# Decadal Plan Mid-Term Review

# White Paper

## Diversity in Australian Astronomy

### Executive Summary

The 2016-2025 Australian Astronomy Decadal Plan recommended that institutions aim for at least 33% participation by women across all levels by 2025. Current data shows that while this goal has been attained at the level A (junior postdoc) level, the fraction of women remains at or below 20% at the higher levels. Negligible change has occurred in the gender balance at levels B-E from 2013 – 2019, despite the pipeline containing over 30% women for over a decade. We provide recommendations for initiatives and targets that astronomer institutions should urgently incorporate in order to achieve 33% women participation at all levels by 2025, including exit surveys, retention targets, and senior hire targets.

In a recent survey conducted across Australian astronomer institutions, it is clear that astronomy departments have undergone a systematic change in culture and inclusion over the past five years through university-scale diversity initiatives, largely triggered by the ASA Pleiades Awards. We investigate the fraction of institutions in Australia with diversity and inclusion initiatives and we provide an overview of these programs. These initiatives include prestigious women-only faculty hires, broad diversity targets, concrete activities to overcome implicit bias, and innovative initiatives to change the academic culture and environment.

Although not explicitly discussed in the 2016-2025 Australian Astronomy Decadal Plan, we provide an overview of the issues faced by people from different religious and cultural backgrounds, the LGBTQIA+ community, and people with disability and major illness. We summarize initiatives that are have been introduced in Australia to support greater inclusion in astronomy, and provide recommendations for departments in this area. We also emphasize the urgent need for to improve awareness of and develop career pathways for indigenous students in astronomy.

## Status of Gender Diversity in Australian Astronomy

As of December 2019, the Australian astronomical community has approximately 350 PhD astronomers and around 300 PhD, Masters, and Honours students across fourteen universities, and three organisations (CSIRO Astronomy and Space Science, the Australian SKA Office, and the Murchison Widefield Array Organisation). This astronomical community hosts two $40M Australian Research Council Centres of Excellence; All-Sky Astrophysics in 3 Dimensions (ASTRO 3D) and Gravitational Wave Discovery (OzGrav). These virtual centres contain approximately 200 people within multiple universities and organisations in Australia, with around 10% members from international partners.

The 2016-2025 Australian Astronomy Decadal Plan showed that within Australian universities and organisations, the fraction of women astronomers in Australia was 33-37% at the PhD level between 2000 - 2013, but only 20% at the senior levels across the same timeframe. If women were retained in the field at the same rate as men, the fraction of women at senior levels in 2013 should have been at least 33%. The Decadal Plan recommended that institutions aim for at least 33% participation by women across all levels of employment by 2025, in alignment with the fraction of women in the PhD cohort. The Decadal Plan recommendations include longer-term (five-year) postdoctoral positions with part-time options, support to return to astronomy research after career breaks, and increasing the fraction of permanent positions relative to fixed-term contracts.

Figure 1 shows the gender fractions for astronomy PhD students, postdocs (levels A-B), and faculty (Levels C-E) for contract and permanent staff as at November 2019. Universities included in these statistics are the Australian National University, CSIRO Astronomy & Space Science, Curtin Institute of Radio Astronomy, Macquarie University, Monash University, Swinburne University of Technology, University of Adelaide, University of Melbourne, University of New South Wales, University of Queensland, University of Southern Queensland, University of Sydney, University of Tasmania, University of Western Australia, and the University of Western Sydney. The PhD student and level A fraction remains at 30-37% and the fraction of women at senior levels D-E remains below 20%.

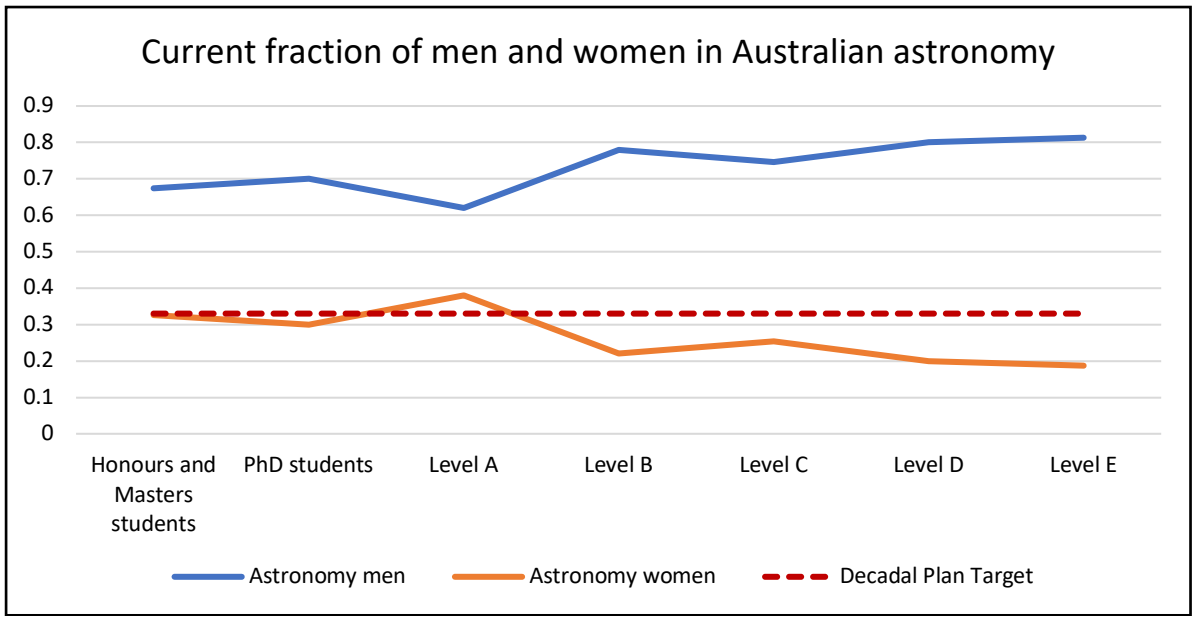


***Figure 1**. Gender Fractions at University Levels in Australian astronomy. The gender fractions encompass all contract and permanent staff in astronomy in Australia from level A to level E as at end of 2019. Postdocs are at Levels A and B.*

To gauge the change in diversity from 2013 to 2019, we use the demographics published in the 2016-2025 Decadal Plan Working Group 3.2 Report. Working Group 3.2 did not report demographics for each of the university levels. Therefore, we refer to astronomers in Levels A – E as "staff" for the purposes of this comparison. Figure 2 shows how the fractions of men and women have changed in the Honours and Masters, PhD student, and Staff cohorts from 2013 to 2019.

