The Milky Way Panorama Credit: ESO / S. Brunier

Newsletter of *A Cosmology Group* - November 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.

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.

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

During the last months I received several requests to review proposals for a new cosmology. Although these were interesting, trying to understand a new cosmology requires more time than I can provide. It seems however that many *ACG* members would like to discuss the ΛCDM model by comparing it with new ideas that are not explicitly apparent in observational data.

So I set up a new web page on a.cosmology.info titled A Cosmology Model where these new ideas could be posted. In order to have a uniform presentation of these models, my only request for listing new cosmologies is that the ideas are sufficiently well developed to make a few simple predictions about observational data. Please refer to the documentation on A Cosmology Model.

Gaia Data Release 2 was released on 25 April 2018 and is generating papers! This month, the *ACG Newsletter* focuses on the building blocks of galaxies: the stars seen by *Gaia* and other, older stars.

Louis Marmet, November 19, 2018
redshift@cosmology.info

Reviewed Publications

Most of the text given here is quoted and adapted from the original articles.
Underline is my emphasis and *my comments are in italics*.

[1] The ACG counts 56 subscribers to *ACG Notifications*, and 54 followers on *Alt Cosmology Yahoo! Group* and *Twitter*.

"**An Ultra Metal-poor Star Near the Hydrogen-burning Limit**"
K.C. Schlaufman *et al.*, The Astrophysical Journal, Vol. 867, No. 2, 2018
doi:10.3847/1538-4357/aadd97, arXiv:1811.00549

As recently as twenty years ago, it was believed that only massive stars could have formed early after the Big Bang. They would not survived to this day because they would quickly burn through their fuel. This paper reports the discovery of 2MASS J180820025104378 B, a star which is 13.53 Gyr-old and the faintest of a binary system. It is significantly lower in mass than all other known Ultra Metal Poor stars.

The 2MASS J180820025104378 system is the most metal-poor star system on a thin disk orbit yet found. (*The thin disk is the part of the galaxy in which our own sun resides.*) Its thin disk orbit is unusual for a metal-poor star, as only one out of 101 stars from Beers et al. (2017) with [Fe/H] $\lesssim$ -2.5 have similar Galactic orbital parameters. The star's extremely low metallicity indicates that it could be as little as one generation removed from the Big Bang. This might imply that our galactic neighbourhood is perhaps 3 billion years older than previously thought. Its location within the usually active and crowded disk of our galaxy is also unexpected.

Note: A bias seems to be introduced in a selection criterion made in the analysis: "We restricted the Dartmouth library to α*-enhanced composition* $[\alpha/Fe] = +0.4$*, stellar age* τ *in the range 10.0 Gyr* $\leq \tau \leq$ *13.721 Gyr, ..."*

"**The merger that led to the formation of the Milky Way's inner stellar halo and thick disk**"
A. Helmi *et al.*, Nature, Vol. 563, p. 85, Oct. 2018
doi:10.1038/s41586-018-0625-x, arXiv:1806.06038

We report an analysis of the kinematics, chemistry, age and spatial distribution of stars in a relatively large volume around the Sun that are mainly linked to two major Galactic components, the thick disk and the stellar halo. The inner halo is dominated by debris from an object we refer to as Gaia-Enceladus. The stars originating from Gaia-Enceladus cover nearly the full sky and their motions reveal the presence of streams and slightly retrograde and elongated trajectories. Hundreds of RR Lyrae stars and thirteen globular clusters following a consistent age-metallicity relation can be associated to Gaia-Enceladus on the basis of their orbits.

With an estimated 4:1 mass-ratio, the merger with Gaia-Enceladus must have led to the dynamical heating of the precursor of the Galactic thick disk and therefore contributed to the formation of this component approximately 10 Gyr ago. The Hertzsprung-Russell Diagram of the halo stars shows the Gaia-Enceladus stars populating Gaia's blue sequence. The thinness of this sequence is compatible with an age range from $\sim$ 10 to 13 Gyr given the stars' abundance sequence, as indicated by the plotted isochrones.

Note the large fraction of stars orbiting in a 'slightly retrograde' motion. If such mergers are common for most galaxies, shouldn't this be easy to see on the integrated HI *spectrum of many galaxies?*

"**The hidden giant: discovery of an enormous Galactic dwarf satellite in Gaia DR2**"
G. Torrealba *et al.*, Submitted to the Monthly Notices of the Royal Astronomical Society. Nov. 2018
arXiv:1811.04082

A previously unknown dwarf galaxy hiding just behind the Milky Way was discovered in the constellation of Antlia using data from the GAIA telescope. The so-called "ghost-galaxy" is by far the lowest surface brightness system known (at 32.3 mag/arcsec^2), $\sim$ 100 times more diffuse than the so-called ultra diffuse galaxies. The Antlia 2 dwarf galaxy is located behind the Galactic disc, explaining why it took so long to discover its existence.

