manuscripts submitted to arXiv received on average 2.8 times more citations than the non-arXiv papers, despite the few high-impact non-arXiv papers mentioned above. Naturally, the most recent papers have not gathered enough citations to achieve a meaningful result. Kolmogorov-Smirnov tests have been conducted to verify our findings. The results suggest that the differences between arXiv and non-arXiv papers are very significant.

We also compared the citation counts of non-arXiv papers with realisations of the same number of randomly selected telbib papers from the same year. For the years of our study, the non-arXiv sets show particularly high fractions of papers with low citations (0–10), followed by only a few papers with higher citations (> 30 citations for publication years 2010–2012; > 20 for publication years 2013–2014; and > 10 for publication years 2015–2017). Two examples from publication years 2010 and 2013 are shown in Figure 3.

Conclusion

Using the ESO Telescope Bibliography (telbib) as a testbed, we investigated the fraction of refereed papers published between January 2010 and July 2017 that were submitted to arXiv/astro-ph and are therefore free to read. Our study revealed an increasing fraction of papers posted on arXiv, from 88.5 % in 2010 to 96.3 % in 2016. The percentage for 2017 (94.3 %) should be treated with caution as the year is not yet complete and the fraction may change. Why some papers are not posted on arXiv is unclear, as there are no significant trends among this group in terms of ESO facilities used, author affiliations or journals involved. A survey among these authors suggested various motivations for non-submission, with the top reason being a lack of time for the submission process.

A comparison of the average citation counts of arXiv *vs.* non-arXiv papers revealed that on average, papers published between 2010 and 2016 that were made available on the e-print server receive a factor of 2.8 more citations. Simulations suggested that these findings are statistically significant. While the differences in citations seem striking at first glance, we note that the sample of non-arXiv papers investigated is small (on average, 55 papers per year). Posting manuscripts on arXiv certainly enhances their visibility among the community, but we cannot draw a definitive conclusion as to whether these differences in citations are solely caused by submission to arXiv or whether other factors are at play.

Based on this study of telbib papers, we conclude that an almost complete availability of the core literature in astronomy through green OA puts the community in an advantageous situation regarding both literature access and dissemination.

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Eichhorn, G. et al. 2003, LISA IV, ed. Corbin, B. G., Bryson, E. P. & Wolf, M., (Washington, DC: U. S. Naval Observatory), 145

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Links

[1] telbib database: telbib.eso.org
[2] telbib methodology: www.eso.org/sci/libraries/telbib_methodology.html
[3] ESO Libraries publications: www.eso.org/sci/libraries/useful_links/publications.html
[4] SPARC Open Access: https://sparcopen.org/open-access
[5] Creative Commons licensing: https://creativecommons.org/share-your-work/licensing-types-examples
[6] arXiv submission rate statistics: https://arxiv.org/help/stats/2016_by_area/index

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Report on the ESO and Excellence Cluster Universe Workshop

Galaxy Ecosystem: Flow of Baryons through Galaxies

held at ESO Headquarters, Garching, Germany, 24 –28 July 2017

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This conference focussed on the "baryon cycle", namely the flow of baryons through galaxies. The following aspects were discussed: a) the gas inflow into systems through streams of pristine gas or as drizzles of recycled material; b) the conversion of this gas into stars; and c) the ejection of gas enriched with heavy elements through powerful outflows. Understanding these different but mutually connected phases is of fundamental importance when studying the details of galaxy formation and evolution through cosmic time. This conference was held following the month-long workshop of the Munich Institute for Astro- and Particle Physics (MIAPP)[1] entitled: "In & out: What rules the galaxy baryon cycle?" It therefore provided an opportunity to share the main outcomes of the MIAPP workshop with a larger audience, including many young outstanding scientists who could not attend the MIAPP workshop.

In total, the conference attracted 132 participants who attended 67 talks over the

Figure 1. Participants of the workshop in front of ESO headquarters.

course of one week[2]. The first day was dedicated to the observational and theoretical constraints of gas inflow into galaxies. The need for gas replenishment in galaxies has been established for a long time in order to explain the constant star formation activity of star-forming galaxies over the past 10 Gyrs. The volume of the observed cold gas reservoir is only sufficient to sustain star formation on relatively short timescales of approximately one Gyr, which implies that a galaxy's gas must constantly be replenished.

Simon White opened the conference by highlighting many unresolved questions regarding the nature of gas infall and the possible role of outflows in regulating galaxy star formation activity. A review by Christopher Martin presented the potential of using the recently commissioned Keck Cosmic Web Imager (KCWI) instrument to map Lyα nebulae around distant quasars and streams of pristine gas infalling into galaxies at very high redshifts. Similarly, Fabrizio Arrigoni Battaia emphasised the role of the Multi Unit Spectroscopic Explorer (MUSE) instrument on the Very Large Telescope (VLT) by discussing a survey of ~ 60 quasars at $z \sim 3$, which aimed to study extended ultraviolet emission tracing the inflow of cool gas from the circumgalactic medium (CGM) into the galaxy.

Joop Shaye showed how mock spectra generated by the EAGLE (Evolution and Assembly of GaLaxies and their Environments) project, a cosmological hydrodynamical simulation, can be used to analyse the Keck Baryonic Structure Survey Data. This analysis suggests that the prominent redshift-space distortions observed in the H I, C IV and Si IV absorption features around galaxies at redshift $z \sim 2$ are predominantly caused by gas infall rather than outflows. Dusan Keres discussed the interconnection of gas inflows and outflows in regulating galaxy star formation activity in numerical simulations. In low-mass galaxies, the inflow of gas triggers star formation and consequently supernovae outflows. The fate of the outflowing gas is either to leave the galaxy, if its velocity exceeds the escape velocity of the system, or to lead to gas circulation by falling back into the galaxy in a so-called "galaxy fountain".