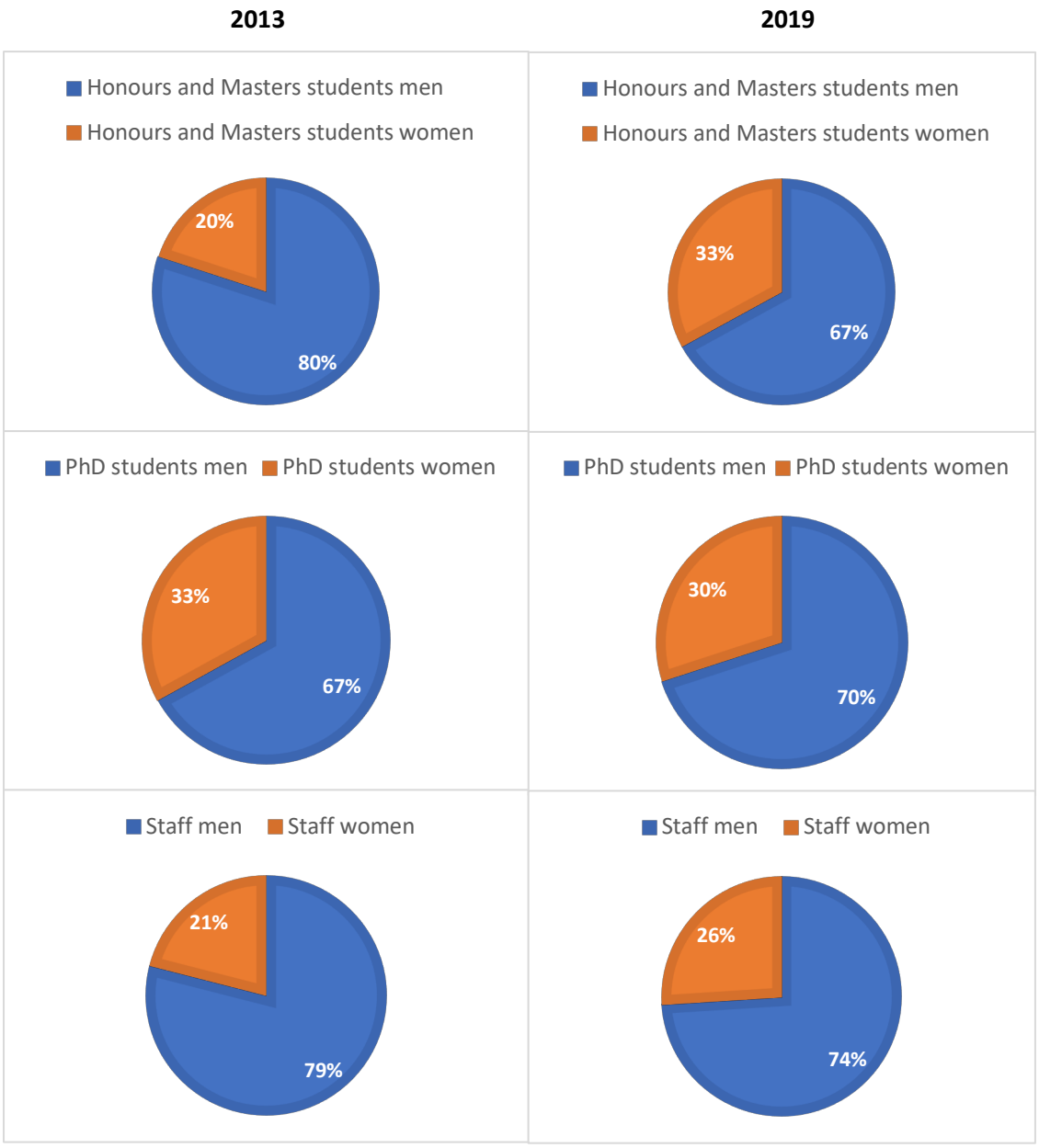


***Figure 2.*** *Gender fractions for Honours and Masters Students, PhD students, and staff from 2013 to 2019.*

The fraction of women Honours and Masters students has risen from 20% in 2013 to 33% in 2019. The fraction of women PhD students has remained roughly constant (33% c.f. 30%), and the fraction of women staff has increased slightly from 21% to 26%.

**To reach the Decadal Plan target of 33% female participation at the senior levels by 2025, astronomical institutions need to take urgent action on departures and hires.**

## Departures from Australian Astronomy

Women are departing Australian astronomy at higher numbers than men. Figure 1 shows that there is a large fall in the fraction of women between Level A and Level B. In Figure 3, we show the difference in the number of men and women in each consecutive level as a fraction of men and women at the level. For example, the number of women departures between Level A and Level B is indicated by $N_A$(women) – $N_B$(women) / $N_A$(women), where $N_A$(women) is the number of women in level A, and $N_B$(women) is the number of women in level B. This quantity is an indicator of the relative amount of departures for levels A-B because people are likely to spend a similar length of time (3-5 years) at each of these levels. The departures indicator is sensitive to the length of time spent at a given level. Positive values indicate a lower limit to the number of departures while negative values mostly indicate people staying at the upper level for a longer period of time. We are unable to normalize by the length of time spent at each level because that data is not available for astronomy. The data show that 62% of women and 17% of men at level A depart Australian astronomy before transitioning to level B.

