

Information on career paths of Australian astronomy PhD graduates

10th December 2014

Astronomy Australia Ltd

Executive Summary

This document presents a summary of information gathered and analysed by Astronomy Australia Ltd (AAL) in relation to post-PhD career pathways for Australian astronomy postgraduates. Together, the data suggests that:

- Approximately half of Australian astronomy PhD graduates moved into non-astronomy fields 5-20 years after completing their PhD.
- Most astronomy PhD graduates that have moved out of astronomy research are employed within academic, government or other not-for-profit sectors.

The following data sources were used to prepare this document:

- Results from demographic surveys carried out by the Australian Academy of Sciences' National Committee for Astronomy (NCA) in 2005 and 2014 as part of their Decadal Planning process. These surveys gave Australian universities an opportunity to provide information on post-PhD employment for recent astronomy graduates.
- A small but detailed analysis by AAL of the current employment of astronomy PhD students who graduated in 2000-2009 from the Australian National University, University of Melbourne and University of Sydney.
- Data from the Australian 2011 Census regarding industry of employment for those who listed an astrophysics PhD as their highest qualification.
- Case studies describing examples of post-astronomy-PhD careers were prepared by AAL in consultation with the individuals, who gave permission for their stories to be included in this document.

In gathering relevant information for this document, it was clear that there is a lack of data on this topic and more detailed studies are needed to understand the career pathways of astronomy PhD graduates. If requested by the Australian Government, AAL would be willing to work with our stakeholders to undertake a more detailed study into post-PhD careers for astronomy graduates.

Context

On 12th November 2014, AAL was invited by the Australian SKA Office to provide information in relation to career pathways for Australian astronomy postgraduate students, which the Australian SKA Office may use to inform a Radio Astronomy Impact Study being conducted by the Science and Technologies Facilities Council (STFC). As AAL does not keep up-to-date comprehensive information on this matter, we requested information and statistics from the Australian Academy of Sciences' National Committee for Astronomy (which undertakes a demographic survey of the Australian astronomy community every ten years) and some of AAL's member representatives from Australian universities. We also conducted an online literature search for relevant information.

A summary of relevant information is provided below, however, it should be noted that there is a clear lack of detailed comprehensive data on the career pathways for Australian astronomy postgraduates. This reflects a broader problem across the Science, Technology, Engineering and Mathematics (STEM) fields. As identified by the Australian Council Of Learned Academies, “*there is a lack of clear data in Australia concerning destinations of STEM graduates and the role of STEM training in a variety of professions*” and a “*key need is data concerning the destinations of STEM graduates (whether at the level of first degree, postgraduate coursework or postgraduate research) in the first 5-10 years after graduation, identifying the respective roles of STEM education and training in relation to: work specific to the STEM qualification; work that is outside field but within STEM; work in occupations with no specific STEM requirements that may nonetheless draw on STEM graduates’ skills and knowledge in a more generic manner.*”¹

Post-PhD career-path data

National Committee for Astronomy – Decadal Planning demographic data

Every ten years the Australian Academy of Sciences’ National Committee for Astronomy (NCA) conducts a Decadal Planning process, which includes a survey of Australian institutes doing astronomy research that captures some information on post-PhD employment. This survey was most recently carried out in 2014, with institutes being asked to indicate the post-PhD employment destination of their graduates over the five year period 2009-2013, by type (academic, teaching, industry), area (astronomy, other science) and location (Australia, international)². Of a total of 159 astronomy PhD graduates, 59% were known to continue in academia, with 49% known to get jobs in astronomy (Figure 1). 18% of graduates went straight into industry or teaching, and the true number is likely to be higher given that the employment outcomes of about a quarter of graduates were unknown, and we expect that the unknowns are more likely to have left astronomy. Figure 2 presents the data for the 38 PhDs that were listed as primarily radio astronomy research in the NCA’s 2014 survey, which is broadly consistent with the data for all astronomy PhDs.

