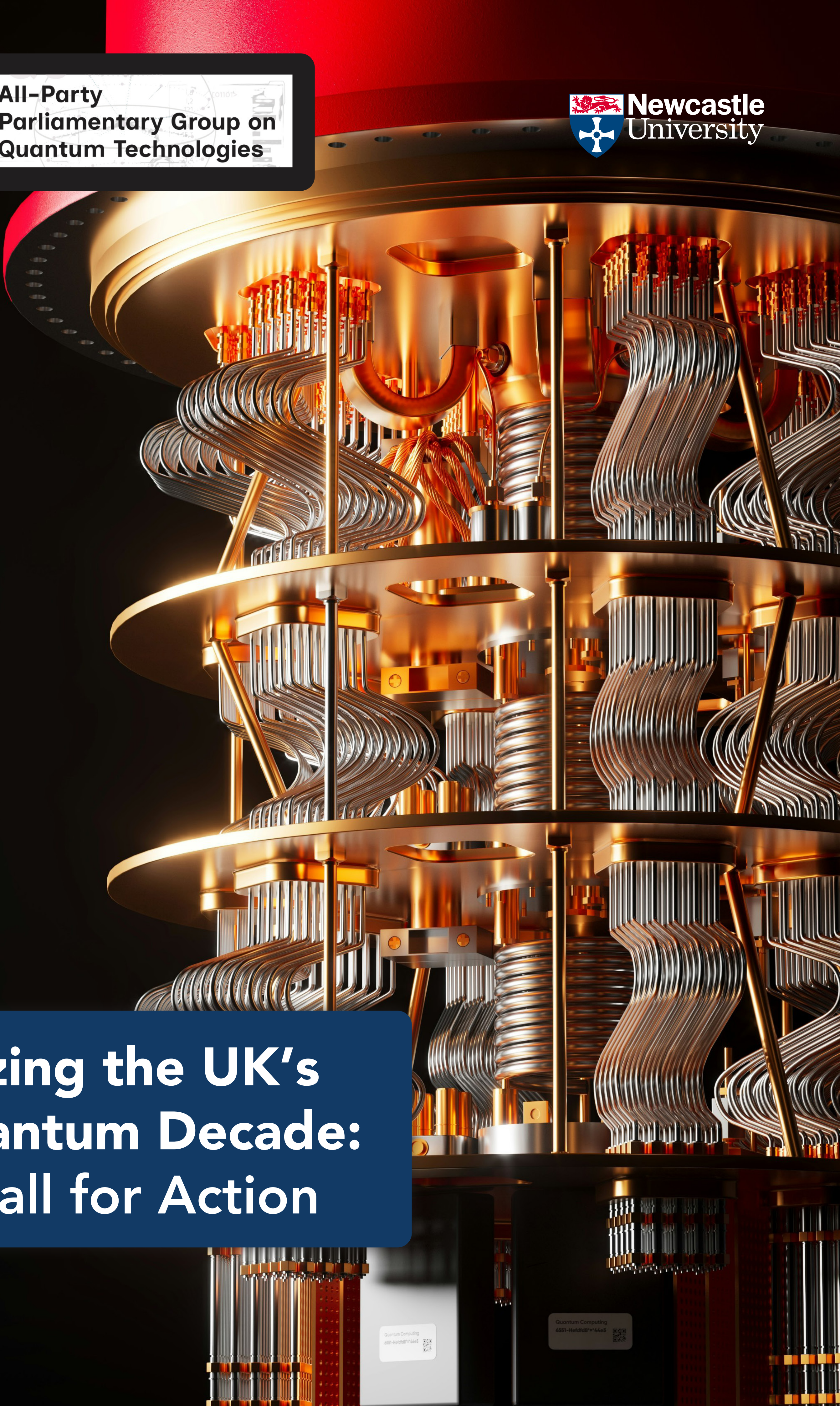
appg All-Party Parliamentary Group on Quantum Technologies

Newcastle University



# Seizing the UK's Quantum Decade: A Call for Action

**About Newcastle University**
A founding member of the Russell Group of research-intensive universities, Newcastle University has been working to understand our world since 1834.

We prioritise societal benefit and sustainability, while breaking down traditional subject barriers.

We are co-creating with our communities and collaborating with our partners to address global challenges.

Our 28,000-strong student community is drawn from over 130 countries, on three campuses in Newcastle, Singapore and Malaysia.

