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Report on the ESO Workshop

ESOz-2020: The Build-up of Galaxies through Multiple Tracers and Facilities

held at University of Western Australia, Perth, Australia, 17–21 February 2020

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We report on the second joint Australia–ESO conference, held in Perth, Australia, following the successful Sydney conference in 2019. The conference was supported by ESO, the Centre of Excellence ASTRO 3D, the International Centre for Radio Astronomy Research, Macquarie University, CSIRO Astronomy and Space Science (CASS), and the Galaxies Journal. The scientific organising committee (SOC) focused on a programme that highlighted the complementarity between ESO and Australian instruments and the science breakthroughs enabled by this combination. In terms of demographics, we followed the same strategies as the previous meeting to tackle unconscious bias, and this again resulted in a well-balanced programme in terms of gender, career stage and geography, proving its effectiveness. Given concerns about global warming and the COVID-19 pandemic, the local organising committee (LOC) allowed several talks to be delivered remotely, and we reflect on that experience here.

Motivation

We are obtaining the first major results from a huge variety of "pathfinder" facilities that are operating with entirely new types of survey instruments. These pathfinders share the common aim of untangling galaxy evolution physics, and so it is important that the first science results are communicated across various disciplines. This was the main purpose of this second Australia–ESO (aka ESOz[1]) conference together with encouraging the community to start having serious conversations about the future coordination of next-generation galaxy evolution surveys.

Truly panchromatic surveys such as the Cosmological Evolution Survey (COSMOS) and Galaxy And Mass Assembly (GAMA) have shown that by coordinating across disciplines, new areas of astrophysics are inevitably opened up. Both of these surveys attempted to measure almost all of the energy generated by stars and active galactic nuclei (AGN) and reprocessed by gas and dust in the interstellar medium in galaxies, giving us fresh insight into the interplay between, for example, environment and feedback. Building on the success of the first ESOz conference in Sydney in February 2019, which was primarily focused on integral field unit (IFU) surveys, this meeting attempted to offer broader interdisciplinary connections. It encompassed the Square Kilometre Array (SKA) Pathfinders in Australia, the ESO large surveys that are being or will be carried out from Paranal, and other instruments that are or will be delivering survey science, for example, the Atacama Pathfinder EXperiment (APEX), the Atacama Large Millimeter/submillimeter Array (ALMA), the Australian Astronomical Telescope (AAT), the extended ROentgen Survey with an Imaging Telescope Array (e-ROSITA), Vera C. Rubin Observatory, the Hubble Space Telescope (HST), the James Webb Space Telescope (JWST), and the 4-m Multi-Object Spectroscopic Telescope (4MOST). In addition to focusing on the synergies between instruments and surveys, it is crucial to consider results and predictions from simulations and models.

The conference was divided into five major themes that inspired the topics discussed each day[1,2]:

- **The baryon cycle in our own Galactic neighbourhood:** galactic archaeology, and the interstellar and circumgalactic gas in the Milky Way and Magellanic Clouds.
- **The local Universe:** the multi-phase baryon mass census (hot, cold and warm medium, stars and stellar halos), environmental and *in situ* physical effects.
- **Transients:** a nascent avenue of learning about galaxy evolution and the intergalactic medium, featuring, for example, fast radio bursts, gravitational waves and gamma-ray bursts.
- **Galaxies across time:** physical processes leading to quenching, angular momentum evolution, and black hole/galaxy co-evolution.
- **Cosmic Dawn and the Epoch of Reionisation:** the census of baryons and activity at $z > 4$, including galaxies, AGN and neutral hydrogen.

Figure 1. Conference photo (left) and conference dinner photo with all female participants (right).

Several current and upcoming instruments were discussed in the context of the windows they offer within the above broad science themes; for example, the Australian SKA Pathfinder (ASKAP), the Murchison Widefield Array (MWA), the South-African SKA pathfinder (MeerKAT), Very Large Telescope (VLT) instruments such as MAVIS[3] and 4MOST[4], both of which have significant Australian participation, ALMA, the AAT and the Australia Telescope Compact Array (ATCA).