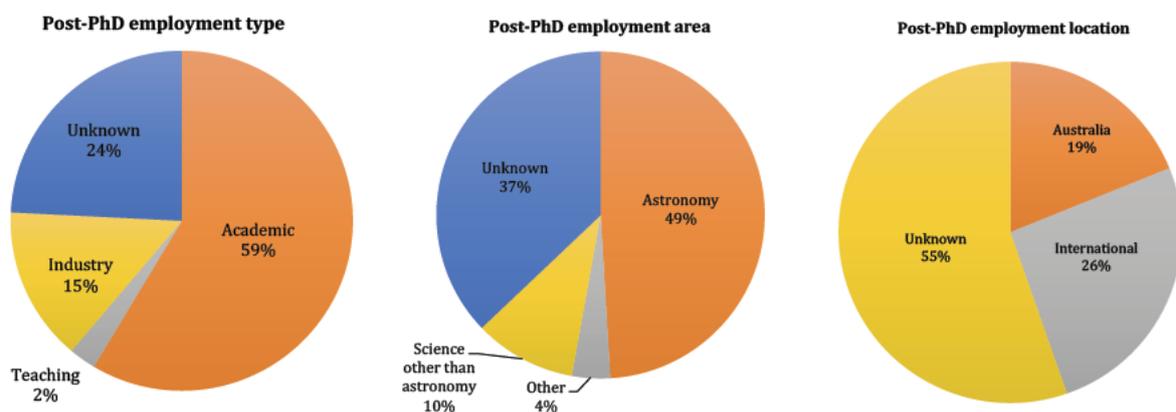


Figure 1: Post-PhD employment for astronomy-PhDs who graduated between 2009-2013 inclusive (N= 159), as measured by a survey conducted by the National Committee for Astronomy of Australian institutes that do astronomy research.

¹ Marginson, S, Tytler, R, Freeman, B and Roberts, K (2013). STEM: Country comparisons. Report for the Australian Council of Learned Academies (p.24) <http://www.acola.org.au/index.php/projects/securing-australia-s-future/project-2>

² Draft Report for the National Committee for Astronomy Decadal Plan 2016-2025 by the Working Group 3.1: Demographics (November 2014)

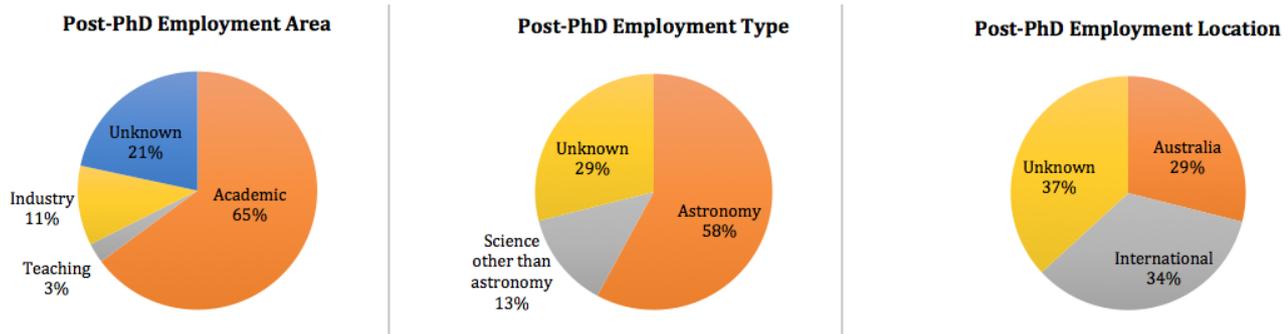


Figure 2: As per Figure 1 but for the 38 PhDs for which radio astronomy was listed as the main area of research.

