Keynote Speech: The Special Relationship - Why PsiQuantum Came Home from the US

Speaker: Mark Thompson, Chief Technologist and Co-founder of PsiQuantum

MARK THOMPSON: My name is Mark Thompson, I'm chief technologist and co-founder of PsiQuantum and I'm going to tell you today the story of PsiQuantum. We are one of the world's largest privately-owned quantum computing companies. We were founded by four UK academics. We went to Silicon Valley, I'm going to tell you why we did that. I'm going to tell you why we came back to the UK. I'll tell you what the future holds.

PsiQuantum has been around now since about mid-2016, and we're headquartered in the heart of Silicon Valley, in Palo Alto. Over the eight or so years that we've been around, we've grown the company to around 300 people. We've raised well in excess now of $700 million and we're valued at over 3 billion.

The company was founded by four UK academics from the universities of Bristol and Imperial College. In my past life, I was a professor at the University of Bristol, along with my colleague Jeremy O'Brien, who set up a research group at Bristol. Ted Rudolf, professor at Imperial College, and Pete Schappert was the best researcher and PhD student that any of us had ever worked with.

The company was set up with one singular goal and mission. That goal and mission of the company was to build and deliver the world's first large scale, fault tolerant, error corrected quantum computer. And that scientific jargon in the middle, large scale, fault tolerant, error corrected, just means useful. We have to be very precise because there's a lot of noise out there in the world at the moment around quantum computers. What's useful, what's not useful. And so we have to be very clear about these terms so that people are clear that we're building something that will be large scale and that will outperform the world's most powerful supercomputers for problems that people really care about.

The idea of quantum computing was first intuitively understood by this rather charismatic physicist, Richard Feynman. I'm sure many of you probably know who he is, and he first kind of made that intuitive connection between physics and quantum and computing in the 1980s. It wasn't until about 13 years later on that Peter Shor from IBM really made the first quantum algorithm that could do something useful. And it was a code breaking algorithm. And he showed that if you could build a quantum computer large enough, you could crack all encryption codes. It's got a lot of people very excited and a lot of people also very worried. And that's when money really started to pour into the area of quantum computing.

Now, the idea of how quantum computing works, if you think about how a normal computer works, we represent information as our transistors being on or off, our information being ones or zeros. In quantum mechanics, we use this weird, almost magical property that things can be in multiple places at the same time. Our transistor can be on and off at the same time. We call it quantum superposition. Schrödinger described this as cat being dead and alive at the same time.

If you think that's weird, quantum entanglement is even more weird. In fact, Einstein called it spooky action at a distance. He didn't really believe this for many years. And in quantum entanglement, you can take two quantum particles, you can entangle them, and no matter how far apart you separate them, there's always a connection between these particles that we just can't explain with conventional Newtonian physics. So they're like a weird kind of magical property of quantum mechanics that we utilise in quantum computing to give an exponential increase in compute power, create compute systems that could massively outperform even the largest supercomputers.

Now, exponential power is a hard thing for humans to grasp and get their head around. So I have a small example here. This is Fugaku. This is the world's largest supercomputer. One of them. It costs about a billion dollars to build. It has about 7 million processor cores within it - 7 million laptop computers. And if you wanted to solve this - it solves many problems, some of the problems, it solves a simulation of molecular structures. And with all of the power of Fugaku, you can just about do a full simulation of my favourite molecule. This might be your favourite molecule too. This is caffeine. Okay, so if we take caffeine it has about 30 atoms. If you add one more atom to my caffeine molecule. So let's call it caffeine plus. If you want to now do a full simulation of that molecule, it now takes two supercomputers, so you double the size of the problem by adding just one atom.

If you look at something a little bit more complicated. This is a molecule that's used in the treatment of haematological cancer. It has, on order, about 100 atoms. Normally I do a poll and ask how many Fugaku supercomputers, but I don't have access to the web app. But to simulate this, it would take a thousand billion Fugaku supercomputers. It's insane, right? This is a problem that scales exponentially. It is forever out of our reach in being able to solve it. But a relatively small quantum computer can solve these sorts of problems really very efficiently. And so these are the kind of problems that we think quantum computers will be really useful for, and not just solving CAP-related problems, but across all of science and technology.