Ranked in the global top 140 in the QS World University rankings 2026, we are a university of innovators. We have built on our foundations in medicine and engineering and added business, humanities, creative arts and social sciences to our broad disciplinary base.

**Newcastle University and the UK Quantum Ecosystem**
This white paper was partially funded through Newcastle University Faculty of Science, Agriculture and Engineering's Policy Fund. This fund is intended to support the university in undertaking research with local, regional, national and international structures (including parliament, central government, devolved administrations, local government, health and education bodies, the justice system and other regulatory organisations).

Newcastle University recognises the importance of building the UK quantum ecosystem. This recognition is illustrated by the recent founding of the Quantum Group in the School of Computing, to provide a home for quantum information science and technologies research in the University.

The University is therefore delighted to have had the opportunity to fund the first ever White Paper of the All-Party Parliamentary Group for Quantum Technologies, to help facilitate the discussion on how best to build the UK quantum ecosystem, to bring about genuine quantum advantage.

**About TYI**
TYI serves as the secretariat for the All Party Parliamentary Group on Quantum Technologies

TYI's expertise and services reflect our mission as a pro-growth, pro-abundance, research-focused political consultancy dedicated to creating a secure and prosperous United Kingdom.

Across our team, we work to develop and influence policy using research, data and expertise in planning, development, local government, quantum technologies, defence, energy, and advanced manufacturing.

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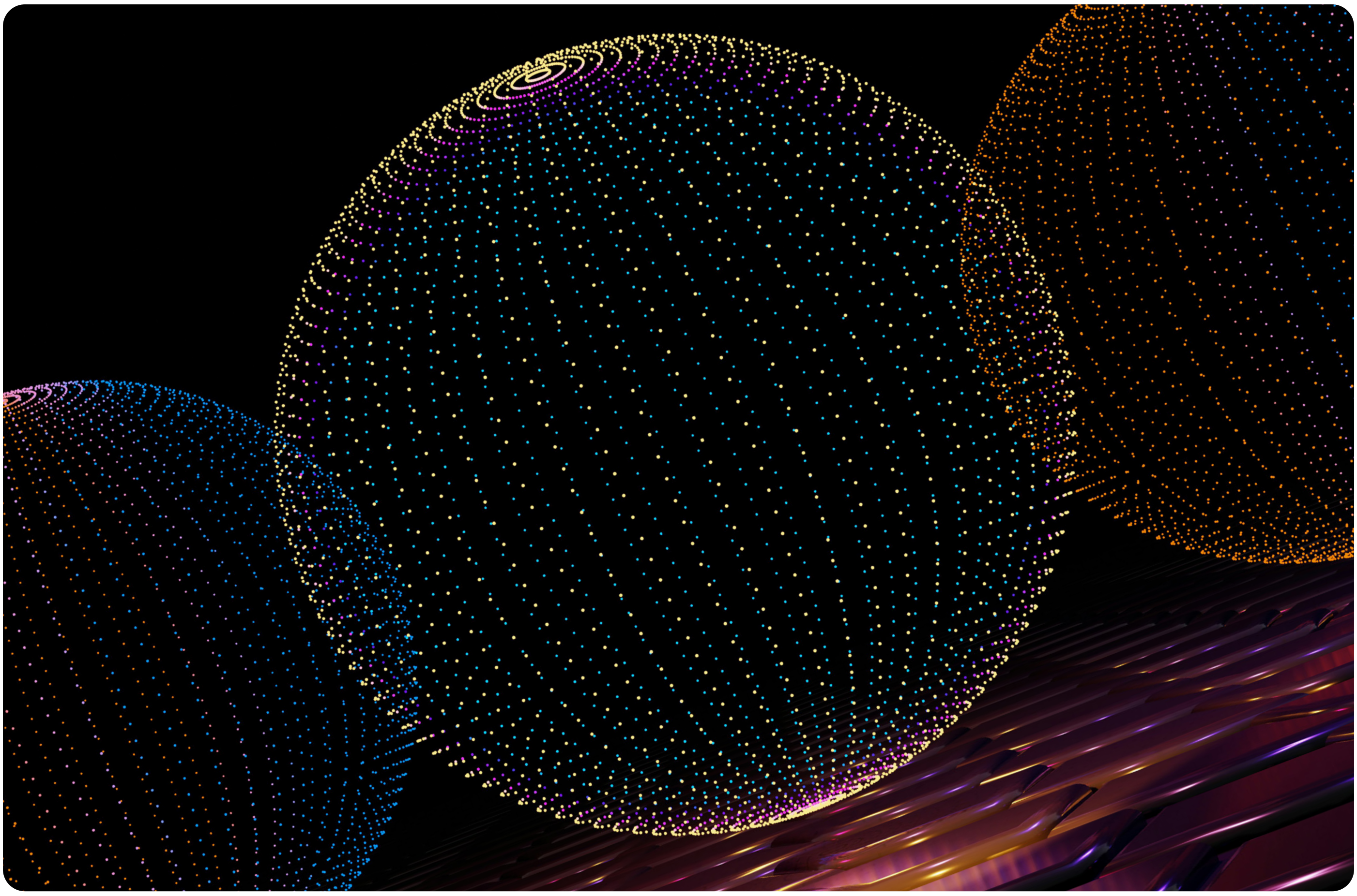