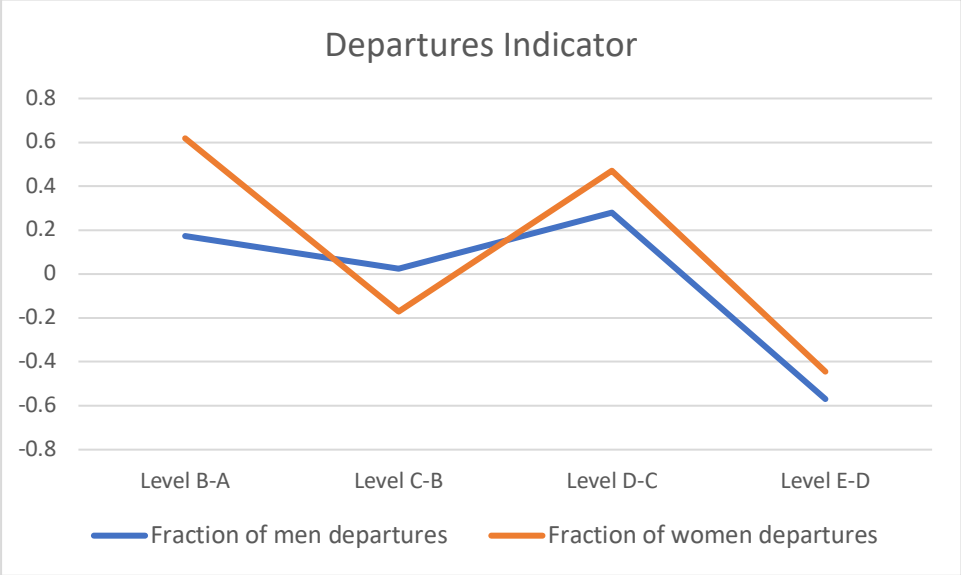


**Figure 3.** *The difference (dN) of numbers of men and women between each level. Positive values indicate departures from Australian astronomy. Negative values indicate that more people are residing at that level than at the previous level.*

People departing Australian astronomy may not be leaving the field. Some people departing from Australian astronomy may be moving overseas to begin new positions in astronomy. Nevertheless, it is clear that women are leaving Australian astronomy at more than double the rate of men between level A and B.

To understand why women are leaving at such a high rate, we need to undertake exit surveys that capture information on the reasons for departure. These surveys need to be statistically complete and allow women and men to anonymously enter a variety of reasons for departing Australian astronomy. This crucial information is currently not captured by Australian universities. The Australian Academy of Science SAGE program proposals (publicly available at https://www.sciencegenderequity.org.au ) indicate that the dominant reason captured by university HR processes for women departing STEMM is “end of contract”.

While HR processes have not captured the true reasons for a larger proportion of women leaving the field than men, it is important to consider the proportion of women and men on on contract positions, because this may be a factor into women's doubts that they will attain a senior position. Figure 4 shows the fraction of women and men in Australian astronomy on contract positions (green) compared to permanent positions (blue).

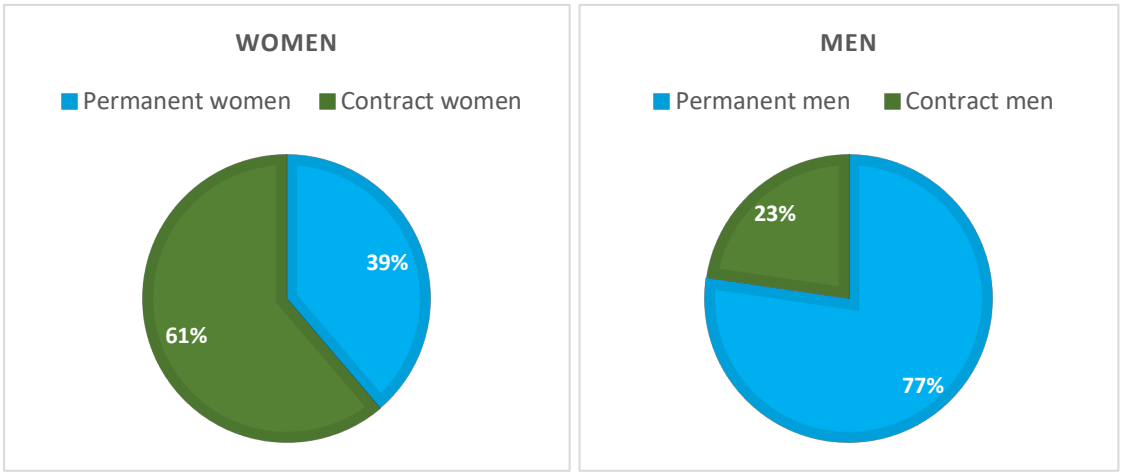


**Figure 4.** *The fraction of women and men in Australian astronomy on permanent (blue) and contract (green) positions.*

The proportion of women on contract positions is 61% compared with 23% of men. This difference is primarily due to the larger fraction of women at level A compared with the fraction of women at level D-E. In Figure 5 we show the proportion of men and women on contract positions, split as a function of academic level. The ratio of women on permanent to contract positions is larger than the ratio of men on permanent to contract positions for the majority of levels (Levels B, C, and D). The numbers of contract men and women at level E and the numbers of permanent men and women at level A are too small for statistical significance.