The NCA's survey for the previous Decadal Plan also found that approximately 20% of graduates from 2000-2004 moved directly into industry or teaching³. A previous study considered a 20-year baseline and found that, as of 1998, approximately 40% of the 114 astronomy PhD students that graduated in 1975-1994 from the Australian National University and University of Sydney were no longer involved in astronomy research⁴. Of those remaining in astronomical research, about half had permanent positions.

AAL detailed analysis

To understand the post-PhD career paths in more detail, AAL conducted an analysis of the current employment (as of November 2014) of astronomy graduates who completed their PhDs at the Australian National University, University of Sydney and University of Melbourne during the ten year period from 2000-2009. The 115 PhDs from these three universities represent approximately half of the total astronomy PhDs completed in Australia during that decade. Of these, approximately 50% currently have jobs in astronomy, 30% have jobs in other fields, and the current positions of 20% could not be determined (Figure 3). For those known to be working outside astronomy, about 30% have jobs in other research or scientific disciplines, 50% work in information technology or analytics, and the remaining 20% work in a range of sectors including teaching, technology development, and administration (Figure 3). It should be noted that about 80% of these non-astronomy jobs are still within the public or not-for-profit sector, and about 20% are in the private/commercial sector.

³ A report to the National Committee for Astronomy for the Australian Astronomy Decadal Plan 2006-2015 By Working Group 1.1 (September 2005). https://www.science.org.au/sites/default/files/user-content/wg1_1report.pdf (page 12)

⁴ Gibson et al. "On the Importance of PhD Institute in Establishing a Long-Term Research Career in Astronomy" Bulletin of the American Astronomical Society, Vol. 31, p.1211 (1999) <http://adsabs.harvard.edu/full/1999BAAS...31.1211G>

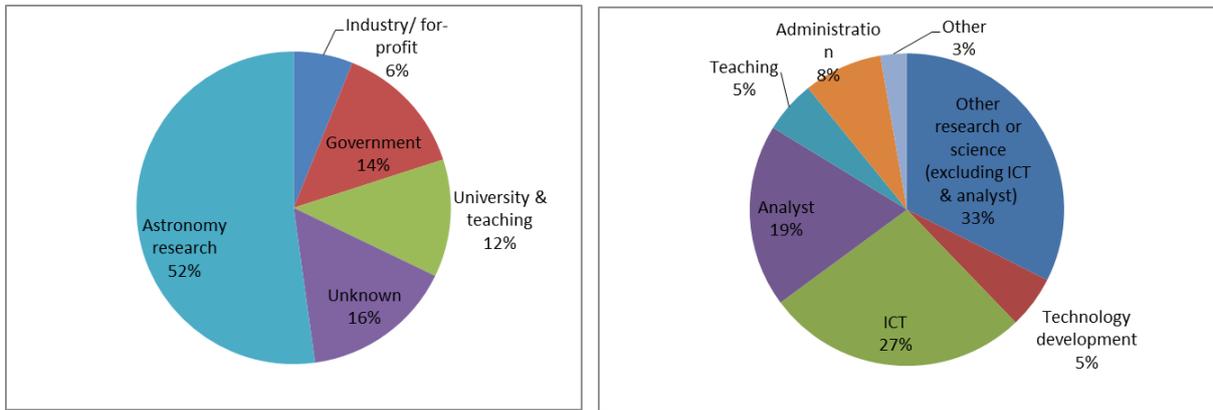


Figure 3: *Left-hand chart*: Current employment for PhD students who graduated from the Australian National University, University of Sydney and University of Melbourne in 2000-2009. *Right-hand chart*: The breakdown by field of employment for those currently employed outside of astronomy research.

Australian 2011 Census data⁵

The 2011 Australian Census includes questions about highest academic degree (and field of study) and industry of employment. Figure 4 shows the industry of employment for those who indicated that their highest degree is an astronomy PhD, for those aged 30-39 (to roughly compare with the age range of the sample in the AAL detailed analysis) and all ages.

