# Australian Astronomy Publication and Facilities Survey
# September 2014

Brian Schmidt, Stuart Wyithe, Robert Barone-Nugent

We have undertaken a survey of Australian Astronomers to ascertain the relative reliance on various techniques and infrastructure for their research. This is a follow-up study to a similar program conducted in 2005 as part of the Decadal Planning process for the 2005-2014 period.

## *Methodology*

Our Methodology remains very similar to 2005. Astronomers were contacted via the Astronomical Society of Australia email list and those members who were currently resident in Australia and had published over the period 2004-2013, were asked to fill out a web form, ascribing percentages of their papers to various facilities, or to different aspect of theory. For our analysis we used the Astrophysical Data Service (ADS) database, including publications that were labeled as astronomy papers, and which were published between 2004-2013. Astronomers were asked to exclude those papers which were not theirs (same name). Citations were taken from all sources - as listed by ADS, to the date of 6 August 2014. One difference between the 2014 and 2005 study was that astronomers were asked to include those papers authored before they arrived in Australia (these were excluded in the 2005 study), as it was felt that this better represented the use of techniques and facilities for those Astronomers resident in Australia at the time of the survey.

This survey does not accurately measure the impact of Australian Astronomy relative to international benchmarks because it is incomplete, and because it uses different methodology than other international surveys. However, it is useful in assessing the relative impact of Australian facilities and techniques on our publications, because it does sample a significant fraction of Australian astronomical papers over the period. In total 308 astronomers participated in the survey (compared to 130 in 2005), entering information for 6655 distinct papers (2063 distinct papers in 2005). This rate reflects a high percentage of participation of actively publishing astronomers in Australia in both surveys: e.g. in 2014, the demographic survey lists 312 astronomers with continuing or fixed-term contracts.

In all cases, if more than one astronomer provided a percentage to the same co-authored publication, we averaged their results, by summing each astronomer's results, dividing by the number of responses. There are different ways (and philosophies) to judge the importance of facilities, and we break these down into 6 separate cases.

**Case 1:** Measure the total number of publications that are attributable to each facility, weighted by the percentage that each astronomer ascribed to each publication. This provides an estimate of the total number of papers being driven by each facility, independent of quality, and independent of the fraction of Australian authors on the paper (as long as it is not 0!). It is a measure of the relative usage of each facility in producing scientific works.

**Case 2:** Same as Case 1, but normalized by the fraction of Australian authors on the paper. In this case, if a paper has 20 authors, 3 of which are Australian, the paper is de-weighted by 3/20, relative to a paper which has only Australian Authors.

Australian Authors are defined, in this case, as people who have filled out the survey – not by their affiliation as listed on the paper. While this would be a bad thing to do in measuring absolute impact, because we are measuring relative impact, it should not affect results significantly. This is our preferred quantity measure, taking into account the rate of Australian participation on a given publication.

**Case 3:** Same as Case 1, but normalized by the total number of citations the paper has received. Each paper with an Australian author is treated equally – a paper with 1 out of 20 Australian authors is not de-weighted with respect to a paper which is solely Australian. This is the simplest way of measuring the sum of quantity times quality of a paper.

**Case 4:** Same as Case 3, but normalized by the average number of citations that papers from around the world have received in that year. Since we are dealing with publications from 2004 (average # of 22.5 citations ) to 2013 (average # of citations 4.6), papers in 2004 are given 5 times more weight than the youngest papers, and this method removes this bias.

**Case 5:** Same as Case 3, but normalized by the fraction of Australian authors. This is a citation weighted, Australian fraction weighted quality index, which ignores the bias of younger versus older papers.

**Case 6:** Same as Case 5, but now weights, as in Case 4, by the average number of citations in a paper's year. This is our preferred quality measure, taking into account rate of Australian participation, age of paper, and citation weighted impact.

Finally, for each cases we have grouped the data into the broad facility areas of Theory, Radio/mm/submm, UV-Optical-IR, X-ray-Gamma Ray, Gravity Wave, and other.