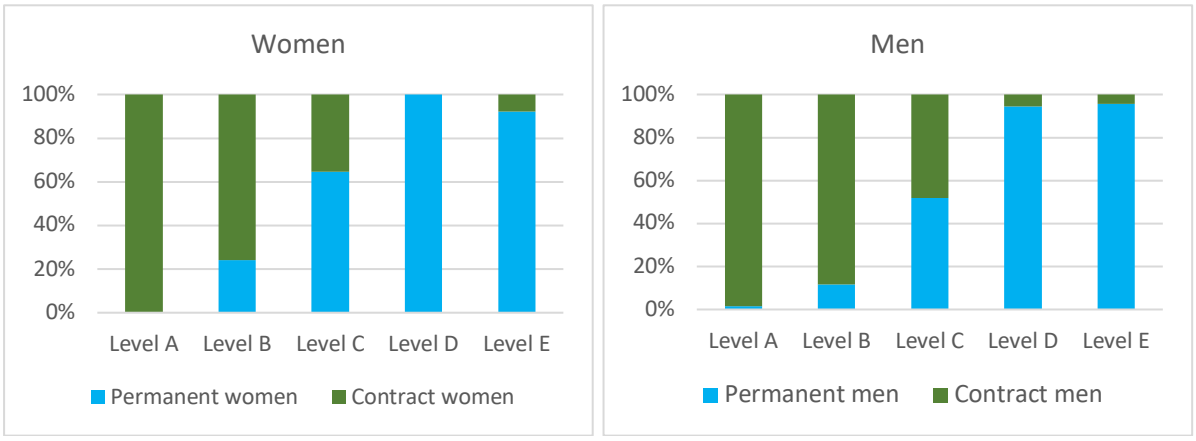


**Figure 5.** *The proportion of women and men in Australian astronomy on permanent and contract positions as a function of academic level.*

To improve the fraction of women at the higher academic levels, stemming the large proportion of women departures from level A is crucial. The first step is finding out why women and men leave Australian astronomy, whether there are differences in the reasons that women and men leave Australian astronomy.

Overseas, some women are more likely to leave astronomy than men due to the need to find a job for a spouse or partner in the same geographical area (Ivie et al. 2016). Over the past few years, some Australian universities initiated dual career hire programs to help dual career couples in academia find positions at the same university. For example, the Australian National University has a dual career hire program that covers all fields at the university. The program includes a central pool of funding that may be applied for which may cover a portion of the salary of the partner hire for two years. Shared funding arrangements are also possible. These programs enable couples from postdocs to senior staff to continue their careers in the same location.

Department retention targets of equal proportions of men and women remaining in astronomy (relative to their cohort) at each level would incentivize departments to (1) determine the causes of departures and (2) provide the conditions required to retain equal proportions of men and women in astronomy. We recommend that:

- **All astronomer departments and institutions conduct a consistent exit survey for all staff who leave their departments.**

- **A peak body such as the ASA develop the exit survey questions and provide the survey to each astronomer department to ensure that departure reasons are captured consistently.**

- **Astronomy departments adopt retention targets of equal proportions of men and women remaining in astronomy each level transition.**

- **Astronomy departments adopt dual hire career policies to help women remain in astronomy in Australia. Astronomy departments could initiate and promote such policies to be developed within their universities if they cannot develop an astronomy-specific policy.**

## Australian astronomy recruitment

It is now clear that previous hiring methods have not been effective in increasing the fraction of women at higher levels in astronomy. Removing implicit bias at every decision-making stage is difficult to achieve even on gender-balanced recruitment committees that have undertaken bias training because on average, both males and females have an implicit bias towards male applications (Aloisi et al. 2019). Modelling of the gender balance of organisations shows that a 3-5% bias in decision-making in favour of men can cause the gender balance of an organisation or a discipline to change from 1:1 gender ratio at all levels to 25-30% women at the highest levels over a 10 year period (Martell et al. 1996, Aloisi et al. 2019, Kewley 2020 *in prep*).

In addition to the implicit bias of recruitment panel members, **all** of the metrics that are used in academia to judge applicants for jobs and promotions have been proven to be biased against women in randomized double-blind trials. Widespread implicit bias against women has been proven in the writing referee reports of papers (Helmer et al. 2017), giving paper citations (Caplar et al.

2017), allocation of grants (Viner et al. 2004), assessment of an applicant's ability to mentor (Moss-Racusin et al. 2012), student assessments of teaching (Fan 2019), allocation of awards (Ma et al. 2019, Lunnemann et al. 2019) and (in astronomy) allocation of telescope time (Reid et al. 2014, Patat et al. 2016). These biases probably play a major role in the gender imbalance at levels B-E in astronomy by impacting recruitment rates, promotion rates and facilitating departures of women from the field.

Meta-analysis of the effectiveness of bias training programs indicates that single bias training sessions do not produce long-term change in behaviour (e.g., Bezrukova16). Ongoing, consistent reminders about implicit bias are needed, but may not fully mitigate bias. Most astronomical departments and organisations in Australia require job selection committees to read information reminding the members about implicit bias before reading applications or before interviews. The Macquarie University Physics and Astronomy department is trialling anonymised recruitment for postdoctoral positions up to the shortlisting phase. However, it is unclear how an interview process could be truly anonymised.

Gender targets are one way to help mitigate gender-based implicit bias. The OzGrav Centre of Excellence has a target of 50:50 gender balance for all new recruits by 2021m with gender balance monitored for selection panel members, applicants for positions, and shortlists. The University of Sydney has adopted university-wide gender targets of 45% women at level D and 40% women at level E by 2025, and at least 40% female appointments to continuing (permanent) academic positions. At University of Sydney, human resources staff track departmental achievement towards these goals and report to diversity and equity committees, with report on gender statistics to the university executive annually. The University of Sydney School of Physics department has exceeded their goals with 7/9 female appointments to permanent positions over the past three years. The Swinburne Centre for Astrophysics and Supercomputing now have a policy that hiring new staff should not decrease the fraction of female staff. However, university-wide strategic appointments (including providing continuing positions to Australian Research Council Future Fellows) can work against such policies.