For PsiQuantum, we're particularly interested in the near term applications of quantum computing across energy, pharmaceutical security, transport, developing new types of materials for efficient solar cells, speeding up drug discovery, code breaking, crypto analysis, developing new types of fuel cells, new air, new types of improved batteries. These are the kind of things that we think quantum computers will really accelerate and effectively unlock a new door of technology innovation for humanity.

Now, of course, we're not the only quantum computing company out there. There are many, some of the really big names. There are Google, Amazon, Microsoft, Intel, IBM, and literally hundreds of small quantum computing startups, all vying to be the first company that can produce that really useful quantum computer. Now, what differentiates us as a company is that we have developed a light-based approach to quantum computing.

We developed that technology in the universities of Bristol and Imperial College. And with my colleague Jeremy O'Brien at Bristol, over about a ten year period, we set up a research activity at the University of Bristol, where we invented the integrated quantum photonic circuit, and we figured out how to use and manipulate light to do quantum computing. Our research group led to a group of about 100 researchers. It drew in over 70 million of funding across the UK and from Europe. And it really, at the time, was the world leading group in photonic based quantum computing.

The pinnacle, I think, of what we did there was we were able to develop one of the world's first two qubit quantum processors. It was the first processor to get online accessible. You could dial up in 2013 from your laptop to a two qubit quantum computer. And that chip now sits in the

British Science Museum, just a couple of miles west from here. So if you want to go and see one of our computers, it's sat next to a Babbage difference engine and an Enigma machine, something I'm actually very proud of.

But in academia, we pushed it as far as we possibly could. We didn't just develop the technology, we also built up the ecosystem. So at Bristol, we were the first to set up a PhD programme dedicated to the training of quantum engineers. Quantum engineers didn't even - the term didn't even exist in 2013. That was a whole new concept. And now that centre is in its 12th cohort. It's trained over 100 PhD students in this technology field. We also created the Quantum Technologies Enterprise Centre.

This was a centre that was set up specifically to take post doctoral researchers out of academia and into industries through an entrepreneurship route. We basically set up a mini MBA. We'd pay these postdoctoral researchers for a year, they would get trained in entrepreneurship, they would come with an idea that we would incubate with them, they would learn to pitch, they would learn to write business cases, and as a result of that, over 40, nearly 50 entrepreneurs went through this training course. It produced over a third of all the current UK quantum companies. Those companies raised in total 160 million and created over 360 jobs. So the return on investment of £5 million injection from EPSRC there is really quite stark.

And of course, this has all been backed by the UK programme in Quantum Technologies, the national programme in Quantum Technologies, which from 2013 to 2024, had a billion investment put into it that has just been renewed in March last year with a further 2.5 billion over the next ten years. This programme has been really instrumental in building a solid research base in the UK and enabling small and large numbers of startups to get formed.

Now, in around 2015, 2016, myself and my co-founders realised that in order to build a quantum computer, we weren't going to do that in academia. And we had to get out of academia and get into the real world and hire real engineers and put some real might behind this. And so we set our tasks of starting PsiQuantum, and we searched high and low for funding across UK, Europe and the US. And we got by far the biggest response and the most traction in the US. And so in 2016, we raised a 13 million round seed fund. And all founders packed up their bags, packed up their families, and we all moved to the west coast of the US and set the company up in the heart of Silicon Valley.

And the reasons that we did that were numerous. In part, the funding that we were getting was much larger than anything else that we'd been talking about with other investors. The talent pool in Silicon Valley really resonated with what we were trying to do as a company. And the culture of Silicon Valley really allowed us to move very fast.

We landed in this incubator called Playground. They were one of our investors. This is a hardware focused incubator. They only invest in hardware companies. They have a portfolio of about a billion of investments across many hardware related companies. And yes, in Playground, there was a playground, and they even had a fake tree in the middle of their lobby. But it was a very serious activity. They had workshops, technicians, a lot of mentorship and a lot of support to get companies like ours off the ground.

And so as a company, we've made incredible progress over the last eight years or so in Silicon Valley. We really focus on the semiconductor enablement of our technology, working within that ecosystem, developing the quantum microchips that can really scale. We've then also had leverage to semiconductor supply chain to then build assemblies, build out these packaged systems. We've then moved into the kind of cryogenic aspects of quantum computing, building out large scale cryogenic modules.