## *Analysis*

The choice of the method of analysis does not change the broad conclusions reached by the survey. It is only if one tries to play league tables between facilities – which this survey is not complete enough to do except in a very rough sense – that one would get different answers between which method is chosen for the analysis. The Appendix lists the results for each Case:

### Total Impact of Facilities based on Number of Publications:

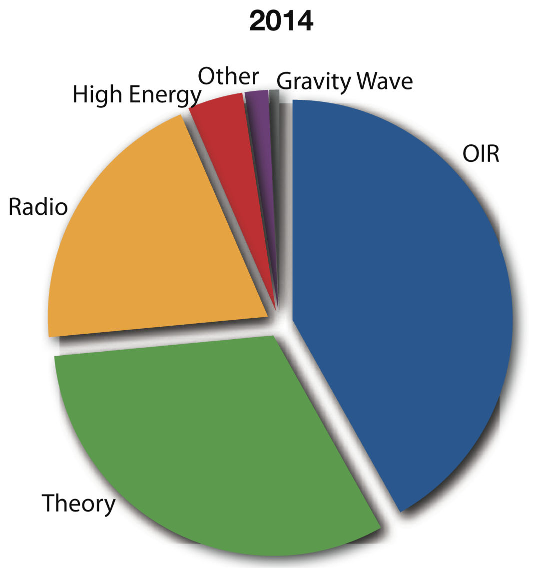
This idea is encapsulated in cases 1 and 2. We believe that the impact to Australian Astronomy is best measured by case 2, which weights large international collaborations by the number of Australian participants. We see that the numbers of Australian astronomy publications that use theory, and optical and radio facilities make up 90% of all Australian-weighted (case 2) publications.

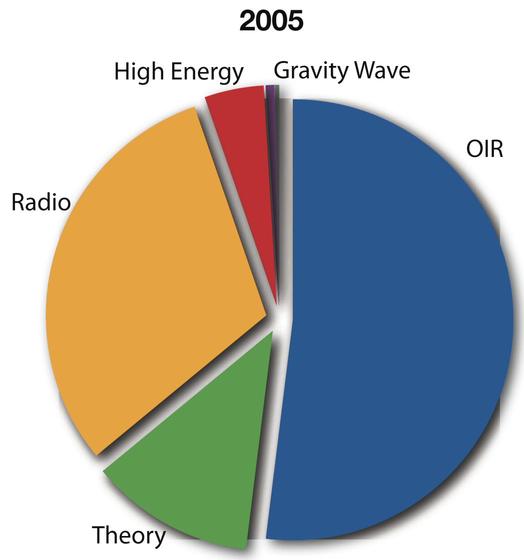
Compared to 2005, a much larger fraction of our work is in the theory domain (rising from 14% to 32%), with optical (dropping from 39% to 35% over the period) and radio (dropping from 35% to 23% over the period) having a decreased share of activity. High energy astrophysics has mildly increased (4.3% to 5.2%) and gravity wave astronomy has increased from (0.9% to 1.8%).

### Total Impact of Facilities including impact as measured via citation rates:

Citation weighted impact is encapsulated in cases 3-6. We believe that the impact to Australian astronomy is best captured by case 6, which tries to take into account the age of the paper, and weights papers by the fraction of Australian contributors. In the analysis that follows, we will use Case-6 numbers of impact-weighted activity.

As in the non-citation weighted indices, Australian Astronomy is dominated by Theory and optical and radio facilities, which together sum to 93.5% of all Australian impact-weighted activity. Again, theory has established itself as a major contributor to Australian activity, rising from 11% of impact-weighted activity in 2005, to 32% of this activity in 2014. The importance of optical and infrared (OIR) has dropped from 49% to 42% over this period, and radio has fallen from 29% to 20%.  High energy astrophysics was steady on about 4%, and gravity wave astronomy has increased to 0.7% of impact-weighed activity from 0.4% in 2005.




Within OIR astronomy, Australian-owned facilities represent only 1/3rd of the outputs of current OIR research, compared to more than half (53%) in 2005. This number may be skewed by the inclusion of researchers publications in the time that they were not resident in Australia in the 2014 survey. 30% of all OIR research is space-based, 25% is 8-m based, 17% AAT-based, 10% other domestic Australian-based, and some 30% based on other international non-8m facilities. Over the decade, 13.6% of all recorded publications had an 8-m component, 7.2% had an AAT component, and 13.1% had a domestic optical telescope component (including the AAT).

Within theory, 61% of all theory impact-weighted activity is computational based, but on non-national scale infrastructure. 30% of activity is analytic theory, with the national-scale facilities of NCI, Swinburne and Pawsey representing 9% of impact-weighted activity. A small fraction of impact-weighted activity can be attributed to overseas large-scale facilities, but the largest fraction of the theory impact-weighted activity appears to be related to small scale computation.

