Australian Government
Chief Scientist

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WORLD QUANTUM CONGRESS

Making a little magic: Building demand for quantum

Thursday 27 September 2023

Washington DC, United States of America

Technology has a funny habit of surprising us.

When I spoke with you here at this event last year, the date was November 30. That was the date Chat GPT was launched.

We've all understood the transformative potential of AI for many years. We've developed artificial intelligence, thought carefully about its applications and about its implications.

And yet Chat GPT was something of a surprise. None of us predicted that within a few short months of that November launch, ChatGPT would become what we in Australia call a barbecue stopper. Even my 86-year-old step-mum who has zero interest in digital technologies asked me whether she needed to pay attention.

This is how advances in science and technology seem to work. We work for decades on the theory or in the lab. We let loose on science fiction. We test applications and make predictions about the real-world impacts. And then, what seems like all of a sudden, along comes an application that sweeps the world with head-spinning speed.

We're living this phenomenon in quantum now, as the decades of fundamental work in science start to be realised across applications such as sensing and navigation, logistics and encryption.

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Quantum has been part of my working life since I was in my early 30s working on high-temperature superconducting devices.

It was a year ago when I stood here and told you about Australia's deep history of research and expertise in quantum technologies, which stretches all the way back before my involvement – to 1959 when Richard Twiss and Alex Little published the first paper on time-correlated photons.

Last year, I told you about the many Centres of Excellence that we've established in Australia over the past two decades, that have built up our quantum ecosystem. These centres are designed to build larger groups and relationships across the system, and concentrate effort in particular areas.

We've had Centres of Excellence on quantum computing, optics, low-energy electronics, gravitational waves and advanced molecular imaging.

Three quantum-specific centres are operating at the moment.

- The Centre for Quantum Computation and Communication Technology is working to realise quantum processors, in silicon, optical and hybrid platforms.
- The Centre for Engineered Quantum Systems is working at the interface of basic physics and engineering, alongside industry partners to develop discrete quantum devices and systems.
- The brand new Centre for Quantum Biotechnology is working on technologies such as portable brain imagers and super-fast single-protein sensors, and exploring questions such as how higher brain function emerges from networks of neurons.

These and the other Centres of Excellence are powerful ways to advance research.

They have attracted researchers to Australia and through them, we have built deep expertise and international collaborations.

Along with our national science agency, CSIRO, which is investing heavily in quantum at the moment, they have helped give rise to a healthy system of quantum start-ups and companies, linked closely with the research sector.

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What this means for those of you from North America or other parts of the world is that if you turn your eyes to Australia, you will find expertise across the quantum landscape.

We have world-leading applications in sensing. For example:

- Nomad Atomics is developing field sensors based on cold atoms for navigation, and to find deposits of the minerals that we need for the energy transition.
- Q-Ctrl and Advanced Navigation are working on quantum assured GPS-denied navigation, including at sea and in airborne applications. QuantX is also working in this area.
- Advanced Navigation combines artificial intelligence and precision robotics with inertial navigation for autonomous systems to operate in extreme environments.

We have world-leading applications in computing.

Diraq is working on silicon quantum dots, and Silicon Quantum Computing is developing atomic-scale integrated circuits.

- Q-CTRL provides quantum infrastructure software for performance management on quantum computers. IBM announced in May that this software would be available natively on their cloud quantum computers later this year.
- Quantum Brilliance is developing diamond-based room-temperature quantum computing systems and has worked with our national supercomputing research centre, the Pawsey Centre in Western Australia, to demonstrate applications and integration with high performance computing. In 2022, Quantum Brilliance installed world-first diamond-based quantum hardware at Pawsey – and has been running algorithms on the room temperature accelerator, to demonstrate the potential for quantum accelerators in classical computing.
- Analog Quantum Circuits is developing fabrication processes to integrate amplifiers, attenuators, circulators, and other components "on-chip", so future generations of quantum technologies can scale.

We lead the way in quantum simulation, whether it’s photonic, silicon-based or ion-trapped.

And we have one of the top international firms in cyber security. QuintessenceLabs offers quantum key generation, crypto-agile key management and quantum key distribution, and helps organisations build secure systems premises, in the cloud, or in hybrid IT ecosystems. Its products are used in North America, the UK, the European Union and the Asia Pacific.

The companies I've mentioned, and I've named just a few, are top of their game in research, working with our universities and government research agencies to solve some of the difficult remaining problems. At the same time, they have an enormously entrepreneurial approach – aimed at developing real-world applications.

It adds up to a super-active ecosystem built steadily over the past two decades – and on steroids over the past three years.

And it means that we have an excellent offering to the international community.