# Introduction

## Dave Robertson MP

Chair of the All-Party Parliamentary Group on Quantum Technologies

As Chair of the All-Party Parliamentary Group (APPG) on Quantum Technologies, I am delighted to introduce the first White Paper that the group has published. Huge thanks are due to Newcastle University for providing the funding that made this paper possible. Without their support, the breadth and depth of contributions you will read here could not have been brought together.

Quantum technologies sit at one of the most consequential frontiers of modern science and engineering. The United Kingdom has been a global leader in this field for over a decade, ever since the launch of the world's first National Quantum Technologies Programme in 2014. We now know that quantum can and will deliver real-world impact: early applications in sensing, timing, communications, and computing are moving out of the laboratory. The question now is whether we will capture the long-term economic, industrial, and strategic value of these technologies.

In the pages that follow, you will find contributions from a wide range of voices across industry and academia, including leading UK quantum companies, research institutes, and university groups working across the field. Some contributors have submitted free-form essays setting out their perspective on the sector; others have responded to a common set of questions posed by the APPG on the future of UK quantum technologies, the challenges facing researchers and companies, and the support needed from Government and private industry to sustain our country's position.

What emerges is a picture of a sector that is world-class in its science, ambitious in its commercial vision, and clear-eyed about the challenges of translating early leadership into durable industrial strength. Themes such as scale-up capital, early-career researcher retention, visa and immigration friction, sovereign supply chains, and policy coherence on quantum security recur across the responses, pointing to areas where parliamentary attention can have the most impact.

I hope this White Paper proves a useful contribution to the national conversation about how the United Kingdom secures its place as a global leader in quantum technologies.

# Foreword

## Dr. Kieran Bjergstrom & Dr. Joe Spencer

Quantum technologies are moving from the scientific frontier to national capability. They are beginning to shape how we measure the world, keep time and navigate, communicate securely, enable new forms of computation and protect the nation and the infrastructure on which modern life depends. Quantum has evolved from a research strength to a core element of the UK's future industrial, security and digital capability base.

This first white paper of the All-Party Parliamentary Group on Quantum Technologies is timely. Quantum intersects three priority national agendas: growth through frontier technologies, resilience in the infrastructure on which the country depends, and the translation of research strength into deployable industrial capability. Alongside critical growth areas such as AI, semiconductors and life sciences, quantum is one of the technology fields from which the UK's next generation of infrastructure, high-value industry and strategic capability will be built.

The UK has already made an early and important commitment. Launched in 2014, the National Quantum Technologies Programme has turned deep academic strength into a coordinated national endeavour, bringing research, industry and public investment together around a strategically and economically important technology area. That commitment has since been reaffirmed through the National Quantum Strategy, the five Quantum Missions and recent funding announcements intended to keep the UK at the forefront of quantum innovation. The UK quantum sector is already moving ahead of the curve, with the capability to engineer systems, grow specialist supply chains, build a specialist workforce and capture economic growth.

This is part of a longer British tradition. From John Harrison's marine chronometer to the first wave of quantum-enabled technologies such as lasers and semiconductor electronics, the UK has repeatedly helped turn difficult scientific problems into practical systems and solutions that came to underpin economies,societies, and our own civilisation. The second quantum era now presents a comparable moment, but in a more contested and strategically significant environment. The UK has the opportunity to turn early leadership into scaled capability and long-term value retained here, anchoring ideas, talent and intellectual property in the UK as the market grows.

