the cosmic optical background. Subtraction of the integrated light of galaxies fainter than the photometric detection-limit from the total COB level leaves a diffuse flux component of unknown origin. Explaining it with undetected galaxies requires the galaxy-count faint-end slope to steepen markedly at $V > 24$ or that existing surveys are missing half the galaxies with $V < 30$.
Challenged ΛCDM inference J deduced from: D, E, F, G.

"**The coherent motion of** Cen A **dwarf satellite galaxies remains a challenge for ΛCDM cosmology**"
O. Mller, M.S. Pawlowski, F. Lelli, *et al.*, A&A 645, L5, 2021
doi: 10.1051/0004-6361/202039973 and arXiv:2012.08138

The plane-of-satellites problem is one of the most severe small-scale challenges for the standard CDM cosmological model. In this Letter, we study the satellite system of Centaurus A adding twelve new galaxies with line-of-sight velocities from VLT/MUSE observations. We find 21 out of 28 dwarf galaxies with measured velocities share a coherent motion. Similarly flattened and coherently moving structures are found only in 0.2% of Cen A analogs in the Illustris-TNG100 cosmological simulation, independently of whether we use its dark-matter-only or hydrodynamical run. Our findings indicate that the observed co-rotating planes of satellites are a persistent challenge for ΛCDM, which is largely independent from baryon physics.
Challenged ΛCDM inference J deduced from: D, E, F, G.

"**Testing the Strong Equivalence Principle: Detection of the External Field Effect in Rotationally Supported Galaxies**"
K.-H. Chae, F. Lelli, H. Desmond, *et al.*, The Astrophysical Journal 904, No. 1, 51, 2020
doi: 10.3847/1538-4357/abbb96

The strong equivalence principle (SEP) demands that the internal dynamics of a self-gravitating system under freefall in an external gravitational field should not depend on the external field strength. We test the SEP by investigating the external field effect (EFE) in Milgromian dynamics, proposed as an alternative to dark matter in interpreting galactic kinematics. We report a detection of this EFE using galaxies from the Spitzer Photometry and Accurate Rotation Curves (SPARC) sample together with estimates of the large-scale external gravitational field from an all-sky galaxy catalog.

The EFE is individually detected at 8σ to 11σ in "golden" galaxies subjected to exceptionally strong external fields, it is statistically detected at more than 4σ from a blind test of 153 SPARC rotating galaxies, and we detect a systematic downward trend in the weak gravity part of the radial acceleration. Tidal effects from neighboring galaxies in the Λ cold dark matter (CDM) context are not strong enough to explain these phenomena. They are not predicted by existing ΛCDM models of galaxy formation and evolution, adding a new small-scale challenge to the ΛCDM paradigm.
Challenged ΛCDM inference J deduced from: D, E, F, G.

- Old Systems

"**The Rapid Buildup of Massive Early-type Galaxies: Supersolar Metallicity, High Velocity Dispersion, and Young Age for an Early-type Galaxy at z = 3.35**"
P. Saracco, *et al.*, The Astrophysical Journal 905, No. 1, 40, 2020
doi: 10.3847/1538-4357/abc7c4 and arXiv:2011.04657

We measured simultaneously stellar age, metallicity and velocity dispersion for C1-23152, an Early-Type Galaxy at redshift z = 3.352, corresponding to an epoch when the Universe was ∼1.8 Gyr old. The analysis of its spectrum shows that this galaxy, hosting an AGN, formed and assembled $\sim 2 \times 10^{11} M_{\odot}$ shaping its morphology within the ∼600 Myr preceding the observations. [...] The analysis points toward a supersolar metallicity, suggesting a star formation efficiency much higher than the replenishment time. Quenching must have been extremely efficient to reduce the star formation to $SFR < 6.5 M_{\odot}$/yr in less than 150 Myr.
One more of those "young but completely evolved entirely self-made galaxy". See also: phys.org/news/2020-12-young-evolved-self-made-galaxy.html *Challenged ΛCDM inference J deduced from: D, E, F, G.*

Number of challenges to ΛCDM inferences (see Nov. 2020 Newsletter):

30 × F: "All galaxies follow the Hubble law,"
27 × G: "All universe expansion: Big Bang,"
20 × J: "Galaxy and structure formation,"
4 × H: "CMB from the distant hot state,"
1 × M: "Dark energy."
27 × D: "GR applied to the universe,"
21 × E: "Velocity and galactic recession,"
6 × I: "Big Bang nucleosynthesis,"
2 × K: "Dark matter,"

From the publications reviewed in Newsletters from May 2020 to February 2021.

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[2] 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[3] receive notifications of *Newsletter* publications and a few additional announcements. You can subscribe to *ACG* by sending a request to `redshift@cosmology.info`.

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[2] When the thesis is supported by empirical evidence.
[3] ACG currently has 82 members.