SPINS, PHOTONS, AND NATIONAL IMPERATIVES: AN INTERVIEW WITH DR. STEPHANIE SIMMONS

Dr. Stephanie Simmons is the Chief Quantum Officer at Photonic Inc, an Associate Professor and Canada Research Chair in Silicon Quantum Technologies at Simon Fraser University, and co-chair of the Canadian Quantum Advisory Council. As one of Canada's leaders in quantum information science and technology (QIST) across many sectors, we were delighted to interview her for this special IYQ edition of *Physics in Canada* to discuss her history in the field, moving research to the private sector, and a vision for Canada's quantum future

Interview conducted by the guest editors of the IYQ edition of Physics in Canada

You started working in quantum information science and technology as an undergraduate student. How did you find your way to quantum technology?

When I first discovered quantum technologies at 16, it was through a newspaper article about the Institute for Quantum Computing in Ontario, Canada. The potential inherent in large-scale quantum computers immediately captivated me, and I've been pursuing it ever since. I completed my undergraduate studies at the University of Waterloo in Mathematics and Mathematical Physics, my doctorate in Materials Science at Oxford University, and then went to the University of New South Wales as an Electrical Engineering research fellow in silicon-based quantum computing. I then returned to Canada to start the Silicon Quantum Technology lab at Simon Fraser University in BC.

What application of that potential grabbed your interest in those early days?

It was the concept of teleportation in quantum computing—the fact that you could harness it to do things made me really think that this would define the future. Today, I think I'm driven by just how close we are to creating the really large scale systems that will enable us to run the high impact algorithms - using teleportation, of course!

How has the field changed in Canada and globally since you got your start?

Early on there were still debates about *IF* quantum computers could ever be built. The big question now is *WHEN* we will see quantum computers that are large enough to unlock the exponential speedups that quantum can provide.

Another big change is the acceleration in the pace of progress. Across Canada and around the world, we're seeing big improvements in hardware, software, error correction – these are addressing some of the core challenges to large scale quantum systems.

The shift from curiosity to implementation is profound. It means we've crossed a threshold. Quantum is no longer just a scientific endeavor; it's a technological inevitability.

To move along that inevitability, what is the mission of your company, Photonic Inc?

Our mission is to build scalable, fault-tolerant quantum computers that can deliver real-world impact. We’re focused on a distributed architecture using silicon spin qubits connected by photons, a design that allows us to *scale up* (increasing the quantity and density of components within a single unit) and to *scale out (*adding units to a network), cost-effectively.

Our vision is to unlock the transformative potential of quantum computing across industries from drug discovery and clean energy to secure communications, finance, and national security. We’re not just building a computer; we’re building the foundation for technologies that will shape the next century.

What has Photonic allowed you to do that would have been impossible in the context of academia?

Being in a company has allowed us to move further, faster. In academia, the focus is often on foundational research — which is essential — but building a scalable quantum system requires sustained, coordinated engineering efforts and significant resources. The private sector enables that kind of momentum. At Photonic, we’ve been able to bring together a multidisciplinary team of global experts, invest in infrastructure, and make long-term bets that would be difficult to support through traditional academic funding models.

What are you looking for when assembling your team at Photonic?

At Photonic, we’re doing something that has never been done, and that starts with assembling a team that is fearlessly ambitious. We look for brilliant, dedicated people who are genuinely excited about making quantum computing a reality.

The physical systems used in your devices at Photonic are spin qubits connected by photons. From a birds-eye view, how do we build and interface with spin qubits?

To be able to unlock the promise of quantum computing, we need systems with so many highly connected qubits that it is not practical to be constrained to a single box. So, we focused on an efficient way to network systems using telecom infrastructure.

At Photonic, we use T-center qubits as the basic building blocks that generate entanglement. The T-center is a colour centre in silicon that can emit photons – particles of light – that are entangled with the spins left behind. And when photons from two separate T centres interact in a certain protocol, you can trigger the ability to connect or entangle the spins in T centres that emitted them, even though the T centres themselves remain physically separated. It's astonishing. These are what's called spin-photon interfaces, which means they have the compute and memory capability in the spin, but they also have the communication capabilities of photons. And that link is through telecom fibre, which is the standard fibre used to string together all of today's internet and modern data centers. It's a super lightweight connection, enabling us to get distributed entanglement and to do distributed computation using that entanglement.

