Australian Government

Chief Scientist

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AUSTRALIAN INSTITUTE OF PHYSICS CONGRESS DINNER

An Ode to Australian Physics

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I was asked to talk about the role of physics in innovation. But I figured that by tonight you might want something a bit lighter. So I thought being the Australian Institute of Physics (AIP) Congress, I would present an “Ode to Australian Physics and the AIP”.

But first, I want to begin by acknowledging the Kaurna people, the traditional owners of the lands on which we are meeting today.

I acknowledge the elders who are caring for those lands. I pay my respects to the old ones who have come before and the young ones who will follow.

Our First Nations people have a long history over many thousands of years, creating and developing their science and knowledge systems. We have much to learn from them, and I look forward to engaging with our First Nations people in the coming year as I lead the revitalisation of the science priorities for the country. This task includes seeking to create links between their systems and the systems that I have been used to working in.

So it seems a bit insignificant that I use this after-dinner speech to consider my 50 plus years in physics, and how physics in Australia has evolved in that time.

I first fell in love with physics when I turned on our black-and-white TV to the University of Sydney’s ‘Summer School of Science’ program aired during the summer holidays. Headlined by Professors Harry Messel and Julius Sumner Miller, I remember it showing the most amazing experiments and new ways of understanding the world around us. That was in the late 1960’s.

They taught me to ask the question, “Why is it so?”

I even had the opportunity to be on Professor Sumner Miller’s TV show! This was in about 1973 – and in another three weeks, that will have been 50 years ago.

In the first episode I was a star performer; in my second appearance, I messed up big time. Thus ended my TV career.

But it didn’t dampen my love for physics! It continued to be my passion when I went on to year 11 in high school, inspired by the Harvard course for project physics.

By the time I went to university in 1976, Australia's place in university physics was still considered to be pretty basic. But that was only by those without the insight to look deeper.

Australia has a long and proud history in many aspects of fundamental physics, and we need to acknowledge it with pride.

Earlier this year, I was delighted to hear a talk by Klaus Von Klitzing (who won the Nobel Prize in 1985) at the International Conference of Semiconductors, held in Sydney's Darling Harbour. He talked about Australia's involvement in the development of physical measurement standards, which was part of the division I worked in during my career at the CSIRO.

This part of CSIRO later became the National Measurement Institute.

And it's only one example of many. Consider Australia's outstanding contributions to:

- Brownian motion by William Sutherland, who published his paper on the topic a year before Einstein;
- Radio astronomy post WW2 with Ruby Payne-Scott;
- Textile physics that created new ways of handling fibres like wool by Rachel Makinson;
- Tony Klein and Geoff Opat in nuclear optics;
- Brian Schmidt, who found that the expansion of the universe is accelerating; and
- Loads of physical standards, like the absolute volt by Graeme Sloggett or the calculable capacitor by Mel Thompson.

Those last metrology standards are critical for physical trade and trade measurement, which is the basis of our ability to have fair trade across countries. It's a great example of where fundamental science quickly translates into something both immediately useful, and eventually essential, to our way of life.

So tonight, I want to look at how physics has changed in Australia over my 50 years of being in love with this discipline of science.

When I was doing my physics PhD, the general idea was that when a good scientist did an experiment, they built their equipment, made a measurement, worked out

what the measurements meant by doing some theoretical modelling, and then published a paper. End of story, and then start the cycle all over again.

The idea that physics research could be something that had tangible impact on the world was an anathema to me.

For many years I heard discussions asking, ‘what is the industry proposition for physics in Australia?’

When I became the President of the Australian Institute of Physics in 2007, we struggled with a couple of things stemming from this viewpoint.

A key issue was that we were trying to grow participation in physics and the AIP. I started by approaching the people with whom I studied and knew were no longer working as bench physicists; those who were now working in the broader sector, including government and industry.

Each person I approached professed failure – elaborating that they didn’t want to join the AIP because it was just a reminder that they failed as a physicist. Not because they weren’t still using those skills, but because they were no longer in research.