Some key scientific results discussed during the meeting included recent breakthroughs in studies ranging from the Milky Way and Magellanic Clouds to the high-redshift Universe. In the last two years, astronomers have been able to quantify the outflow rate from the centre of the Milky Way associated with the Fermi bubble as well as from the Small Magellanic Cloud in several gas phases, including ionised and molecular gas. Gaia and ESO/AAT spectroscopic follow up have allowed a detailed understanding of the chemical structure and interaction history of the Milky Way. These results are key in placing the Milky Way into the broader context of galaxy formation. Recent years have also seen significant progress in closing the gap between the extragalactic background light and the contribution from galaxies from the far-ultraviolet to the far-infrared. Several talks also focused on the rise of environmental effects and the build-up of the Hubble sequence, extending studies to $z > 2$. A novel field that has gained significant interest is fast radio bursts (FRBs), which thanks to their dispersion measurement allow exquisite constraints on the density of the intervening intergalactic medium. Many breakthroughs presented highlighted the power of Australian and ESO facilities working in tandem. Particular examples of this include the VLT+ASKAP combination to study FRBs and intervening absorption systems to radio galaxies, and MWA+VLT+ALMA to study $z > 3$ radio galaxies and $z > 6$ reionisation sources, among others. Many talks showcased the power of current SKA pathfinders, which are already making significant progress, accomplishing in one day what used to take hundreds of hours.

Several problems were also discussed during the meeting. Many galaxy formation

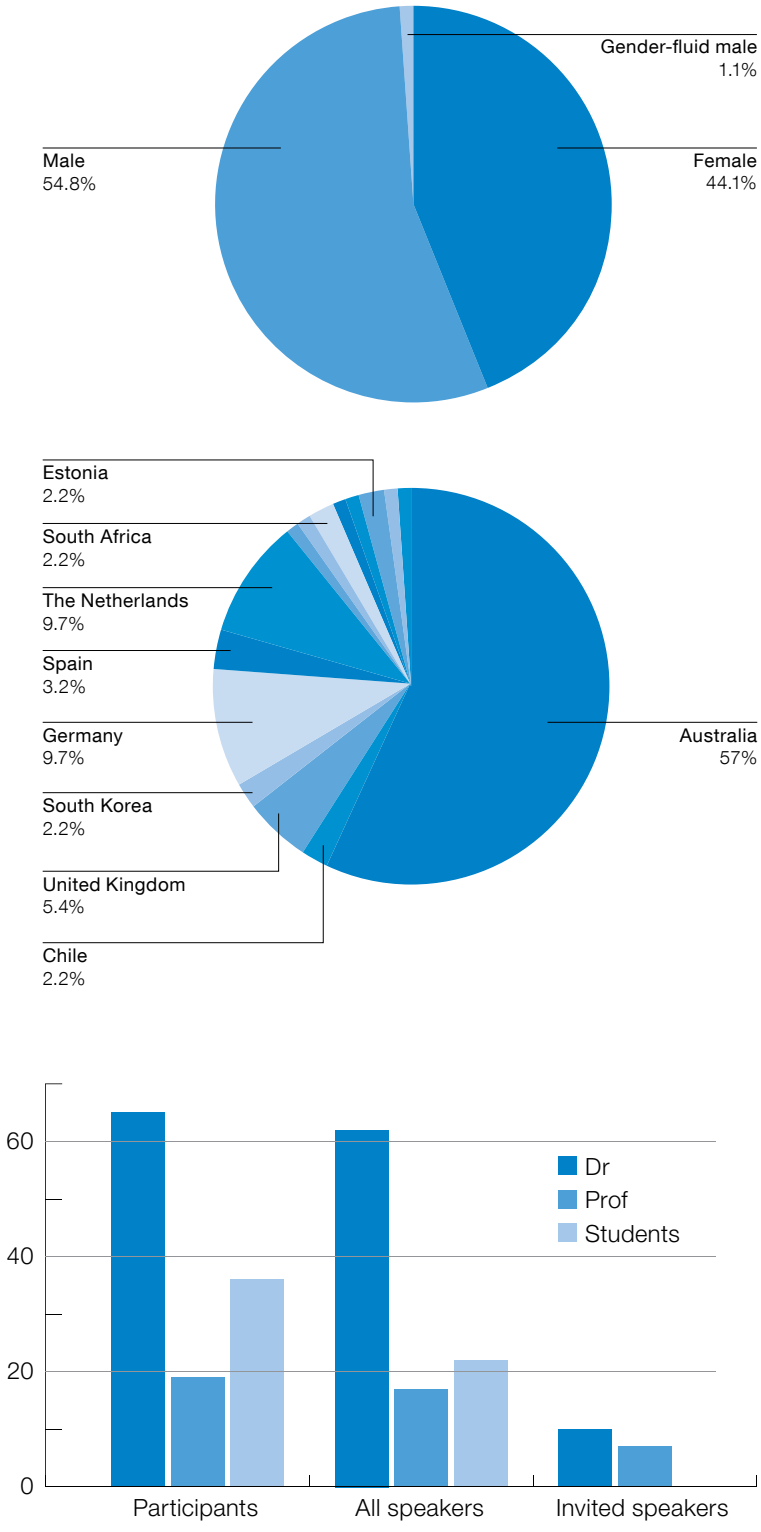

Figure 2. Distributions of gender (top-left panel), geography (top-right panel) and career stage (bottom panel). Though the first two were directly collected from the registration information of the participants, the latter was determined by their preferred title and hence is less robust.