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One of the strengths of how we do things in Australia is that we're outward-looking. Our researchers are excellent collaborators; our research system is known for its open and outward focus. This is partly a necessity; we're a small population with a smallish domestic market. The flow of people and commodities in and out is just part of our DNA.

I'm sure the audience here knows this already because some of our quantum intellectual firepower is based here in North America. This includes the founders and leaders of companies like IBM, PsiQuantum and Xanadu.

The Wiggles are ours, too! Keep that in mind.

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I've also been pleased to see the flow of investment inward to Australia. Companies including IBM, AWS, Google, Infleqtion, Microsoft and Rigetti are all looking our way.

For example, the University of Melbourne has partnered with IBM establish an IBM Quantum Hub which gives access to state-of-the-art quantum computing. The hub is researching a range of problems in practical quantum computing – everything from machine learning to materials, transport-optimisation problems, and quantum chemistry.

Infleqtion is establishing its Australian headquarters in Melbourne, in partnership with Swinburne University of Technology – and partnering widely across the country.

They're focussed on sovereign prototyping and manufacturing capability, leveraging existing world class research excellence in photonics and atomic vapour quantum technologies in Victoria. They're working to identify and validate future use cases to solve commercially relevant problems in quantum computation. And their software business is developing security protocols for quantum cloud computing with support from the Australian Army.

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These international organisations are looking to Australia, not because of Bondi Vet, or let's be honest, our absolutely stunning environment and fairly nice personalities.

They're interested in us because we have what they need:

- A rapidly growing ecosystem with impactful businesses.
- Geopolitical stability, strong regulation and high standards.

- A friendly, barrier-free market. A sector happy to co-work with businesses in the US and to co-invest.
- World-class research. Top experts working on applications that will change the world, whether in medicine, defence, mapping, computing, or cryptography. Even sport!
- And a nation that gets quantum, that has real ambition in this space.

I'm selling it – but it's an easy sell. I've morphed into the travelling salesman!

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I want to turn now to our National Quantum Strategy and some of the things I've been doing as Australia's Chief Scientist to advance the vision that all of us in this room share.

The Australian Government adopted a National Quantum Strategy in May. It has five themes:

1. Thriving research and development, and investment – because we need to keep funding discovery at the same time as we bring applications forward.
2. Access to essential infrastructure and materials, because we must make sure that Australian-based researchers have access to the best capability.
3. Growing the quantum workforce, because critical mass doesn't just apply to markets – it's also how you ignite ideas and solve problems.
4. Standards and frameworks that support Australia's national interests and recognise the importance of being part of an interoperable global effort.
5. A trusted, ethical and inclusive quantum ecosystem. Because we must have the social licence to progress quantum as part of our every day.

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Our approach in Australia is strategic.

We're focused on is playing to our strengths and ensuring that we build on synergies with other parts of our economy and on our national priorities.

We have a unique physical environment, 65,000 years of knowledge held by the Aboriginal and Torres Strait Islander peoples, and our location in the Asia-Pacific.

We have strengths in biotechnology and heath research.

We have strengths in agriculture and in transport.

We have strengths in mining.

We will achieve the best outcomes in Australia by taking a systems approach – considering these natural endowments and special capabilities, not as separate pursuits, but as interconnected strengths that have synergies.

To my mind, our quantum ambition is closely tied to these sectors: Renewable technologies including minerals extraction; health and medical technologies; and the supply chains for components such as those in semiconductor manufacturing.

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Because we are home to some of the world's biggest deposits of critical minerals for the energy transition, I anticipate we will lead the world in non-GPS navigation in underground and deep-walled mines, where there's a clear use-case.

But our ambition is not simply to mine critical minerals – to dig and ship. Our ambition is to process them up the value chain so we can occupy a new niche in the supply chains for high-tech manufacturing.

As well as materials for the energy transition, we're focused on pharmaceuticals and RNA technologies, and electronics and semiconductors.

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Semiconductors, photonics and quantum are part of a trifecta that has the potential to provide the acceleration that we need. We have a number of advanced manufacturing initiatives in aspects of semiconductor and photonics devices. Australia has a largely hidden but highly integrated photonics industry, worth some billions to our economy.

I referred already to the work that Infleqtion is doing here in manufacturing capability. Silex is another example. They're using laser technology to purify silicon for quantum microprocessors.

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This also means, of course, that our quantum effort is part and parcel of our global partnerships.

The US is central. We have the AUKUS arrangement with the US and the UK, and the Quad partnership with the US, Japan and India.

I co-chair the Quad Investor Network Centre of Excellence in Quantum Information Sciences with the four nations. I was pleased to have the opportunity to meet with the co-chair from India, Professor Ajay Sood on a visit to Gandhinagar for a meeting of the G20 chief scientists a few weeks ago. I had the pleasure of speaking with the co-chair from Japan, Professor Hiroaki Aihara, virtually on 1 September. And I look forward to meeting my US co-chair here in Washington.