But imagine the wastage of human potential if we assume the only winning outcome for a physics student is to become a professor! We know that for physics and astronomy graduates in Australia, less than 10% will go on to work as a university tutor or lecturer. It made me wonder if the remaining 90% of those graduates thought they were failures? No wonder we were losing physicists!

I am extremely pleased that over the last 50 years we have come to the realisation that physics has a role everywhere. That physicists have roles everywhere – within academia, research agencies, government, industry and beyond. And we need to celebrate that.

Another issue we faced was that at the time I finished my PhD, the idea of commercialising physics research in Australia was not considered at all. Who would be interested in fundamental work on an esoteric material called indium nitride? That was my PhD topic.

Well, a Japanese research team was. They won a Nobel Prize for it in 2014. And now everyone who uses LED lights benefits from that commercialisation.

Now we know that physics is essential to addressing the major challenges facing our planet. Maybe it's developing new mineral processing methods to reduce their environmental footprint. Or perhaps it's looking at how we can commercialise new solar cells that operate at night. Maybe it's new ways of separating water for hydrogen and oxygen using solar power, or developing quantum information sensors. The list goes on!

And throughout this transition from the lab bench to the community, the Australian physics community has been fantastic at first identifying an opportunity, and then coming together to seek funding and support.

Think of radio astronomy. Australia has a long history of being involved in radio astronomy, right from when pioneers such as Ruby Payne-Scott thought it would be great to take the radar developed through World War II and see what radio signals we got from stars. Last week, we saw the start of construction on the first part of the Square Kilometre Array Low in Western Australia - a massive Australian and international project looking to the edges of the universe. The site has been christened *Inyarrimanha Ilgari Bundara* – an indigenous name meeting 'Sharing the Sky and Stars'.

Another area where we have huge potential is quantum physics. Back in the early 2000s, Bob Clark and Gerard Milburne pulled together a community of quantum physicists and set an ambition to create a quantum computer here in Australia, as part of a whole quantum capability.

Over the 23 years that followed, we saw 2500 PhD students trained, and 14 centres of excellence being supported. The rest of the world is looking at Australia's quantum science and research sector with envious eyes. Not only that, what we're seeing is the beginning of an industry.

I've seen quantum researchers transition from seeing their jobs as creating papers and teaching students, to something more commercially focussed. I'm seeing people

taking a risk and starting up businesses to commercialise some of the things they've created.

We are seeing a supply chain and quantum ecosystem come together - from things like error correction, through to things like Liquid Instruments creating electronics systems, Redback for optical sensing systems, through to making optical clocks by QuantX and high strength magnetic fields by Elemental Instruments. Eventually there are aspirations to reach the quantum holy grail - the full stack of error corrected quantum computers.

This is extraordinarily fantastic to see, and it's wonderful to have the Australian Government supporting this industry too. It really shows the power of our community, and demonstrates that when we get ourselves organised and focused, we can achieve amazing things.

Another impressive thing that we're doing is the way we're going about adapting our field to the changing world around us.

When I attended my first major AIP meeting back in 1981, I recall that Neville Fletcher gave quite a memorable speech. During his address he referred to an old Rutherford quote: "All the science is either physics or stamp collecting".

I think we've moved away from that idea - that physics is at the top of the tree and everything else is just a pathway to applying it - and I think we're much better for it. Now, physics is part of many interdisciplinary projects working across boundaries to make new discoveries and new impact. Quantum Biology is an example.

I also want to highlight the need to be patient, persistent and trust the theory. Einstein's theory of gravitational waves took 100 years to be proven; this month, fusion energy has finally been demonstrated after being promised as being '10 years away' for about the last 30 years. Quantum computing is the next one we need to wait for. Never underestimate committed physicists working together! As I say often, if it is not against the laws of physics everything is possible.

But while all this is fantastic for the field of physics it must be daunting for an early career researcher, who feels that the expectation is to do it all – to have a major

breakthrough in their research, to invent something, to win a Nobel prize, and of course, to start up a company.