Within radio/mm/sub-mm, more than 2/3rds of impact-weighted activity is Australian based with approximately 30% each attributed to the Australian Telescope Compact Array and Parkes, and 10% to other Australian facilities. The role international facilities play in Australian radio astronomy has more than doubled since 2005, up from 15% to 31% of all impact-weighted activity. This increase of foreign facilities may be skewed by the inclusion of researchers publications in the time that they were not resident in Australia in the 2014 survey.  Over the decade 9.0% of all publications had an ATCA component, 16.6% had an Australian based radio component, and 26.4% of all publications had a radio component.

Although theory along with optical and radio facilities together make up 93% of the total citation-weighted impact of Australian astronomy, only a quarter of papers involved more than one of the three areas: 6.5% of papers used Optical and Theory, 13.3% used Radio and Optical, and 4.6% used Radio and Theory.

***Appendix: 1.1 CASE 1***

| Area | Percent |
|---|---|
| Theory Computational Other | 11.3 |
| UV/Optical/IR International Space-based | 10.1 |
| Optical/IR International Other Ground-based | 9.3 |
| Optical/IR non-Australian Other 8m-class | 7.2 |
| Theory Analytic | 7.1 |
| Radio ATNF ATCA | 5.9 |
| Radio <90 GHz International | 5.3 |
| Optical/IR AAT | 4.9 |
| Optical/IR Other | 4.8 |
| Radio ATNF Parkes | 4.2 |
| X-Ray Space | 3.5 |
| Gamma-Ray | 3.3 |
| High Energy Other Ground Based | 2.5 |
| Gravitational Wave LIGO | 2.3 |
| Optical/IR Other Australian Based | 2.3 |
| Radio mm/sub mm | 2.3 |
| Other | 2.2 |
| Optical/IR Australian Gemini | 1.9 |
| Optical/IR UKSchmidt | 1.3 |
| Radio ATNF Mopra | 1.1 |
| Radio Other | 1.0 |
| Theory Computational Swinburne | 0.9 |
| High Energy AUGIER | 0.8 |
| Theory Computational NCI/ANUSF | 0.7 |
| Radio ATNF VLBI | 0.7 |
| Optical/IR Australian Keck | 0.6 |
| Optical/IR Antarctica | 0.6 |
| Optical/IR Australian Magellan | 0.4 |
| Radio Other Australian Based | 0.4 |
| Gravitational Wave Other | 0.3 |
| Radio MWA | 0.3 |
| Optical/IR VLT | 0.3 |
| High Energy Other Airshower | 0.1 |
| Theory Computational Pawsey | 0.1 |
| Radio ATNF Tidbinbilla | 0.1 |

| | |
|---|---|
| OIR | 43.8 |
| Radio/mm/sub-mm | 21.1 |
| Theory | 20.1 |
| High Energy | 10.2 |
| Gravity Wave | 2.6 |
| Other | 2.2 |

## *Appendix: 1.2 CASE 2*

| Area | Percent |
|---|---|
| Theory Computational Other | 15.9 |
| Theory Analytic | 13.1 |
| Radio ATNF ATCA | 8.2 |
| Optical/IR International Other Ground-based | 6.2 |
| Optical/IR AAT | 6.0 |
| Optical/IR non-Australian Other 8m-class | 5.8 |
| UV/Optical/IR International Space-based | 5.7 |
| Radio ATNF Parkes | 5.7 |
| Radio <90 GHz International | 4.1 |
| Optical/IR Other | 3.7 |
| X-Ray Space | 3.1 |
| Other | 3.0 |
| Optical/IR Other Australian Based | 2.6 |
| Optical/IR Australian Gemini | 1.6 |
| Theory Computational Swinburne | 1.6 |
| Gravitational Wave LIGO | 1.4 |
| Optical/IR UKSchmidt | 1.3 |
| Radio ATNF Mopra | 1.3 |
| Radio mm/sub mm | 1.2 |
| Theory Computational NCI/ANUSF | 1.1 |
| Radio Other | 1.1 |
| High Energy Other Ground Based | 0.9 |
| Radio ATNF VLBI | 0.8 |
| Gamma-Ray | 0.8 |
| Optical/IR Antarctica | 0.7 |
| Radio Other Australian Based | 0.7 |
| Optical/IR Australian Keck | 0.6 |
| Gravitational Wave Other | 0.4 |
| Optical/IR Australian Magellan | 0.4 |
| High Energy AUGIER | 0.3 |
| Radio MWA | 0.2 |
| Optical/IR VLT | 0.2 |
| Theory Computational Pawsey | 0.2 |
| Radio ATNF Tidbinbilla | 0.1 |
| High Energy Other Airshower | 0.1 |

| | |
|---|---|
| OIR | 34.8 |
| Theory | 31.9 |
| Radio/mm/sub-mm | 23.3 |
| High Energy | 5.2 |
| Other | 3.0 |
| Gravity Wave | 1.8 |