The ASTRO 3D Centre of Excellence has an extremely ambitious target of 50:50 gender balance at all levels of the Centre by end of 2021. Gender balance enables males and females to serve on committees, act as role models, and take part in education/outreach programs in equal numbers, providing equitable work balance for its members, as well as modelling the working environment that is needed to encourage equal numbers of girls and boys into STEM. ASTRO 3D has seen its gender balance rise from 30% to 41% in its first three years and is currently on track to reach its 50:50 goal. This rise has been through strong awareness of implicit bias, awareness of the need to achieve gender balance, diversity on hiring committees and short-lists, and open membership. ASTRO 3D hiring committees are required to be at least 50% female, and short-lists are required to be at least 50% female. The gender balance is tracked at all Centre university nodes, in all surveys/projects, and at all levels in the Centre, with results presented quarterly to the Centre Executive Management Committee and the Centre Diversity, Equity and Inclusion Committee, and annually to the Centre Advisory Board and to the Australian Research Council.

Female-only positions are the only way to completely avoid gender-based implicit bias in recruitment processes. The Australian Commonwealth Equal Opportunity for Women in the Workplace Act 1999, states that all employers with 100 or more employees and all higher education institutions must implement an 'affirmative action program' to promote equal opportunity for women. Individual states are bound by both this Act, and state-level Equal Opportunity Acts. In several states, including Victoria, Western Australia, and New South Wales, the Equal Opportunity Acts specifically allow universities to advertise female-only positions to correct their historic gender

gap. In some states, such as Tasmania, special governmental exemption is required to advertise female-only positions.

One of the main concerns often expressed regarding female-only positions is that the female hired may be labelled as a ``token" woman. Several Australian mathematics, physics and astronomy departments have shown that this concern is easily removed by making such positions highly prestigious and/or by making multiple offers simultaneously. Both of these mitigations encourage outstanding women in the field to apply for the positions, and these women may not have applied had the advertisement been for an average open hire.

The University of Melbourne Maths Department paved the way for female-only hires in Australia. To correct historical systematic hires of men, the University of Melbourne Maths Department advertised two female-only positions. They received significantly more female applicants than they had received in a previous open position. When asked why they had not applied for previously advertised positions, female applicants said that by advertising for female faculty members, the University of Melbourne Maths Department must be a female friendly department and they would like to work in a female friendly environment. The Maths Department received many excellent applications and made multiple offers. For future open positions, they still received more applications from women than they had received in the past. The University of Melbourne Maths department have now doubled the number of women faculty from 9 in 2014 to 17 by the end of 2018. According to the Maths Department chair, this increased fraction of women has had two major effects: (1) the external perception of the department has changed to a female-friendly department, and (2) the department has undergone an internal cultural change.

Astronomy departments across Australia have begun following the lead set by the University of Melbourne. As part of its negotiations with universities, ASTRO 3D secured several continuing positions at its node universities to help provide career paths in Australia for its postdoctoral researchers. The University of Melbourne Physics and Astronomy Department and the University of Western Australia combined an ASTRO 3D 4-year fellowship with continuing (tenured) positions and created prestigious female-only fellowship+continuing positions. The University of Western Australia received many outstanding applications, and made two offers, instead of one. The University of Melbourne Physics and Astronomy Department recently made a similar female-only fellowship+continuing position recruitment. As part of their long term workforce planning, the Melbourne Physics and Astronomy Department has now instituted a policy that if future open searches lead to a male appointment, the following search will be female only. This policy allows the department to predict and control the minimum fraction of female staff in their faculty. The School of Physics at the University of Sydney has a similar policy.

The Research School of Astronomy and Astrophysics at the Australian National University (ANU) has tried two approaches to removing implicit bias on hiring panels. One approach requires two positions to be advertised, of which at least one position will be offered to a woman. The selection panels create two short-lists, a male short-list and a female short-list, and selects two candidates from each of these two short-lists. This method prevents gender-based implicit bias, although increasing the fraction of women with this approach is slower than through female-only hires. Recently, the Research School of Astronomy and Astrophysics and the ANU Centre for Gravitational Waves advertised for a female gravitational wave astrophysicist. Like the Universities of Melbourne and Western Australia, they received multiple outstanding applications and hired two females, rather than one. Similarly, the ANU maths department recently advertised a female only position, and received so many outstanding applications that they hired not one but three women.

The success of female-only hires and gender fraction targets is now well-established.

**To achieve 33% women at levels C-E, we recommend that Astronomy departments offer female-only continuing positions and/or adopt gender hiring targets similar to the University of Sydney and the two Centres of Excellence.**

## Role models

Research tracking the progress of PhD students in physics indicate that women leave the field more often than men due to (a) a lack of female role models who are seen to have a good balance between their family life and academic career, (b) a dislike of the culture or atmosphere, and (c) doubts that they will attain a senior position (Whitelegg 2002). **Note that providing female role models is not enough.** If a woman has a good work-life balance, that balance needs to be **visible** to junior women in the department.

There are many ways to provide female role models. Some departments are offering female-only visiting positions. The International Centre for Radio Astronomy Research (ICRAR), that encompasses astronomers at both Curtin University and the University of Western Australia, has an annual Visiting Fellowship for senior women in astronomy to visit both Curtin and UWA and provide mentoring opportunities for staff and students (particularly women) as well as to promote research and scientific interactions. In 2016, CSIRO Astronomy and Space Science (CASS) began an engineering visitors program that has a focus on inviting and supporting female engineers. This is part of a broader CASS plan to create multiple pathways to recruit and maintain women engineers.

Because junior women need to see role models with a good balance between family life and career, departments should allow children to be visible in the workplace, and should adopt practices to highlight and celebrate work-life balance. Examples include the Australian Academy of Science ``Win of the Week" program where staff member's personal achievements and positive stories (both within and outside work) are collected and sent to the entire Academy Secretariat, and the ASTRO 3D ``We Are People" section in their fortnightly newsletter, where ASTRO 3D members describe their hobbies, sports, interests, or recent travel.

