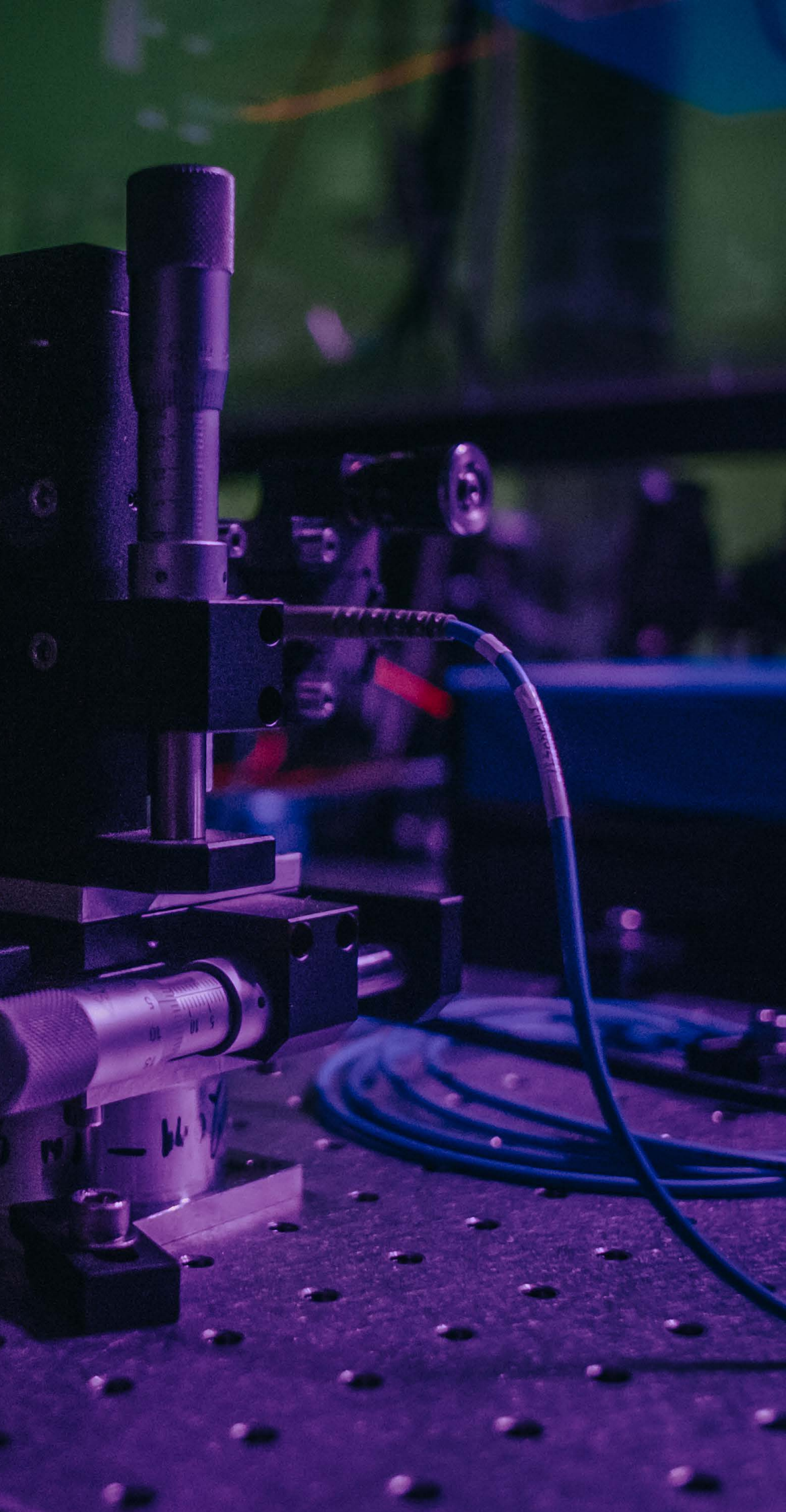


QUANTUM IN
AUSTRALIA

ISLAND PHYSICS REPORT





SUPPORTING A QUANTUM INDUSTRY IN AUSTRALIA

Australian quantum science researchers and industry representatives met for a four day conference in August 2018 on Magnetic Island to lay out the future of Australia's emerging quantum industry.

