BY EUGENE YIGA

Quantum Leap

As CEO of Oxford Quantum Circuits, Dr. Ilana Wisby is pioneering a future where quantum computing transforms industries and solves some of the world's most complex challenges.

The United Nations General Assembly has declared 2025 as the International Year of Quantum Science and Technology, celebrating a century of quantum mechanics and its significant impact on technology and culture. Quantum computing, once a theoretical concept, is now becoming a tangible reality poised to redefine industries and solve problems previously deemed unsolvable.

One person at the forefront of this technology is Dr. Ilana Wisby, CEO of Oxford Quantum Circuits (OQC), Europe's leading quantum computing company. As a deep tech entrepreneur, a champion for women in technology and leadership, and an adviser to the World Economic Forum's Global Future Council on Quantum Computing, her vision is clear: a brighter future that includes everyone, powered by quantum computing.

"I truly believe that quantum computing can be a tremendous force for good," Wisby says. "At OQC, we're dedicated to bringing about a brighter future by putting quantum technology into the hands of humanity to help solve some of the world's most challenging problems."

Unlocking new possibilities

Quantum computing represents a paradigm shift from classical computing. While classical computers process information in bits (zeros and ones), quantum computers use quantum bits, or qubits, which can exist in multiple states simultaneously due to a phenomenon called superposition.

"Every molecule and atom is inherently quantum mechanical," Wisby explains. "Today, we can't effectively simulate these quantum systems with classical computers. This limitation hinders our ability to develop new materials, drugs, and solutions for complex problems."

In the pharmaceutical industry, quantum computing could revolutionise drug discovery by accurately simulating molecular interactions. Being able to model complex proteins and enzymes precisely could accelerate the development of new medications and treatments.

In energy, quantum computers could optimise battery materials, leading to more efficient and longer-lasting energy storage solutions. This has huge implications for renewable energy and electric vehicles.

Financial institutions stand to benefit as well. Quantum algorithms can tackle complex optimisation problems, such as portfolio optimisation and risk assessment, with unprecedented speed. This would allow banks and investment firms to process vast amounts of data to make better-informed decisions.

Solving complex challenges

One of the most compelling applications of quantum computing lies in solving optimisation problems that are currently difficult or even impossible for classical computers. A classic example is the travelling salesperson problem, which seeks the shortest possible route that visits a set of cities and returns to the origin.

"Classically, this problem becomes exponentially harder as the number of cities increases," Wisby says. "Beyond a certain point, it would take a classical computer longer than the age of the universe to solve it. But quantum computing can handle such complexity."

This has direct applications in logistics and telecommunications, where routing and network optimisation are critical. "By optimising network efficiency and resource allocation, telecom companies can save significant time and money," she explains. "Quantum computing allows us to analyse real-time data in ways that were previously impossible."

Dr. Ilana Wisby

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Building the quantum future

OQC is at the cutting edge of making quantum computing accessible and practical. The company specialises in superconducting quantum technology known as the Coaxmon, which is the core intellectual property that originated from research at the University of Oxford.

"We use superconducting metals cooled down to millikelvin temperatures — colder than outer space — to create artificial atoms that serve as qubits," Wisby describes. "These qubits leverage quantum mechanical principles like superposition and entanglement to perform computations."

By harnessing these principles, OQC's quantum computers can process complex, multivariable problems efficiently. "This means we can tackle challenges that are unsolvable with classical computers," she says.

Integration and accessibility

For quantum computing to realise its potential, it must be integrated into existing digital infrastructures. OQC is making this a reality by partnering with industry leaders such as Equinix, one of the world's largest colocation data centre providers, and Nvidia, known for advancements in GPU (graphical processing unit) technology.

"We're focused on delivering enterprise-ready quantum solutions," Wisby emphasises. "Our quantum computers are not isolated lab experiments; they're integrated into the world's existing secure digital infrastructure."

By combining the strengths of CPUs, GPUs, and QPUs (quantum processing units), OQC enables hybrid algorithms that leverage the best of both classical and quantum computing. This hybrid approach ensures high performance and low latency, which is crucial for real-time applications.

Accessibility is also a key focus. OQC provides multiple ways for clients to access their quantum systems, whether it's through public cloud, private cloud, or direct interconnect. "We want to make sure that interacting with quantum computers is as seamless as possible," she says. "Our goal is that you won't even realise you're using a quantum computer; you'll just be able to solve problems that were previously unsolvable."

Ethical considerations and security implications

With the immense power of quantum computing come significant ethical and security concerns, particularly in the realm of encryption. One of the most pressing issues is the potential for quantum computers to break current encryption methods, such as RSA encryption, which underpins much of today's secure communications.