But the path is not meant to be linear. We need diverse people with different interests and skills at each stage of the process; from discovery to research translation. Even for those rare unicorns who do achieve the full spectrum – they don't do it all at the same time!

What we do need everyone to do, is to undertake their work with the highest integrity – showing behaviours that the wider community can trust. We need to have the highest research quality by making sure we measure what we think we are measuring, use the best equipment, the right statistics, and partner with the right people. If we have those settings right, then excellence will flow - which we measure for the individual, then the team, then the institution, and then aggregate for the country! No pressure.

This is particularly important given the role physics has to play in securing our economic future.

You would have seen the newspaper articles about Australia's economy's complexity being on par with Oman, ranking in the low 70s as determined by the Harvard index. In many ways, it's understandable - we are a country that has prospered for decides because of our mining industry. It is very sophisticated, highly automated. But as we move to a circular economy, this industry may not be able to carry us post 2050 in the same way. We currently have about 1-2% of businesses creating new-to-the-world products for the export market. Innovation is low in industry.

Australia needs to transition to be a knowledge-based economy. Physics is at the centre of this transition – space, hydrogen, quantum, defence industries to name a few.

We also need to embrace and support our full human potential if we are to deliver this. Physics has always had low female participation. To increase numbers, an easy win would be simply supporting women in the field.

You have no doubt heard of the leaky pipeline. I have seen multiple women at events and conferences who then later seem to disappear. I still wonder how I managed to stay – it's not often you hear of a 7-month pregnant woman getting an indefinite position – but this happened to me after 5 years of postdocing.

Once I had my first child, I had to build a childcare centre as there were none, then after school care. There were times when my childcare fees outweighed my income. **This needs to change**. Childcare **is** better these days, but it's patchy – there are areas where there is a glut and others where there is a drought. And the cost is a perennial issue.

Early in my career, I used to regularly attend the conferences in Wagga Wagga. But when I had kids, I stopped. Firstly, it was hard to leave multiple children to attend a conference. And secondly, the Wagga conferences were religiously held in the first week of the school year, undoubtedly one of the most inconvenient times for a parent of young children to travel. I remember complaining about this 30 years ago. I am glad to see that all these decades later, it has finally been moved to address that concern. But how many other barriers are there that we need to remove?

I'd also like to take this opportunity to acknowledge Marion Stevens Kalceff. Years ago, she wrote a paper mapping out the different career pathways for women and men. I suggest you look it up. It is an eye opener.

I am also pleased that Minister Husic has a review underway looking at the issues for women in STEM. I envisage that some of the work that I am doing on research metrics will help to identify ways to measure, acknowledge and reward, the overlooked parts of the research system that make it all work.

Finally, I want to finish off with the importance of the AIP and conferences such as this in building your career. I would not be here today without it.

My involvement with AIP over the years has taught me many skills that have held me in good stead for senior roles. I met collaborators, mentors and sponsors, and had opportunities to hone my political nous. Being part of this community has been a major contribution to my career.

The business of science and physics is dependent on volunteerism and collective action. Don’t forget that the science sector relies on people to volunteer to organise a conference, edit journals, do the peer review. So those of you who are early career researchers, realise you might be sitting next to the person who will review your grant or paper; or be the one to collaborate with and offer you a job. So be sure to say hello to your neighbour!

I am proud of physics in Australia. Over the decades that I have been a physicist, I have seen a community that has matured, and a discipline that has delivered exceptional science outcomes – from involvement in big international projects such as LIGO, CERN and SKA, through to leading research in quantum. We have shown what is possible when we collaborate and work together. I have seen real support for women, diversity, and inclusion, not just lip service. I have seen a discipline move from thinking that its role is to just do science, to creating new industries for Australia. I have seen researchers win a Nobel Prize and others spin out companies that have taken on the world.

I hope you can see why I love Australian physics and why I am so immensely proud of our community.

Thank you very much.