The second day of the conference was dedicated to reviewing our current understanding of the evolution of the gas content of galaxies though cosmic time and the efficiency in converting it into stars. Claudia Lagos showed how semi-analytical models with very different predictions about galaxy gas content can reproduce the evolution of the galaxy stellar mass function and the cosmic star formation history remarkably well. This points to the need for the next generation of models to focus on correctly reproducing the neutral and molecular gas content of galaxies through cosmic time.

Eva Schinnerer presented several highlights of the Physics at High Angular Resolution in Nearby GalaxieS (PHANGS) project, which is mapping a sample of local star-forming galaxies at high angular resolution. MUSE and ALMA high-resolution observations show that: a) the star formation efficiency is not uniform, with significant variations inside the galaxy; b) the molecular gas structure depends on the local environment within the system; and c) active galactic nuclei (AGN) feedback might alter the velocity and chemistry of the gas. Moving to higher redshifts, Reinhard Genzel reviewed our current understanding of the evolution of the gas content of galaxies though cosmic time, using a sample of more than 600 galaxies with CO detections from the Institut de Radioastronomie Millimétrique (IRAM) and the Atacama Large Millimeter/submillimeter Array (ALMA), and infrared detections from the Herschel Space Observatory. Several scaling relations were discussed, including the evolution of the cold gas depletion time *versus* specific star formation, which show consistent results in different tracers of the cold gas mass.

The last two days of the conference were dedicated to discussing whether gas outflows were due to either AGN or stellar feedback. The aim was to understand the following aspects: a) the multi-phase nature of a gas outflow; b) its connection to the inflow; c) its effect on the galaxy cold gas content and thus star formation activity; and d) its effect as preventive feedback in massive halos. As a first step, several speakers presented both observations and simulations, trying to clarify the occurrence of outflows and galactic winds in AGN and star forming galaxies. David Rupke reviewed the demographics of AGN outflows in the local Universe, and showed that most nearby quasars host galactic scale outflows in ionised gas, most likely powered by the quasar itself.

Ongoing surveys such as KASHz (KMOS AGN Survey at High redshift) and SUPER (SINFONI Survey for Unveiling the Physics and the Effect of Radiative feedback) will extend studies to much higher redshifts and link the properties of large-scale outflows with those of the galaxies' central black holes (for example, through measurements of the Eddington ratio, luminosity, black hole mass).

Thorsten Naab gave a review, from a theoretical perspective, of the galactic winds due to stellar outflows in several gas phases (molecular, neutral and ionised). While the simulations suggest that in most cases the gas should escape the galaxy, the observed outflow velocities for both AGN and stellar feedback outflows are well below the galaxy escape velocity. This could point to the circulation of gas that falls back into the system after outflowing from the disc to a small distance away, leading to accretion of recycled material.

The potential impact of outflows on the gas content of a galaxy and therefore its star formation activity was the subject of much discussion. Roberto Maiolino showed observational evidence for outflows to remove gas locally within the galaxy without affecting the global galaxy properties. As also pointed out by Romeel Dave during his review, AGN-driven outflows may provide preventive feedback by dumping energy into the galaxy halo and therefore preventing further gas accretion. However, the uncertainties in the current estimates of the mass-loading factor and wind geometry are still large, and the observational evidence for clear gas inflow into galaxies is elusive. Integral field spectroscopy with MUSE and ALMA will reveal much more about the nature of galaxies as "gas factories" in the near future.

Links

[1] MIAPP workshop: http://www.munich-iapp.de/programmes-topical-workshops/2017/galaxy-baryon-cycle

[2] ESO Excellence Cluster workshop: http://galaxyecosystem.wixsite.com/ecog

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Report on the ESO Workshop

Early Stages of Galaxy Cluster Formation 2017 (GCF2017)

held at ESO Headquarters, Garching, Germany, 17–21 July 2017

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The formation of the largest gravitationally bound structures in the Universe, clusters of galaxies, and how these environments affect the galaxies within them are major themes in cosmology and galaxy evolution. The high-redshift progenitors of clusters, called "protoclusters", are still in the process of hierarchical assembly. The transition from protocluster to cluster is gradual, driven by accretion and spectacular mergers that are expected to last roughly one billion years. This workshop aimed to address open questions in protocluster and cluster formation, to define the similarities and distinctions between the two, and to evaluate the best tools and methods for their detection and study.

Protoclusters, high-redshift galaxy clusters and merging clusters represent the first stages in the formation of the most massive known bound objects in the local Universe. The accepted view in hierarchical structure formation is that protoclusters and galaxy clusters form via mergers, the most energetic events since the Big Bang, and via the accretion of material along intercluster filaments. Merging cluster environments represent the only astrophysical laboratories where we can study a relatively short (< 1 Gyr) but decisive period in the evolution of clusters: a period that impacts the formation and evolution of both the intracluster plasma and the member galaxies of the cluster.

This workshop brought together experts who study the evolution of protoclusters and clusters across the entire electromagnetic spectrum. This workshop was unique due to the equal mix of scientists studying galaxy clusters and protoclusters (the precursors to galaxy clusters typically located at redshifts $z > 2$, i.e., the first 3 Gyr since the formation of the Universe), and also due to the goal of precisely defining what links and dis-