It should be noted that Census results capture a different sample from the NCA and AAL data, as they do not include PhD graduates who are living overseas at the time of the census, but they do capture information on those who obtained their PhD overseas but were living in Australia at the time of the census. Another caveat with the census data is that it is not possible to determine whether the employment is specifically in the area of astronomy research.

Nevertheless, the 2011 Census data indicates that for the 30-39 year-olds (as at 2011), 80% of astronomy PhD holders were employed in industries classified by the Australian Bureau of Statistics as Higher Education or Scientific Research Services, 7% were not employed (“not applicable”), and 7% were in Computer System Design or Engineering Design/Consulting and related services. For the data from all age groups, the percentage in Higher Education or Scientific Research Services is 58% with a larger proportion in a range of other industries and not employed (partly due to retirement in the older age groups).

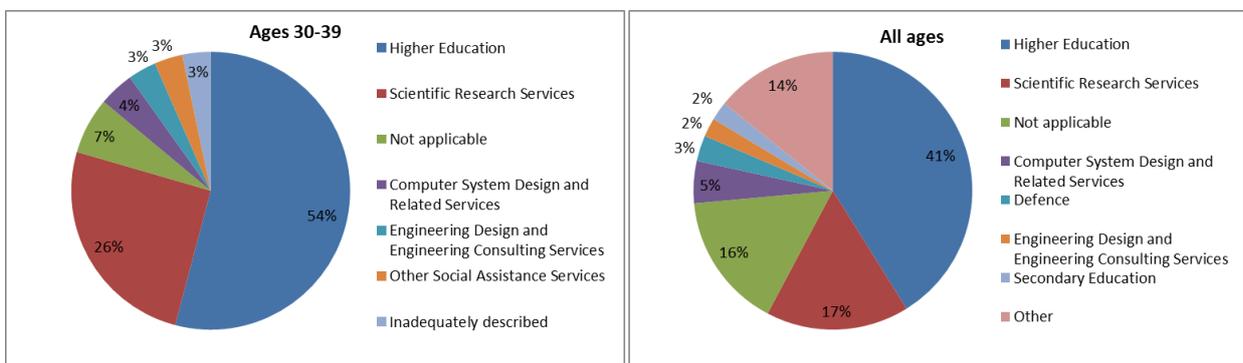


Figure 4: *Left-hand chart*: Current industry of employment from 2011 Australian Census for those aged 30-39 with an astronomy PhD listed as their highest degree (N=122). *Right-hand chart*: As per the left-hand chart but for all ages (N=367). Those who did not indicate current employment are labelled “not applicable”. It should be noted that the census data is returned as a table with the numbers in each cell randomly adjusted to ensure that no data are released

⁵ 2001 ABS Census data can be queried using Tablebuilder available at: <http://www.abs.gov.au/websitedbs/censushome.nsf/home/tablebuilder>

that could risk the identification of individuals in the statistics. Therefore, no reliance can be placed on small cells as they are impacted by random adjustment⁶.

Case studies

The following case studies describe post-PhD careers of several astronomy graduates who have applied their astronomy research skills in other fields and sectors. These individuals have given permission for their stories to be used as case studies in the Australian SKA Office's submission to the Science and Technologies Facilities Council. We can provide additional case studies if the Australian Government finds these useful.

Ilana Feain, PhD, Co-founder and CEO of Nano-X

Ilana Feain is a co-Founder and acting CEO of Nano-X, where she leads the development of a novel and cost-effective radiotherapy machine designed to level the playing field in global accessibility to equitable cancer treatment. Ilana obtained her PhD in astrophysics from the University of Sydney in 2006. In 2007, Ilana was awarded the Inaugural L'Oreal For Women in Science Fellowship for her research and outreach work with Global Jet Watch, placing telescopes in girls schools across the world. After receiving her PhD, Ilana became a research astronomer and project scientist on the Australian Square Kilometre Array Pathfinder (ASKAP) at CSIRO Astronomy and Space Science. This led to Ilana developing a cross-disciplinary research program to enable ASKAP's novel receiver technology to be used beyond astronomy, including in health and defence. Ilana then made a major career change in 2014, when she moved into medical physics, accepting a senior research fellowship in the Radiation Physics Laboratory at the School of Medicine of the University of Sydney.