We recommend that:

- **All astronomer institutions ensure that their colloquium and seminar schedules are 50% women. This would improve the fraction of role models available for junior women.**
- **All departments offer programs that promote work-life-balance, and encourage staff to display their work-life balance.**

## Mentoring

Mentoring students through their undergraduate and graduate careers is important for stemming the flow of women out of academia. The Monash University Women in Physics & Astronomy (WiPA) group provides regular informal morning tea and luncheons for female 3rd year, Honours, Masters and PhD students and staff. Attendees are encouraged to discuss matters of concern and seek advice from any of the WiPA members about their career, work and study. In 2018, the group established an undergraduate mentoring program, where undergraduate female students are paired with a female PhD student or a post-doc for formal mentoring.

Some institutions in Australia are actively working to avoid contributing to stereotype threat, a situation that occurs when people are at risk for living up to a negative stereotype about their group, such as the false negative stereotype that girls aren't good at mathematics or science. Both ASTRO

3D and OzGrav ensure that educational and outreach materials are gender neutral, with imagery and videos reflecting a diverse and inclusive environment. Both males and females take part in education and outreach activities to provide a variety of role models. However, unless 50:50 gender balance is achieved, this requirement places additional workload on female staff members.

**We recommend that**

- **all astronomer departments offer mentoring programs for astronomy undergraduates, graduates, as well as staff.**
- **mentoring circles be used rather than one-on-one mentoring if one-on-one mentoring results in a higher workload for women and other minorities.**

## Culture in Australian Astronomy

To gauge how widespread the diversity and culture initiatives now are across Australian astronomy, in Kewley et al. (2019), we surveyed all 17 astronomer institutions on the initiatives that they have introduced to improve gender balance and diversity. Figure 6 shows the fraction of institutions that have adopted family friendly initiatives and activities aimed at improving gender balance and diversity. Many of these initiatives were introduced as part of a department's application for an ASA Pleiades Award. A total of 14/17 (82%) of astronomer departments and organisations have applied for a Pleiades Award and a further 3 institutions are preparing Pleiades applications for the next round. A total of 12/17 (71%) institutions have received a Pleiades Award. It is clear that the ASA Pleiades Awards program has been instrumental in driving cultural change through Australian astronomy.

Almost all (16/17, 94%) astronomer departments or organisations now have a diversity and inclusion committee, a diversity, equity and inclusion policy, and a staff code of conduct. A total of 59% of astronomer departments have a departmental or college-wide conference code of conduct that specifies the conduct and behaviour expected of department members when they are at external conferences. This code of conduct is in addition to codes of conduct that apply within the astronomer departments.

Some universities, such as the University of New South Wales (UNSW), have hired dedicated equity, diversity, and inclusion officers that operate at the Dean level, overseeing the individual equity and diversity committees in each department and enforcing the diversity goals of the university.

To improve the academic climate in departments, it is critical to identify issues and problem areas that might not be brought to the attention of the leadership of an organisation. The majority (88%) of astronomer departments and organisations in Australia now run anonymous climate surveys either annually or every second year. These independently-run surveys have proven highly effective in helping leadership improve the climate at departments and organisations. For example, in response to the results of their 2018 culture survey, all ongoing staff in the Macquarie University physics and astronomy department attended "Workplace Behaviour - Drawing the Line" workshops in 2019. These facilitated workshops examined the issues of unlawful and inappropriate behaviours, values of respect and teamwork, and how to draw the line between what is acceptable and unacceptable in a variety of situations.

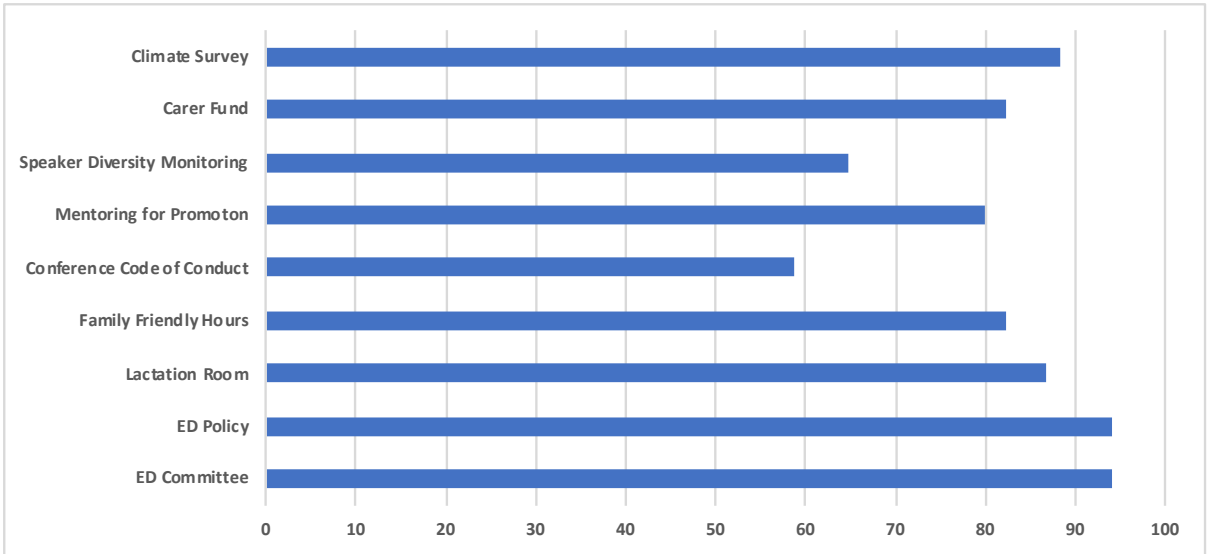


**Figure 6.** (From Kewley et al. 2019) *Percentage of Australian astronomer departments with diversity initiatives}. The fraction of Australian astronomer departments and organisations that have (1) a regular climate/culture survey, (2) carer's funding for travel to external conferences, (3) monitoring of the gender balance of speakers for colloquia and seminars, (4) mentoring of women for promotion to senior levels, (5) a conference code of conduct, (6) family friendly meeting hours for seminars, colloquia and staff meetings (10am - 2pm or 9am - 3pm), (7) a lactation room, (8) an equity and diversity policy, and (9) an equity and diversity committee.*

To support astronomers with children, 87% of Australian astronomer departments and organisations now offer a lactation room, and 82% of departments have changed the timing of all seminars, colloquia, and staff meetings to between 9am-3pm or 10am-2pm, to allow astronomers to attend these events as well as drop off and pick up their children from school. Most (82%) of astronomer departments and organisations (or their host institutions) offer a carer program that funds children and carers to travel with the parent to conferences or other work travel.