## *Appendix: 1.3 CASE 3*

| Area | Percent |
|---|---|
| Optical/IR International Other Ground-based | 13.7 |
| Theory Computational Other | 13.5 |
| UV/Optical/IR International Space-based | 11.5 |
| Optical/IR non-Australian Other 8m-class | 7.5 |
| Optical/IR Other | 6.3 |
| Gamma-Ray | 5.6 |
| Optical/IR AAT | 4.5 |
| Theory Analytic | 4.2 |
| Radio <90 GHz International | 4.0 |
| Radio ATNF Parkes | 4.0 |
| Radio ATNF ATCA | 3.1 |
| Radio mm/sub mm | 2.6 |
| X-Ray Space | 2.5 |
| Optical/IR Australian Gemini | 2.1 |
| High Energy Other Ground Based | 1.9 |
| Gravitational Wave LIGO | 1.8 |
| Optical/IR UKSchmidt | 1.6 |
| High Energy AUGIER | 1.5 |
| Optical/IR Other Australian Based | 1.5 |
| Other | 1.0 |
| Radio Other | 0.9 |
| Theory Computational NCI/ANUSF | 0.6 |
| Radio ATNF Mopra | 0.5 |
| Optical/IR Australian Keck | 0.5 |
| Theory Computational Swinburne | 0.5 |
| High Energy Other Airshower | 0.5 |
| Optical/IR VLT | 0.5 |
| Optical/IR Australian Magellan | 0.3 |
| Radio ATNF VLBI | 0.3 |
| Optical/IR Antarctica | 0.3 |
| Radio Other Australian Based | 0.2 |
| Gravitational Wave Other | 0.2 |
| Radio MWA | 0.2 |
| Theory Computational Pawsey | 0.0 |
| Radio ATNF Tidbinbilla | 0.0 |

| | |
|---|---|
| OIR | 50.3 |
| Theory | 18.9 |
| Radio/mm/sub-mm | 15.9 |
| High Energy | 12.0 |
| Gravity Wave | 2.0 |
| Other | 1.0 |

***Appendix: 1.4 CASE 4***

| Area | Percent |
|---|---|
| Theory Computational Other | 13.2 |
| Optical/IR International Other Ground-based | 12.9 |
| UV/Optical/IR International Space-based | 11.8 |
| Optical/IR non-Australian Other 8m-class | 7.5 |
| Optical/IR Other | 6.1 |
| Gamma-Ray | 5.2 |
| Optical/IR AAT | 4.6 |
| Theory Analytic | 4.4 |
| Radio <90 GHz International | 4.2 |
| Radio ATNF Parkes | 3.7 |
| Radio mm/sub mm | 3.5 |
| Radio ATNF ATCA | 3.0 |
| X-Ray Space | 2.4 |
| High Energy Other Ground Based | 2.2 |
| Gravitational Wave LIGO | 2.0 |
| Optical/IR Australian Gemini | 1.8 |
| Optical/IR UKSchmidt | 1.6 |
| Optical/IR Other Australian Based | 1.4 |
| High Energy AUGIER | 1.3 |
| Other | 1.3 |
| Radio Other | 0.9 |
| Radio ATNF Mopra | 0.7 |
| Optical/IR Australian Keck | 0.6 |
| Theory Computational NCI/ANUSF | 0.6 |
| Theory Computational Swinburne | 0.6 |
| Optical/IR Australian Magellan | 0.4 |
| Optical/IR VLT | 0.4 |
| High Energy Other Airshower | 0.3 |
| Radio MWA | 0.3 |
| Radio ATNF VLBI | 0.3 |
| Gravitational Wave Other | 0.2 |
| Optical/IR Antarctica | 0.2 |
| Radio Other Australian Based | 0.2 |
| Theory Computational Pawsey | 0.1 |
| Radio ATNF Tidbinbilla | 0.0 |

| | |
|---|---|
| OIR | 49.3 |
| Theory | 18.9 |
| Radio/mm/sub-mm | 16.8 |
| High Energy | 11.5 |
| Gravity Wave | 2.3 |
| Other | 1.3 |