In her current role with Nano-X, Ilana is motivated to improve accessibility of radiotherapy treatment for cancer, which represents the biggest global health burden facing the world in the next few decades. Radiotherapy is the most cost-effective way to treat patients both curatively and palliatively, but the current generation of radiotherapy machines cost \$5–6 million. Using frugal innovation, Ilana's team invented and patented Nano-X to deliver best-practice treatment at about 10% of the cost of current machines. Furthermore, their solution drastically simplifies the radiotherapy machine for remote usability. According to Ilana, "my background in radio astronomy, and as a project scientist for the Australian Square Kilometre Array Pathfinder, equipped me with a broad range of skills that I transferred to the Nano-X project, including instrumentation, signal processing, problem solving, analysis and project management".

Paul Brooks, PhD, General Manager, Trident Subsea Cable

Paul Brooks is the General Manager - Networks & Technology at Trident Subsea Cable, which is a privately-funded start-up firm planning to build a new \$400 million subsea and terrestrial optical fibre network linking Perth with the Pilbara/North West Shelf and internationally to Jakarta and Singapore. International and domestic telecommunications carriers, service providers, and the mining/oil/gas industry, as well as the Square Kilometre Array will all benefit from using the Trident cable system.

Paul Brooks received his PhD in Astrophysics from UNSW in 1995, where he researched CCD imaging and astronomical image processing while developing Internet communications software part-time for a commercial company. That software was later used in an infra-red telescope in Antarctica to provide remote-control capability over the Internet from Australia.

Since graduating Paul stayed in the telecommunications industry, holding a number of telecommunications and Internet engineering roles. Sometimes described as a "Serial CTO", Paul's

⁶ <http://www.abs.gov.au/ausstats/abs@.nsf/Lookup/2901.0Chapter38202011>

expertise in telecommunications network design, planning and operation stems from extensive hands-on experience in Broadband Access and large-scale data networking. Paul now runs his own consultancy practice, providing leaderships and technical expertise to service providers, regulators and enterprises in Australia, New Zealand, and several other countries. He played a significant role leading the telecommunications industry engagement and designs for the National Broadband Network, and designing the first non-Telstra subsea optic-fibre cable from Victoria into Tasmania. Paul is on the Board of the Internet Society of Australia, providing technical expertise in policy debates such as ISP data retention and content filtering.

Returning to his astronomy background, Paul is also on the Board of the Interplanetary Networking Group, working with groups such as NASA and JPL to redesign Internet communications protocols to cope with the long time delays and intermittent nature of interplanetary communications.

Paul states: "*Several factors combined to facilitate my career in telecommunications:*

My astrophysics work involved a great deal of hands-on electronics and software development, as well as deep familiarity with the emerging Internet, moving large image files around between the lab and the observatory. Astronomers and other scientists needs for moving bulk datasets around to and from remote locations played a significant role in the development and expansion of the early Internet for research purposes, and this background provided a ready experience for interviewing at telecommunications companies. Also astronomy postgraduates and researchers learn a great deal about the properties and propagation characteristics of light and radio waves, and the future of telecommunications is with fibre-optics and wireless technologies.

The rigour and experience of constructing scientific papers and funding proposals are exactly the same skills required to put up robust business cases, and I have found the commercial world values the ability to put forward a logical business case, policy paper or legal expert witness report constructed with a clear sequence of conclusions, building on known facts. The disciplines of thinking and investigating problems in a scientific manner, establishing facts and drawing well-reasoned and difficult-to-refute conclusions are rare and highly valued in the business world, as is the experience in evaluating information sources and keeping up-to-date with the field.