The angular half-light radius of the new dwarf is $\sim$1.3 degrees, which translates into a gigantic physical size of $\sim$2.8 kpc, on par with the measurements of the largest satellite of the MW, the LMC, but with a luminosity some $\sim$4000 times fainter. From spectroscopic measurements, the dwarf's systemic velocity is 290.9 ± 0.5 km/s, its velocity dispersion, 5.7 ± 1.1 km/s, and mean metallicity, [Fe/H] = -1.4. From these properties the authors conclude that Antlia 2 inhabits one of the least dense Dark Matter (DM) halos probed to date. Dynamical modelling and tidal-disruption simulations suggest that a combination of a cored DM profile and strong tidal stripping may explain the observed properties of this satellite. The origin of this core may be consistent with aggressive feedback, or may even require alternatives to cold dark matter. Bringing the object's half-light radius in accordance with the rest of the Galactic satellite population appears difficult.

"**Challenging a Newtonian prediction through Gaia wide binaries**"
X. Hernandez *et al.*, arXiv:1810.08696, Oct. 2018

Under Newtonian dynamics, the relative motion of the components of a binary star should follow Kepler's laws and show a $\Delta v \propto \Delta r^{-1/2}$ scaling with separation Δr. Taking a carefully selected small sample of 83 solar neighbourhood wide binaries from the the Hipparcos catalogue, we identify these same stars in the recent Gaia DR2 to test the prediction mentioned above using the latest and most accurate astrometry available.

The results are consistent with the Newtonian prediction for projected separations below 7000 AU (*0.034 pc*), but inconsistent with it at larger separations, where accelerations are expected to be lower than the critical $a_0 = 1.2\times10^{-10}$ m/s^2 value of MONDian gravity. Although the gravitational anomaly detected appears on crossing the a_0 threshold of MOND, in MOND as such, the results are equally unexpected as the external field effect of MOND should dominate. This strongly challenges the validity of Newtonian dynamics at the low acceleration regime, and shows the existence of gravitational anomalies of the type generally attributed to the presence of a hypothetical and dominant dark matter component, this time down to the relatively tiny sub-parsec stellar scales.

If it challenges Newtonian dynamics, MOND, and dark matter, is this a measurement problem?

"**The onset of star formation 250 million years after the Big Bang**"
T. Hashimoto *et al.*, Nature 557, 392, May 2018
doi:10.1038/s41586-018-0117-z, arXiv:1805.05966

The mature stellar population in the gravitationally lensed galaxy MACS1149-JD1 implies that stars were forming back to even earlier times, beyond what we can currently see with our telescopes. ALMA detected an emission line from doubly ionized oxygen OIII, indicating that the dominant stellar component formed about 250 million years after the Big Bang ($z \sim 15$).

"This extremely distant, extremely young galaxy has a remarkable chemical maturity to it," said Wei Zheng, an astronomer at Johns Hopkins University in Baltimore, who led the discovery of this galaxy. "I am sure that the future combination of ALMA and the James Webb Space Telescope will play an even greater role in our exploration of the first generation of stars and galaxies," said Zheng.
Read more at: https://phys.org/news/2018-05-alma-most-distant-oxygen-universe.html#jCp

"**Ages of 70 Dwarfs of Three Populations in the Solar Neighborhood: Considering O and C Abundances in Stellar Models**"
Z.S. Ge *et al.*, The Astrophysical Journal, Vol. 833, Issue 2, article id. 161, Dec. 2016
doi:10.3847/1538-4357/833/2/161, arXiv:1612.01622

Knowledge of various stellar populations is of utmost importance for understanding the formation and evolution of the Galaxy. Oxygen and carbon are important elements in stellar populations: their behavior refers to the formation history of the stellar populations. With observed high-quality spectroscopic properties, we construct stellar models with C and O elements to give more accurate ages for 70 metal-poor dwarfs. The age distribution profiles indicate that high-α halo and low-α halo stars match the in situ accretion simulation by Zolotov et al., and the thick-disk stars might be formed in a relatively quiescent and long-lasting process.