simulations produce plausible universes from quite different physics, making it less clear how “success” is defined in the realm of theory and simulation. Perhaps the onus needs to be put back on observers to really uncover the most constraining measurements. There was some suggestion that tight 2D distributions such as the mass-size plane might be amongst the best to use when tuning simulation parameters. In addition, we are still a long way from fully modelling or observing gas in all its complex phases; for example, we rarely observe H_2 directly and assume uncertain X factors to convert from CO, [CI] or dust continuum. We also only have indirect detections of the weakly ionised hydrogen medium (WIHM), which seems to be the main source of baryons in the Universe. A contentious issue continues to be where theory and observation should meet, with advocates from each camp arguing that they are best placed to infer the H_2 distribution of galaxies.

Main conclusions

Several talks highlighted the fact that we are entering a new era of instruments and surveys that are planned simultaneously, bringing engineers and astronomers more closely together than ever before and maximising the scientific outcome of the investment. Most of the talks highlighted the need to study baryons and galaxies across the electromagnetic spectrum. This allows us to uncover a variety of phenomena, including outflows from the Milky Way and Magellanic Clouds, intergalactic gas around galaxies unveiled through FRBs and other transient phenomena, and accounting of baryons — stars, cold gas, neutral gas, ionised gas, dust etc. — across cosmic time, for example. The simulation talks summarised the main predictions as well as current areas of success and tension with observations. However, a cautionary note was that galaxy formation theory is not a fundamental theory and perhaps the focus should preferentially be on qualitative trends. The Australia–ESO community is clearly gaining momentum and these conferences have contributed tremendously to showcasing the benefit of this collaboration as well as promoting new ones.

Demographics and Remote participation

Demographics

During the organisation of the conference, we paid particular attention to making the event as inclusive as possible by controlling various biases in the selection of participants (for example, gender, seniority, and geographic distribution). The SOC decided to follow the guidelines of the first conference in the series (Zafar, De Breuck & Arnaboldi, 2019), which specify: (1) anonymising the contributed abstracts prior to ranking them; (2) asking the SOC members to declare any conflicts of interest with abstracts and remove themselves from reviewing those; and (3) anonymising the votes from the SOC. As with the previous ESOz conference, these measures naturally produced a programme with a good gender, geographic and career stage balance as shown in Figure 2. These results provide evidence that these measures, which are easy to apply, already go a long way towards systematically reducing implicit biases, and we recommend that future conference organisers adopt them.

Remote participation

Our conference took place during late February 2020 and its organisation was affected by the COVID-19 pandemic, even though it was relatively early in the evolution of the pandemic. More specifically, some of our participants were based in China, and by that date the Australian government had already imposed a ban on visitors from China. In addition, some participants had to cancel for last-minute personal reasons. The LOC worked hard to accommodate all participants who asked to give their talks remotely. The conference ended up with about 130 participants, approximately 10 of whom joined remotely while the rest were on site. We had five remote talks. One of the challenges we faced was that most remote speakers did not participate beyond giving their talks, which detracted slightly from the purpose of a “meeting” — only one participant was online remotely for the whole conference. This raised the question of how to encourage people to commit to a conference if they are physically elsewhere. A positive side, though, is that current platforms, such as Zoom, work well and make it possible to have a large number of remote participants. The current circumstances the world is suffering because of the pandemic have forced many countries to close their borders. The restrictions have led astronomers to cancel their travel plans, and it is clear that these issues are going to become more urgent and need to be addressed by the community as a whole.

Future

We note with sadness that this meeting was one of the last astronomy meetings to be hosted in Australia — and indeed the world — for the foreseeable future, owing to the COVID-19 pandemic which was dawning as the meeting took place. The consensus at the meeting was to host the next ESO–Australia conference at ESO in Garching, with a strong preference for it to be held during the European summer of 2021. There are some caveats over any future meeting dates because of the uncertainties around COVID-19, but the hope is that this goal is still realistic. The attendees at this meeting were certainly keen to come together again to further develop existing and new research connections between ESO and Australia.

Acknowledgements

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References

Zafar, T., De Breuck, C. & Arnaboldi, M. 2019, The Messenger, 176, 48

Links

[1] Presentations archived at Zenodo: https://zenodo.org/communities/esoaus2020
[2] Link to workshop programme: https://www.icrar.org/conferences/aus-eso-ii/
[3] MAVIS webpage: http://mavis-ao.org/
[4] 4MOST webpage: https://www.4most.eu/