The conference was led by the ARC Centre of Excellence for Engineered Quantum Systems and sponsored by the ARC Centre of Excellence for Future Low-Energy Electronic Technology, ARC Centre of Excellence for Exciton Science, and the legacy ARC Centre of Excellence for Quantum-Atom Optics. The goals of the conference were to provide an overview of current quantum science research, strengthen relationships between industry and researchers, and lay out the future of quantum industry in Australia.

Conference participants discussed three key themes in relation to the establishment of a quantum industry in Australia. The themes were:

- Quantum science applications
- Potential for collaboration with industry sectors
- Emerging workforce needs

The purpose of this report is to document participant discussions and highlight insights from the conference. This is done with the intention of continuing a dialogue with stakeholders with the ultimate goal of building a robust quantum industry for Australia.

In many ways, this discussion was well-timed as Australian research in quantum continues to go from strength to strength. Highlights from the past years or so include our 2018 Australian of the Year - quantum physicist Professor Michelle Simmons, who leads one of four ARC research Centres of Excellence in the quantum arena. In the same period,

Sydney universities have been working together to establish an academy for a new generation of quantum engineers, and quantum-based start-up companies have begun to emerge.

Through presentations and panel discussions, participants were asked to identify opportunities for researchers and industry to work together to advance blue sky research and technological applications for quantum science. They also highlighted the challenges influencing these collaborations and the emerging quantum industry. To motivate the discussion, invited industry representatives were asked to address the question:

“How do we turn a \$100 million investment into a \$10 billion dollar industry?”

The detailed terms of this question were deliberately left undefined, to emerge from the discussion.

Front cover
Quantum Technology
Lab. Image by Patrick
Self

Left
Bose-Einstein
Condensate Lab. Image
by Patrick Self

Industry in Australia

In the 2016 Australian Industry Report¹, Chief Economist Mark Cully remarked that maintaining Australia's competitiveness internationally requires "constant vigilance on the part of all players—industry, government, education providers, and the science and research community". In this report, competitiveness is referred to as a dynamic concept, one which goes beyond simply maintaining performance levels. Instead, competitiveness requires continuous improvement on the firm, sectoral, and national level².

Healthy competition drives innovation, which creates new products and new ways of producing those products. This innovation benefits the economy and the competitiveness of Australian business³. Ways to measure innovation in this way include identifying businesses engaging in innovation and businesses collaborating on innovation. Small businesses account for majority of active private businesses in Australia⁴. They represent a significant portion of employment and, according to the Reserve Bank of Australia, their direct contribution to the nation's economy is substantial. In 2011, the proportion of Australian SMEs engaging in innovative activity was higher than the same cohort across the OECD. Meanwhile, Australian large enterprises are also considered innovative. Generally, Australia is good at incorporating new-to-business innovations, but poor at introducing new-to-market innovations⁵.

Businesses that collaborate on innovation are more likely to increase productivity and profitability and introduce more novel innovations. Despite this, Australia SMEs perform less well with regards to collaboration when compared to their peers in the United Kingdom and Japan. Our large firms do better, but the degree of collaboration between Australian businesses and universities and non-commercial research institutions was still among the lowest in the OECD in 2011⁵.

To tackle the challenges Australia faces in innovation, six Industry Growth Centres have been established by the Australian Government. The Industry Growth Centres are not-for-profit organisations led by industry experts that are designed to help industry sectors build stronger futures. The centres look at: advanced manufacturing, food and agribusiness, medical technologies and pharmaceuticals, mining equipment, technology, and services, oil, gas, and energy resources, and cyber security. These focus areas represent opportunities for the emerging quantum industry in Australia as quantum-based technologies have multiple potential applications, including health, mining, computing, and navigation.

The need to investigate opportunities for Australia in this emerging market is compounded by potential value of the sector. Globally, estimates suggest that quantum technologies could become comparable in size to the consumer electronics sector⁶.

1. Australian Government - Office of the Chief Economist, (2016), 2016 Australian Industry Report, see: publications.industry.gov.au/publications/australianindustryreport2016/index.html
2. OECD indicators 1992
3. Australian Government - Department of Industry, Innovation and Science, (2014), Australian Innovation System Report 2014, Canberra, p. 1
4. Nicholls, S., Orsmond, D., (2015) The Economic Trends, Challenges, and Behaviour of Small Businesses in Australia, Reserve Bank of Australia, see: www.rba.gov.au/publications/confs/2015/nicholls-orsmond.html
5. Science, Technology and Industry Scoreboard , (2015), Businesses engaging in innovation data sourced from OECD
6. UK Parliamentary Office of Science and Technology, (2017), Quantum Technologies, Number 552

Quantum science

Quantum science applications

The question of how to create a sustainable quantum industry in Australia was central to discussion during the conference.