"With around 50 to 100 high-quality, error-corrected qubits, quantum computers could run algorithms capable of factorising large numbers, effectively breaking RSA encryption," Wisby warns. "Malicious actors are already harvesting encrypted data, anticipating the day when quantum computers can decrypt it."

Sovereign states around the world are investing heavily in quantum technology. That's why Wisby believes we need to ensure we're ready for the quantum future with post-quantum cryptography and new security protocols. "We need to have these conversations now, not after the fact," she insists. "Just because something is well intended doesn't mean it's well applied."

A call to engage

Wisby urges businesses and governments to start engaging with quantum computing today. "This technology isn't 15 years away; it's here now," she says. "If you think you were late to the game with AI, you definitely don't want to miss the quantum wave."

She also highlights the importance of education and awareness. "We need to learn from AI," she notes. "The conversations about AI ethics and regulations happened too late. Quantum is probably about five years behind where AI was, so we have an opportunity to get ahead."

Learn more: *https://oxfordquantumcircuits.com/*

DEMYSTIFYING QUANTUM MECHANICS

Quantum computing harnesses the unique properties of quantum mechanics to perform computations that are far beyond the capabilities of classical computers. Understanding these fundamental principles helps illuminate how quantum computers achieve their extraordinary power.

Superposition: In quantum mechanics, particles can exist in multiple states simultaneously, a phenomenon known as superposition. Unlike classical bits, which are either 0 or 1, quantum bits (qubits) can be both 0 and 1 at the same time. This allows quantum computers to process a vast number of possibilities simultaneously, dramatically increasing computational power and enabling the solution of complex problems much faster than classical computers.

Entanglement: Entanglement is a phenomenon where two or more qubits become linked, and the state of one instantly influences the state of the other, no matter how far apart they are. Entangled qubits can perform coordinated computations, allowing quantum computers to solve problems with an efficiency unattainable by classical systems.

Quantum interference: Quantum interference allows quantum states to combine in ways that can amplify the probability of correct answers and diminish the probability of incorrect ones. This means that quantum algorithms can leverage interference to increase the likelihood of arriving at the correct solution when measurements are made.

‘Malicious actors are already harvesting encrypted data.’

REAL-WORLD APPLICATIONS

Cryptography

Quantum computing poses both threats and opportunities in the field of cryptography. On one hand, quantum computers could potentially break widely used encryption methods like RSA and ECC (elliptic curve cryptography) by efficiently factoring large numbers or computing discrete logarithms. To counter this, researchers are developing quantum-resistant cryptographic algorithms, known as post-quantum cryptography. These new methods aim to secure data against both classical and quantum attacks.

Quantum mechanics also offers new ways to secure communications through quantum key distribution. QKD allows two parties to produce a shared random secret key, which is secure against any computational or technological advances because any attempt at interception alters the key’s quantum state, thus alerting the parties to the intrusion.

Material science

Quantum computers excel at simulating quantum systems. This makes them ideal for advancing material science. For example, by accurately modelling molecular interactions at the quantum level, quantum computers can significantly accelerate the drug discovery process. This could lead to the development of new medications for diseases that are currently difficult to treat.

Quantum simulations can also aid in discovering new materials with desirable properties, such as superconductors that work at room temperature or materials that can efficiently capture carbon dioxide, which would be a huge aid in climate change mitigation.

Another application is in chemistry, where designing efficient catalysts can lead to energy savings and reduced environmental impact. Quantum computing can help in modelling and optimising these catalysts.

Optimisation

Quantum computing offers powerful tools for solving complex optimisation problems that are beyond the reach of classical computers. In logistics and transportation, companies can optimise routing and scheduling to reduce costs and improve efficiency. For example, airlines could optimise flight schedules, and shipping companies could find the most efficient delivery routes.

In finance, quantum algorithms can optimise portfolios, assess risk, and detect arbitrage opportunities by processing large datasets more efficiently than classical computers. And in telecommunications, quantum computing can optimise network traffic and resource allocation, leading to improved service quality and reduced operational costs.

KEY TAKEAWAYS

1. Addressing the challenges of quantum computing requires multidisciplinary collaboration among physicists, engineers, computer scientists, and industry leaders.
2. Continued investment in research and development is essential for overcoming technical barriers and advancing quantum technology.
3. Developing industry standards for quantum hardware and software can facilitate compatibility and integration.
4. Training the next generation of scientists and engineers in quantum technologies is key to sustaining progress.
5. As these challenges are met, quantum computing will move closer to becoming a practical tool that can transform industries and solve some of humanity’s most pressing problems. GIBS