Most of the attention in the media is paid to superconducting circuits as the platform for building quantum computers. Why should we be pursuing alternative platforms like silicon spins? Should we be pursuing others as well?

Superconducting qubits were among the first quantum technologies to capture widespread media and investor attention, for good reason. They enabled some of the earliest demonstrations of quantum algorithms at a few dozen qubits and helped bring quantum computing into the public imagination.

The consideration of other modalities reflects the fact that no single platform has yet proven it can scale to commercial utility. That's why initiatives like DARPA's Quantum Benchmarking Initiative (QBI) are so important. QBI was launched to rigorously assess whether any quantum modality can realistically deliver more computational value than it costs within the next decade. Crucially, it applies equal scrutiny to all platforms to determine which approaches are truly viable at scale. In that context, pursuing alternatives like our photonically-linked silicon spin qubits isn't just a hedge — it's a strategic imperative.

Can you describe your role as the co-chair of Canada's Quantum Advisory Council to the National Quantum Strategy?

The role of the Quantum Advisory Council is to bring the perspectives of academia, industry, and other quantum players to the government to inform policy and provide updates on what could be achieved and how we can keep the quantum advantage that Canada had the foresight to build with decades of research.

What makes quantum unique from a research funding perspective? Why do we need a National Quantum Strategy?

Quantum technologies are unlike most other research domains because they sit at the intersection of deep science and transformative economic potential. Quantum technologies are dual use, which means they have known defense and commercial applications, and therefore are not just a scientific endeavour; they are a platform technology that could underpin future advances in many sectors. That breadth of impact means the stakes are high, and the opportunity is enormous. A National Quantum Strategy is essential to ensure Canada doesn't just contribute to the global quantum ecosystem — but helps shape it.

What's a tangible way in which the National Quantum Strategy has started to shape the environment in Canada?

The National Quantum Strategy highlights the fact that building a strong quantum economy is important, and requires an integrated approach - it can't be created by just supporting research, or talent development, or commercialization. Doing it well requires a comprehensive understanding of the necessary inputs, supports, and desired outcomes both within the country and on the international stage. We've seen this play out in Canada including quantum as a key priority in the G7 talks this June and in the subsequent Kananaskis Common Vision for the Future of Quantum Technologies that was released from those discussions.

What would you encourage the government to do more of to support the development of QIST in Canada?

I'm thrilled to see the government taking bold, strategic action by setting a clear timeline for implementing Post-Quantum Cryptography. This signals that Canada is serious about securing its digital infrastructure and leading in quantum readiness.

We need to ensure that Canada remains a place where quantum companies can start, scale, and stay. That means supporting rigorously vetted companies, even when it involves calculated risk. Anchor firms are essential to building the ecosystems that attract and retain top talent, drive innovation, and generate long-term economic value.

We've seen this story before. Canada helped pioneer AI, but much of the economic benefit went elsewhere. We can't afford to let that happen again with quantum. Realizing our potential will depend on the choices we make today — scaling homegrown companies, securing supply chains, and anchoring quantum deployment here at home. This is a moment to lead in building the global quantum economy.

What advantages does Canada have in quantum technologies? Are there any disadvantages that we'll need to work hard to overcome?

Canada's greatest advantage in quantum is its head start. Decades of investment in research have built a deep bench of talent, world-class institutions, and a collaborative ecosystem that's already producing globally competitive companies.

The challenge? Turning that early lead into long-term economic impact. We need to overcome our risk aversion, especially when it comes to scaling deep tech. If we wait until technologies are "proven," others will be ahead in mobilizing commercially, and we risk losing the return on investment and the talent we've trained. Supporting homegrown companies now is how we turn potential into prosperity.

Looking forward, what's the biggest current bottleneck to useful quantum computers?

The biggest bottleneck to useful quantum computers today is demonstrating scalable, fault-tolerant architectures. We need robust systems that can both scale up and scale out. Scaling up improves the quality and quantity of qubits within a module, while scaling out connects those modules into a larger, networked system capable of distributed computation.

But it's not just about scale — it's about scaling cost-effectively. To deliver real-world value, quantum systems must be architected from the start to support modularity, interoperability, and efficient entanglement distribution across nodes. These are technically demanding challenges but solving them is essential to move from experimental demonstrations to commercially useful quantum computing.

What would you say to a young student interested in pursuing quantum science and technology in their future?