Researchers and industry participants alike drew attention to the differences between commercialisation of technology and demonstrating concepts in the lab. Despite the challenge of bridging this gap between research and commercialisation, the consensus of conference participants was that increased emphasis on research translation at Australian universities allowed for increased collaboration between researchers and industry.

One of the obstacles to this collaboration was the nature of research funding and the difficulty of ascertaining that technology would be delivered within the life span of academic grants. For the conference participants, this meant researchers must

think more broadly about how they apply their skills to quantum technologies.

The initial areas identified for research translation in quantum were: imaging, sensing, cybersecurity, and clock synchronisation. These priority areas build on current projects that already use the properties of quantum physics to enhance technology. The Sapphire Clock project, led by Professor Andre Luiten, is one example. This clock is incredibly precise - it gains or loses just one second over 40 million years - and has been rolled out in our national defence systems. Meanwhile, in cybersecurity QutescenceLabs - the oldest quantum company in Australia - is a global player in quantum random number generation and quantum key distribution.

Below
At the University of Sydney, EQUUS researchers in Professor David Reilly's team are improving MRIs



Support for collaboration

Potential collaboration with industry sectors

Collaborating with research organisations was considered by the industry participants to be an opportunity to inject new thinking, new ideas, and new technologies. They also believed they would gain a broader view of the new and emerging technology while still delivering on end-of-year goals.

In October 2018, Scott Wilkie of sovereign cloud infrastructure provider Australian Cloud told researchers at the STA Science meets Business conference that Silicon Valley has three steps for new projects: idea, manifestation, and the minimal viable product. "If you take more than six months," he said, "you've lost your opportunity." In a similar sense, SMEs participants at Island Physics were looking for ideas that would "fail quickly". They argued that businesses needed projects that would either succeed or fail fast.

One obstacle to collaboration between industry and academia was centred around language barriers. Assumptions were considered to be rife in both groups around what research was relevant for industry and what research scientists should be conducting. To prevent this guesswork and enhance the ability of the two groups to collaborate, participants suggested that a forum should be established in Australia to provide a space for industry to outline the challenges they face and allow researchers to suggest relevant research-based solutions.

Another challenge for collaboration was the management of Intellectual Property (IP) and the transition between research, application, and commercial product. IP agreements need to be clearly outlined before forums and collaborations take place.

Below Industry attendees at Island Physics included: Dr Vikram Sharma of QutenessenceLabs, Dr Maja Cassidy of Microsoft, and Professor Jared Cole of RMIT and H-Bar Quantum Consultants



Workforce needs and next steps

Emerging workforce needs

Australian-trained postgraduates in quantum physics are placed domestically and internationally within research institutions, industry, and policy. They form a vital part of the future quantum workforce.

The move of quantum technologies from research into commercial products will require a new generation of quantum engineers – with knowledge of physics, engineering, computer science, and more. The work readiness of our postgraduate students and their links with industry are important to the evolution of the quantum industry within Australia. Attendees identified the need for students to learn additional business skills as a potential problem for students in the Australian system, which is bound by strict timelines for competition. The CSIRO Industry PhD program is one viable model for training the workforce of our new quantum industry.

Similar concerns around workforce development were noted in the initial discussions for the Canadian national quantum strategy. Researchers noted that training and recruiting highly qualified personnel was essential, and that obstacles – including work permits and student visas – were burdensome. Australia may be able to learn from the subsequent work done by Canada to support the cultivation and recruitment of talent for the emerging quantum industry.

An opportunity was identified for Australian universities to provide graduate level qualifications for domestic and international students to prepare for quantum-enabled industries. The University of Queensland and Macquarie University are already actively exploring this potential market with near-term programs under development.

Next steps

Australia has a decades long track record of supporting quantum research in our universities. Now, with increasing investment from industry, we will start to see new quantum-based technologies emerge from that research on the world stage.

To ensure Australian businesses are ready for the quantum age, we must build a dialogue between the quantum research community and industry and government partners in order to identify areas where quantum science can solve industry problems. Those problems might include new ways to tackle encryption or the use of quantum sensors for agriculture and mining.



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