Implicit bias causes women to be nominated less frequently for invited colloquia, and they are also less likely to self-nominate for colloquia in science (Nittrouer 2018). To help overcome implicit bias in nominating speakers for colloquia, 65% of astronomy departments and organisations are monitoring and modifying the gender balance of colloquium and seminar speakers to increase the fraction of women speakers to match the fraction of women in Australian astronomy. Inclusion of women at Australian conferences are now also being monitored and, in some cases, published. The gender demographics of delegates, presenters, and awards at the 2018 Australian Space Research Conference were published with analysis showing that female representation at this conference has fallen between 2015 -2018, except among Plenary speakers (Jones et al. 19). The ASTRO 3D Centre of Excellence has taken a more proactive role in achieving gender balance at conferences by only funding conferences or workshops where the scientific organising committee and speakers at all levels (review, invited, targeted, and contributed) and participants are targeted to be 50% female.

Women receive awards at a rate that is lower (sometimes significantly lower) than the fraction of women in the (Ma et al. 19, Lunnemann et al. 19). It is difficult to estimate how much of this effect is due to a lack of nominations and how much is due to implicit bias in reference letters or committee deliberations because the gender fraction of nominations is frequently not available to the public. The Astronomical Society of Australia has been publishing the fraction of female nominations for their prizes each year. We recommend that other organisations that offers awards

to astronomers, such as the Australian Academy of Science, also publish the fraction of female and male nominations.

In Australian universities, females are less likely to be nominated or to self-nominate for promotion than males, causing females to remain at lower university levels longer than males (Winchester 2006, Winchester 2015). This effect contributes to the gender gap seen at the higher levels in Australian universities (Figure 1), and causes a salary gap because indexed salary rises are often based on a percentage of the current salary (Challice et al. 2018). However, when women apply for promotion at Australian universities, they are usually promoted with equal or greater success rates than men (Winchester 2006). To promote women's advancement to the senior levels, the majority (80%) of Australian astronomer institutions have now introduced dedicated mentoring for women to support faster promotion of women to the senior levels.

In summary, many Australian astronomer departments and institutions have made recent changes to improve the culture and to make the workplace more family-friendly. There is still work to do. We recommend that:

- **All astronomer institutions offer the culture initiatives shown in Figure 6.**
- **Astronomer institutions lobby their universities and other award-giving organisations to publish the number of nominations for awards, and to improve the number of awards given to women.**
- **Astronomer institutions ensure that nominations for awards be gender balanced.**
- **All astronomer institutions offer mentoring for promotion to all staff, with success monitoring to ensure that women and other minorities are being nominated for promotion and receiving promotion at similar success rates to white males.**
- **All astronomer institutions investigate and correct salary gaps in their departments**
- **All astronomer institutions promote practices that allow children to be visible in the workplace.**

## Support for the LGBTQIA+ community

The UK Institute of Physics, Royal Astronomical Society and Royal Society of Chemistry prepared a report in 2019 on the workplace for LGBT+ Physical Scientists, which can be read here: https://www.rsc.org/globalassets/04-campaigning-outreach/campaigning/lgbt-report/lgbt-report_web.pdf

This report concludes that nearly one-third of physical scientists from sexual and gender minorities in the United Kingdom have considered leaving their jobs because of their workplace climate, and that many LGBT+ physical scientists have experienced or observed exclusionary behaviour in the workplace.

Exclusionary practices, such as only offering single-sex toilets, are common. Some universities, such as Curtin University, have now converted single occupancy (ambulant) toilets into unisex toilets. The Macquarie University Astronomy department has been proactive in the development of a campus-wide policy for creating gender-neutral toilets.

Several institutions are running LGBTQIA+ events, such as morning teas or lunches, as well as providing LGBTI Ally training to their staff and students. Astronomers are active in the Australian QueersInScience organisation. QueersInScience builds a supportive environment and cohort within universities for LGBT-STEM researchers, support staff, and students. In 2019, QueersInScience ran

the first Australian LGBT-STEM Day Symposium. The symposium aimed to showcase and celebrate the achievements of internationally recognised Australian LGBTQIA+ researchers, provide role models for emerging professionals in STEM, and promote awareness and understanding of the issues faced by LGBTQIA+ people in science and ways to solve those issues. Held in Melbourne, and sponsored by several universities and science institutes, including the Astronomical Society of Australia, the Australian Academy of Science, CSIRO, and ASTRO 3D, this event attracted over 200 attendees. The symposium was so successful that 98% of attendees stated that they would attend again, and 99% would promote the event to others. QueersInScience is now expanding to other universities across Australia.

We recommend that:

- **The Australian Astronomical Society (perhaps in combination with the Australian Physical Society) run a similarly comprehensive survey to the survey run by the Royal Astronomical Society to gauge the workplace climate for the LGBTIA+ community. This report would help inform astronomer department policies and practices.**
- **Astronomer departments introduce inclusion practices including (but not limited to) LGBTI ally training, the introduction of unisex toilets, and the expansion of dual career hire policies and departmental social events to explicitly include same sex couples.**
- **Astronomer departments support attendance at, and sponsorship of, QueersInScience and other similar support meetings and organisations at their universities and institutions.**

## Embracing different ethnic and religious backgrounds

People from ethnic and religious minorities experience racial prejudice and harassment in astronomy (Clancy 2017). Research shows that encouraging people to express and share diverse cultural interests in mainstream settings reduces prejudice against minority ethnic groups (Bannon 2013). Some astronomy and physics departments have begun programs to address this issue.