As a company, we're now moving into the scaling and infrastructure and facilitization of our technologies. And it's really this cryogenic module part with why we came back to the UK, why we focused on setting up an activity within the UK, because the UK has really specialist, unique cryogenic expertise. And we were very fortunate enough to get about 9 million of funding from UKRI at the time to enable us to set up the first non-US R&D activity in the UK.

So we chose to set up the activity in the northwest of the UK, at Daresbury Laboratories. This is a particle physics research laboratory, one of three national labs that are run by the Science and Technology Facilities Council. It was an old nuclear physics research facility from the 1960s. It's home to three Nobel prizes. And it's not just a government research facility. They have a really nice public private partnership going on there, where there are 150 companies on site, some working with STFC, some completely on their own, about 2000 people on site in total. It also hosts the UK's largest supercomputer that's dedicated to industrial research. And the site has plans to grow.

And we found a very natural home here at Daresbury. And the main reason that we went there was to access the talent, but also the cryogenic expertise. At the back of the site here is this huge giant cryo facility. Just think mega fridge, and these things take years to build and they're quite unique infrastructure, and Daresbury has one of the world leading cryogenic cryoplant facilities.

So we've tapped into that and really accelerated our development roadmap. We launched the site back in October last year, hosted by Michelle Donelan, Secretary of State for Science, Technology and Innovation. And this is the Daresbury site. And we now have a building on site next to the cryogenic labs. And within that building, using the UK supply chain, we've designed and built the world's largest cryogenic cooled quantum module. And we call this the PsiCube, for obvious reasons. And this system, just about in context, has ten times the cooling capacity, ten times the cooling volume and ten times the efficiency of the next best system that you can get. So this has been a real leap for us in terms of capability, and that's been enabled by the infrastructure at Daresbury, the skill sets at Daresbury, but also the UK supply chains.

These are manufactured in Oxfordshire, and we've moved very fast, in fact, much faster than people in the US thought we were able to go, because of the way the science parks work, the way you can get access, the mindset and how they're used to dealing with these sorts of problems. And so the way that we look to scale our technology is to take these modules, these prime modules, and replicate many of them, and connect those modules together with electrical interconnects and photonic interconnects and build out a giant quantum supercomputer. But for all intents and purposes, it looks very much like the inside of a normal data centre, or normal supercomputer. So this is how we're scaling our technology.

We recently announced a deal with Australia of a billion Australian dollars to build that quantum data centre in Australia. And so our first large scale quantum computer will be built in Brisbane in Australia, backed by a billion, or about 500 million of UK pounds. And that is the first government to make a big bet on one quantum company in this way. We talked about big bets, and that was talked about just a few minutes ago. This is clearly a bet from Australia, that PsiQuantum, are going to build the first large scale, useful quantum computer, and that will be in Brisbane. And the goal there is to anchor a significant burgeoning ecosystem in quantum within the Brisbane area. And so that site has been identified and that project is well underway, and we expect that to come online sometime in 2027.

And so, as a company, we've been through the science phase. We did a lot of the really fundamental science in the universities, and this is really where the UK really excels. We moved to Silicon Valley to really focus on the semiconductor and building out a scaled company. We're now looking back at the UK again for R&D developing high tech novel solutions around cryogenics, and now Australia for the scaling and facilitization of our technology.

And so, in terms of the UK as a science superpower, it's one of the questions at the very beginning, is the UK a science superpower? I voted yes. Undoubtedly, the UK is shoulder to shoulder with the best in the world at research innovation. I would say that there's not a problem in creating startup companies. My little £5 million incubator has produced 30 plus startup companies. I think it's that scaling of those companies and rapidly scaling to the point where they can have real international influence. There's maybe a part that's missing, and I think it's also worth acknowledging a special relationship with the US. Like, there is undoubtedly a special relationship there. The US undoubtedly really benefits from the UK, the research system within the UK. How can we make that benefit in the UK more? Right? What can be done there to strengthen that special relationship in a sort of bi-directional kind of way?

So, with that, I'd like to thank you all very much for listening.