A post-graduate student workload includes the experiences of presenting work to small and large audiences of peers, examiners and senior luminaries in the field, as well as a teaching component conducting lectures and tutorials for under-graduate classes. This experience of public speaking and fronting a lecture hall has been invaluable when presenting a project to a boardroom, and appearing confident and relaxed speaking at a large industry conference.

A PhD in any science has exotic appeal to the business world where scientific qualifications are rare, and in my experience brings with it a level of automatic respect for demonstrated capability, opening doors to conversations with senior figures and opportunities to become involved in projects that might not have otherwise opened up. The Astronomy and Astrophysics fields in particular captures the public imagination like few other sciences. These combine to help a holder of an astrophysics PhD stand out from the crowd of other candidates with similar professional experiences."

Chris Wilkinson PhD, Patent Attorney

Chris is a patent attorney whose focus on the ICT and engineering sectors requires a blend of technical and legal skill. Chris became a patent attorney after following an unusually diverse scientific career. He studied physics and applied mathematics at the University of Adelaide and obtained a Bachelor of Science with honours in experimental physics. As an undergraduate he also picked up vacation scholarships with the CSIRO in their radio astronomy division, and in the lens

design group with a lens manufacturer. He then did a PhD in experimental astrophysics at University of Adelaide, helping to build and calibrate an accurate timing system for a cosmic ray detector located in the Utah desert. Chris' PhD involved a combination of hardware, software and data analysis skills that proved to be highly transferable to other disciplines.

After completing his PhD, he took a job with the Defence Science and Technology Organisation working as a researcher in explosive blast effects, before switching fields to work as a bioinformatician to assist biologists to understand the genetic basis for diseases and cell development. This role involved designing experiments using high throughput gene analysis platforms that can study tens of thousands of genes at once, and analysing the results to try and make sense of the complex biological systems being studied.

After working as a researcher for 8 years, Chris left the coal face of scientific research to become a patent attorney. "This job allows me to maintain a strong connection with science and engineering, with the legal side of it providing intellectual challenges and requiring creativity in order to maximise protection for new inventions. A science career can lead you anywhere, but sometimes that is out of necessity rather than design or choice. As a patent attorney, I am valued by clients for my ability to talk to them technically and provide them with the IP advice and assistance they need. One of the reasons I originally chose a scientific career was to find out new knowledge and to help people, and ultimately that is what I'm still doing."

Wilfred Walsh, PhD, Company Founder of Biosphere Capital

Wilfred Walsh is the company founder of Biosphere Capital, an international advisory and trading company in the areas of clean and renewable energy, specialising in emissions reduction technologies and finance.

Wilfred has both extensive business and academic experience. He is an experimental astrophysicist, physicist, and university educator with over 20 year's research, management and university course development and teaching experience. His early research focussed on studies of galaxies to investigate star formation, dark matter and dark energy, and he completed his PhD in Astrophysics from CSIRO and UNSW in 1993. He has worked on astrophysics technology research at CSIRO Australia, Max-Planck Gesellschaft, Germany and Harvard University, USA, specializing in radio detectors and installations in Antarctica, where he spent the 2002 winter stationed at Amundsen Scott South Pole Station doing astrophysics, site testing and atmospheric research using a prototype sub-mm wave radio telescope.

Since 2006, he has worked in the renewable energy sector as a business owner, as well as a researcher and a university educator. He currently leads a Solar Potential and Energy Meteorology group at the National University of Singapore, and he is the Managing Director for Biosphere Capital Pte Ltd, that he founded in 2007 to provide technical and financial consultancy services to the renewable energy industry. He is also a founding Director of Zansara Pte Ltd, a startup company that aims to develop and promote novel mosquito control technologies. Wilfred has also been a partner of HCI Pty Ltd, a Sydney technology consultancy and has acted as an adviser to the Australian government on research policy.