The Curtin University astronomy diversity committee funded a Cultural Intelligence workshop that was highly rated among participants. This workshop covers how culture affects our workplace and society, identifying new ways to think about culture, and research-based solutions on how to bridge cultural gaps. Some companies may be hired to provide cultural intelligence workshops (https://culturalintelligence.net.au), while some universities offer their own (https://cce.sydney.edu.au/course/DAIC).

Cultural morning teas or lunches are one way to promote different cultures and religious backgrounds. Including a talk or discussion on different cultural and religious backgrounds provides information as well as promoting inclusion. Some departments have recently begun offering such initiatives. For example, the Curtin astronomy group also hosts an International/Cultural Lunch to celebrate the strong diversity within the department. The University of Sydney School of Physics has begun cultural morning teas. The most recent morning tea focused on Islam with a short talk by a muslim staff member.

The University of Melbourne Physics and Astronomy department now has a dedicated prayer/meditation space that can be reserved by any staff or student member. In 2019 ASTRO 3D began providing a prayer/meditation space at its Annual Retreats and Science Meetings.

Feeling empathy for others is one of the few proven ways to help people modify their implicit biases (Shih 2009, Shih 2013, Teding2016). The University of Tasmania has engaged with the Hobart Human Library, which delivers diversity education workshops to schools and workplaces. The

Human Library uses storytelling to challenge stereotypes and build empathy through personal stories about discrimination and bullying based on culture, religion, refugee background, gender, sexual orientation, physical or mental ability. Similar programs would benefit astronomer departments across the country.

We recommend that

- **Astronomer institutions provide cultural and religious awareness training to their staff and students.**
- **Institutions celebrate different culture and religious backgrounds through special events and seminars.**
- **Departments provide prayer/meditation spaces.**
- **The scheduling of astronomy meetings workshops and conferences include awareness of religious holidays and events.**

## Indigenous representation

The Australian Indigenous population is underrepresented at Australian Universities. While some universities have introduced indigenous astronomy into their education and outreach programs, programs to tackle this issue are largely lacking from astronomy institutions.

Awareness programs include the CSIRO Reconciliation Action Plan. This plan covers all CSIRO (not limited to astronomy) and aims to improve awareness and understanding of Aboriginal and Torres Strait Islander people. The Macquarie University Physics and Astronomy department is working with Walanga Muru, the Macquarie Indigenous Centre, to incorporate Aboriginal astronomy into Astronomy Open. A similar program is operated by the University of Western Sydney.

Awareness programs are critically important and they are not enough. Astronomy has a special place in Aboriginal culture, and astronomer institutions could lead the way in initiating indigenous pathways to careers in STEM. Programs could include: expanding education and outreach programs to local indigenous communities, offering indigenous work experience programs, and mentoring for research projects at indigenous schools. To ensure that these programs have a high chance of success and that these programs are offered in a culturally sensitive way, these programs should be offered in conjunction with staff indigenous awareness programs, and in consultation with indigenous engagement experts (possibly through collaborations with members of university indigenous studies departments).

**We recommend that Astronomer institutions offer indigenous awareness programs to their staff and students, and begin programs that promote STEM pathways to indigenous students.**

## Support for people with disabilities and major illness

Astronomy is becoming more accessible to people with disabilities. Sonification software now allows blind and visually impaired astronomers to analyse astronomical data (Candey et al. 2012, Garcia et al. 2019), and sophisticated voice recognition software enables astronomers that are unable to use keyboards to analyse data and write publications. **Virtual access, recording, and subtitling should be provided for conferences and workshops to promote the inclusion of people with disabilities, illness, or other travel constraints. Universities also need to develop new methods to support the advancement of people with disabilities or major illness through the promotion process, which can be perceived as an insurmountable hurdle.**

## Summary and Main Recommendations

Australian astronomy has undergone many positive changes in diversity and culture over the past few years, largely thanks to the ASA Pleiades Awards. However, the fraction of women at the higher levels (levels C-E) remains critically low, and has not improved between 2013-2019. Women are leaving Australian astronomy at double the proportion of men after a Level A position. Exit surveys to gauge the reasons for these departures are critically needed Australia-wide.

All individual astronomer departments should introduce retention targets and recruitment targets of at least 33% women at each level. New programs to increase the fraction of female undergraduate and graduate students in astronomy programs and science in general are needed.

Other areas for improvement for the retention and promotion of women include the mentoring and provision of role models for young women. Departments should require that the gender balance of speakers at least match the fraction of women in Australian astronomy, as given in the Decadal Plan. Visitor programs promoting women visitors and their families should be introduced Australia-wide. It is important to emphasize that just providing role models is not enough to improve the retention rates of women. Role models need to be visible to have a good work-life balance. Initiatives that promote and celebrate work-life balance are needed across Australia.

Australian astronomy needs to be doing more to support members of different cultural and religious backgrounds and members of the LGBTI community. Cultural intelligence education and programs that promote acceptance of people from a broad range of religious backgrounds are needed. All astronomer institutions should provide education on the issues faced by LGBTQIA+ members of the community, as well as further initiatives to build a welcoming culture for members of the LGBTQIA+ community, such as support for QueersInScience programs across Australia, encouraging and supporting applications from same-sex couples for dual career hire funding, and introducing non-gendered toilets at more astronomer departments and institutions. Departments should develop Reconciliation Action Plans or similar programs to promote Indigenous awareness and provide mentoring and pathways for indigenous students in STEM.

Finally, some members of the Australian astronomy community are working with disability and major illness. These disabilities and illnesses may not be obviously visible in the workplace. Virtual access, recording and subtitling should be provided for conferences and workshops, and support and mentoring for promotion should be provided for these members.

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