This network is about building quantum supply chains and industry connections between the four countries.

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The other side of the equation for me is to build demand in the domestic economy – to make sure industries that will be impacted by quantum and can benefit from quantum, start leaning into this future. That's where I can add value.

To this end, I have my own speed-dating project! My version of quantum speed dating is introducing different sectors in the economy to the matching experts in quantum. Putting them in a room together and seeing if we can't make a little magic.

First cab off the rank was the sports sector. In August, quantum scientists, sporting executives, managers and athletes spent the day together in Canberra at the Australian Institute of Sport where we explored the possibilities that quantum offers – everything from

on-field screening of injuries, to time-keeping and predictive technologies, to sports integrity.

Those of us in the research world spend a lot of time thinking about where the science might take us. So it was fantastic to spend time on really practical possibilities.

As you're probably aware, nothing ranks above sport for us in Australia. So, if we can get the sports sector thinking about quantum, we've effectively got the ear of the entire nation.

I sometimes think Nick Kyrgios operates in the quantum world: So intuitive! So unpredictable! Fabulous.

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I'm working on similar events with other industries.

Health is of course a big one. I'm also planning to engage the finance sector – as you know the data security risks are real and urgent in that sector.

Transport and logistics are obvious contenders for us. We're developing technologies for non-contact vehicle weighing, and for safe shipping of hydrogen.

Space and communications is another one. And of course, mining and mineral exploration and processing, as I've said.

My aim with these get-togethers is to open eyes and ears to the possibilities of quantum, and encourage sectors to look ahead, to invest, and to prepare for what's around the corner.

This is where we see our economic future in Australia, and of course we're working closely with our friends in the US.

I don't want to suggest we have this in the bag. I'm well aware of the enormous challenges ahead of us. Quantum computing is hungry for deep-tech infrastructure, precision machinery, and foundries at scale. This is a challenge for us, not only in Australia but in many parts of the world. Building superconducting foundries that can make millions of devices is a big jump in risk and bravery – and it has to be done at the right time for the market.

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But I'm an optimist.

First, because I know the power of science and the breakthrough power of knowledge, built on human imagination and ambition, and that endless curiosity and the self-belief that our species has in spades. I am constantly astounded and inspired by what we have achieved.

And it gives me confidence that we will achieve more unanticipated transformations in insight and capability, even in my lifetime. This belief in science as our superpower has driven my career.

Companies like the ones I've mentioned today – the ones many of you have glued your careers to – represent the investment of billions of dollars and years of work.

This is a reminder of what we can achieve when we bring excellent, painstaking science and marry it up with ambition, significant investment and a step-by-step determination to solve problems and test solutions.

The reality is that those of you investing in quantum are not investing in a pipedream. You're investing in an understanding that the promise of quantum is achievable. You know that if the physics is correct, then it becomes an engineering challenge.

Of course, there's some distance to go to get a full error-corrected quantum computer, but what's ahead of us is a series of technical, engineering challenges – very complex technical challenges, but ones that can be solved.

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The second reason I'm an optimist is because I have confidence in the human capacity to find the right path.

I know I'm on shakier ground with this one. And I'm as concerned as anyone about the social challenges that have accompanied the digital era, and the malign potential of digital advances in the wrong hands. I'm not a Pollyanna about these things.

But here we all are, in this room, a gathering of experts from many nations, focused on the right questions. We're doing what needs to be done: talking about the transformative potential of quantum technologies, but also foresighting the risks, and talking about the guardrails and ethical principles that will frame our digital future.

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I started my remarks today by talking about that fast-slow phenomenon that we know so well in science. Stephen Jay Gould called it punctuated equilibrium in his field of evolution. Well. Chat GPT punctured our equilibrium.

And it will be the same with quantum. Those of you in your 30s, perhaps doing a postdoc in quantum tech, probably remember the Tamagotchi as your first personal digital device, followed, depending on your parents, by an ipod. Your lifetimes are in step with the digital era and I would love to be alive in 50 years to watch that play out in the exponential fashion that we all anticipate.

The march of quantum, like the march of AI, has begun.

I'm sure that as I speak with you today, somewhere in the labs of the global quantum community, a moment of discovery is happening. None of us know where that might lead. We can't say for sure which advances will scale first, nor what applications might eventuate, some of which may be still unimagined.

But what we can do is continue to come together as a quantum community to maximise those moments of discovery. Bring them through to impact with as much urgency as we can – and keep our eyes on the long game, the purpose of all this activity: To advance an excellent set of transformative technologies for the good of the planet and society.

On that note, I feel that I shouldn't keep you away from the lab a moment longer!

Thank you.