We obtain several stars with peculiar ages, including 2 young thick-disk stars and 12 stars older than the universe age ($t > 15$ Gyr). Among these stars, CD-610282, G05-19, G53-41, HD 193901 were determined with ages in the range of $12 - 15$ Gyr by Schuster et al. (2012) with Y^2 isochrones, but our results give age values in the range of $15.5 - 22.5$ Gyr obtained with CO extreme mix models. The age differences between our results and those by Schuster et al. mainly come from different observation properties, i.e., T_{eff}, $\log g$, and [Fe/H].

The simplest explanation seems to be a universe older than 22.5 Gyr.

"**HD 140283: A Star in the Solar Neighborhood that Formed Shortly after the Big Bang**"
H.E. Bond *et al.*, The Astrophysical Journal Letters, Vol. 765, Issue 1, article id. L12, 2013
doi:10.1088/2041-8205/765/1/L12, arXiv:1302.3180

HD 140283 is an extremely metal-deficient and high-velocity subgiant in the solar neighborhood, having a location in the HertzsprungRussell diagram where absolute magnitude is most sensitive to stellar age. Because it is bright, nearby, unreddened, and has a well-determined chemical composition, this star avoids most of the issues involved in age determinations for globular clusters.

Employing modern theoretical isochrones, which include effects of helium diffusion, revised nuclear reaction rates, and enhanced oxygen abundance, we use the precise distance to infer an age of 14.46 ± 0.31 Gyr. The quoted error includes only the uncertainty in the parallax, and is for adopted surface oxygen and iron abundances of [O/H] = -1.67 and [Fe/H] = -2.40. Uncertainties in the stellar parameters and chemical composition, especially the oxygen content, now contribute more to the error budget for the age of HD 140283 than does its distance, increasing the total uncertainty to about 0.8 Gyr.

Within the errors, the age of HD 140283 does not conflict with the age of the Universe, 13.77 ± 0.06 Gyr, based on the microwave background and Hubble constant, but it must have formed soon after the big bang.

This one is a bit different; a fun diversion with a beautiful photograph! (Thanks to J. Delaney for the suggestion!)

"**Anisotropic winds in a WolfRayet binary identify a potential gamma-ray burst progenitor**"
J. R. Callingham *et al.*, Nature Astronomy, 19 Nov. 2018 doi:10.1038/s41550-018-0617-7

"We report observations of a previously undiscovered Wolf-Rayet system, 2XMM J160050.7-514245, with a spectroscopically determined wind speed of ~3,400 km/s. In the thermal infrared, the system is adorned with a prominent $\sim 12''$ spiral dust plume, revealed by proper motion studies to be expanding at only ~570 km/s. As the dust and gas appear to be coeval, these observations are inconsistent with existing models of the dynamics of such colliding-wind systems. We propose that this contradiction can be resolved if the system is capable of launching extremely anisotropic winds. Near-critical stellar rotation is known to drive such winds, suggesting that this Wolf-Rayet system may be a Galactic progenitor system for long-duration gamma-ray bursts.

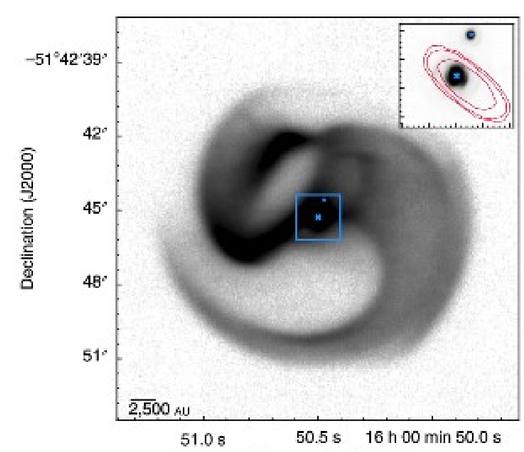

Fig. 1 | VISIR 8.9 µm image of Apep taken on 2016 August 13, displaying the exotic dust pattern being sculpted by the system.

The spectacular dust plume revealed at 8.9μm is shown in Fig. 1, exhibiting a form strongly reminiscent of the Archimedean spirals produced by the WR pinwheels [observed with the mid-infrared camera VISIR on the ESO's Very Large Telescope] We here adopt the moniker 'Apep' after the sinuous form of this infrared plume. Apep, the serpent deity from Egyptian mythology, is the mortal enemy of the Sun god Ra; we think this is an apt allusion to the image that evokes a star embattled within a serpents coils." (*Image copied without permission from the online accessible paper provided by* Springer Nature SharedIt ;-)