***Appendix: 1.5 CASE 5***

| Area | Percent |
|---|---|
| Theory Computational Other | 19.4 |
| Theory Analytic | 9.4 |
| Optical/IR International Other Ground-based | 8.9 |
| Optical/IR non-Australian Other 8m-class | 7.2 |
| UV/Optical/IR International Space-based | 7.2 |
| Radio ATNF Parkes | 6.6 |
| Optical/IR AAT | 6.5 |
| Radio ATNF ATCA | 5.7 |
| Optical/IR Other | 4.5 |
| Radio <90 GHz International | 3.8 |
| X-Ray Space | 2.7 |
| Optical/IR UKSchmidt | 1.9 |
| Optical/IR Other Australian Based | 1.8 |
| Optical/IR Australian Gemini | 1.6 |
| Other | 1.4 |
| Radio mm/sub mm | 1.4 |
| Theory Computational NCI/ANUSF | 1.4 |
| Radio Other | 1.3 |
| Theory Computational Swinburne | 0.9 |
| Gamma-Ray | 0.9 |
| Radio ATNF Mopra | 0.8 |
| Optical/IR Australian Keck | 0.7 |
| Radio Other Australian Based | 0.6 |
| Optical/IR Antarctica | 0.5 |
| Gravitational Wave LIGO | 0.5 |
| Radio ATNF VLBI | 0.5 |
| Optical/IR Australian Magellan | 0.4 |
| Optical/IR VLT | 0.4 |
| High Energy Other Ground Based | 0.3 |
| Gravitational Wave Other | 0.2 |
| High Energy AUGIER | 0.2 |
| Radio MWA | 0.1 |
| Theory Computational Pawsey | 0.1 |
| High Energy Other Airshower | 0.1 |
| Radio ATNF Tidbinbilla | 0.0 |

| | |
|---|---|
| OIR | 41.7 |
| Theory | 31.2 |
| Radio/mm/sub-mm | 20.8 |
| High Energy | 4.2 |
| Other | 1.4 |
| Gravity Wave | 0.7 |

## *Appendix: 1.6 CASE 6*

| Area | Percent |
|---|---|
| Theory Computational Other | 19.3 |
| Theory Analytic | 9.6 |
| Optical/IR International Other Ground-based | 8.4 |
| UV/Optical/IR International Space-based | 7.4 |
| Optical/IR non-Australian Other 8m-class | 7.3 |
| Optical/IR AAT | 7.0 |
| Radio ATNF Parkes | 6.1 |
| Radio ATNF ATCA | 5.5 |
| Optical/IR Other | 4.2 |
| Radio <90 GHz International | 3.6 |
| X-Ray Space | 2.5 |
| Optical/IR UKSchmidt | 2.1 |
| Optical/IR Other Australian Based | 1.8 |
| Other | 1.7 |
| Optical/IR Australian Gemini | 1.5 |
| Radio mm/sub mm | 1.5 |
| Theory Computational NCI/ANUSF | 1.3 |
| Theory Computational Swinburne | 1.2 |
| Radio Other | 1.2 |
| Gamma-Ray | 1.0 |
| Radio ATNF Mopra | 1.0 |
| Optical/IR Australian Keck | 0.8 |
| Optical/IR Australian Magellan | 0.6 |
| Radio Other Australian Based | 0.5 |
| Gravitational Wave LIGO | 0.5 |
| Radio ATNF VLBI | 0.4 |
| Optical/IR Antarctica | 0.4 |
| Optical/IR VLT | 0.4 |
| Radio MWA | 0.3 |
| High Energy Other Ground Based | 0.3 |
| Gravitational Wave Other | 0.3 |
| Theory Computational Pawsey | 0.3 |
| High Energy AUGIER | 0.1 |
| High Energy Other Airshower | 0.1 |
| Radio ATNF Tidbinbilla | 0.0 |

| | |
|---|---|
| OIR | 41.9 |
| Theory | 31.6 |
| Radio/mm/sub-mm | 20.0 |
| High Energy | 4.1 |
| Other | 1.7 |
| Gravity Wave | 0.7 |