Go for it! Quantum is one of the most exciting areas in science and technology today and there are so many ways to contribute. Whether your interests lie in physics, engineering, computer science, or even policy, there's a place for you in this field. The skills are flexible, the problems are fascinating, and the impact could be enormous. If you're curious, there are great resources out there to help you get started and a growing community ready to welcome you in.

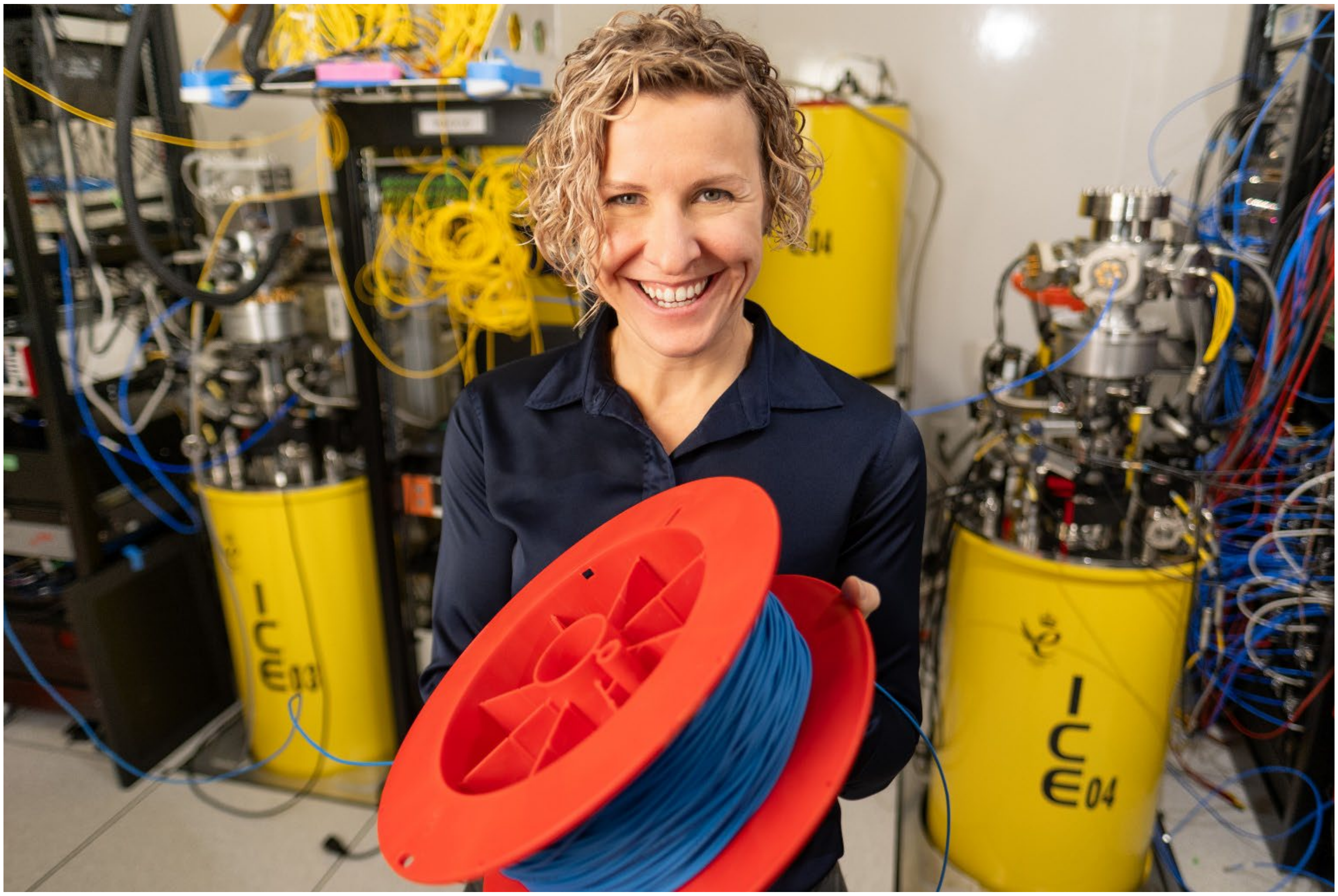

Figure 1. Dr. Simmons holds a roll of telecommunications fibre used in her work to route photons between qubits in different cryostats. Compatibility with telecommunications infrastructure like these fibres is a major advantage in networking multiple quantum devices to scale up to larger systems.