The contributions brought together in this paper draw on the experience of companies, researchers and practitioners working across quantum technologies, including those responsible for financing and deploying systems in practice. Together, they show a sector moving from proof to product. For the UK, the task is to make that transition scalable, with the quantum systems engineering, specialist workforce, patient capital, supply-chain capacity and early routes to adoption needed to turn technical momentum into national value.

They also show why quantum should not be treated as a single market moving at a single pace. Some technologies are already approaching operational use in areas such as defence and intelligence, Positioning, Navigation and Timing (PNT), and quantum-secure communications. Quantum computing is attracting significant investment and shaping industrial choices today, while its full potential depends on longer-term progress in hardware scale-up and system integration. This mix of near-term deployment and long-term endeavour gives quantum its strategic character. Countries able to create early markets, test environments and manufacturing routes will influence how these technologies are trusted, procured, and scaled. The UK's prize is a sector that generates domestic growth as visibly as it produces scientific firsts. Should the right policy decisions be made, it could act as the new Workshop of the World.

This white paper brings together perspectives from those closest to the technology and its path to use. It shows that the UK has the foundations and national aims required to build a quantum-enabled economy, grow companies and supply chains, and use quantum technologies in ways that strengthen the economy, society and national security. The contributors are clear that these aims are achievable, but not automatic. Success will depend on translating scientific strength into visible outcomes: a larger share of global quantum markets and private investment, technologies deployed in sectors that matter to the public, companies able to scale from the UK, and capabilities that strengthen growth, resilience and security. If that is achieved, quantum will not only remain an area of British scientific strength; it will become a source of lasting public value and national confidence.

# ORCA Computing

The UK government, through early foresight and a strong innovation heritage, recognised that it had a unique opportunity to become a first-mover leader in a deep tech sector critical to both national security and long-term economic growth. The launch of the world's first national quantum strategy in 2014 demonstrated a clear willingness to invest in a nascent but high-potential industry, positioning quantum as a transformative pillar of the UK's future.

The results have been significant. More than £1 billion invested over the past decade has catalysed dozens of innovative quantum computing, sensing, and communications companies, created hundreds of jobs, and attracted substantial private capital from both domestic and international investors. This has cemented the UK as a top-tier global quantum ecosystem.

## The Commercial Imperative

Ultimately, the key to translating this strong foundation into sustained global competitiveness lies in public–private partnerships that accelerate commercial adoption. While the government has carried much of the momentum to date and continues to do so through the latest national strategy, we are now reaching a point where greater responsibility must shift to large private-sector incumbents. These organisations will be the critical catalysts for scaling real-world quantum applications.

Of course, this transition is not without challenges. Large enterprises are driven by clear ROI expectations, and many remain cautious about investing in technologies that may not deliver returns in the near term. However, real progress will be defined by how quickly quantum is applied to practical, real-world challenges, with organisations moving beyond exploration to realise measurable outcomes.

The UK, particularly London, has a deep capital base and significant investment potential, but a key barrier remains risk appetite. It is essential that we continue to actively engage, educate, and incentivise investors and corporations on the long-term value and strategic importance of quantum technologies.

## Partnerships as a Catalyst

We are at a critical inflection point, where partnerships between private enterprises and quantum companies, particularly in use-case and application development, can dramatically accelerate both sector growth and broader economic impact.

Programmes such as the National Quantum Computing Centre's SparQ and Digital Catapult's Quantum Technologies Access Programme are already demonstrating the power of collaboration between end-users and quantum innovators. These initiatives offer a clear window into the future of applied quantum and must continue to be supported and scaled.

## The Decade Ahead

Ultimately, the future of quantum in the UK lies in commercial uptake. The UK is home to globally influential enterprises uniquely positioned to drive real-world impact. The coming decade will be defined not simply by access to quantum technology, but by those with accrued practical insight versus those without such grounding, making it essential that these organisations are actively incentivised to partner on real-world use-case development. Once enterprises see a clear, credible path to ROI, they will have the confidence to accelerate adoption at scale.

The UK is uniquely positioned to be the world leading quantum nation in five years' time. The depth, strength, and maturity of its ecosystem, driven by focused government initiatives and a decentralised approach to its national strategy through the quantum hubs, has created an interconnected quantum sector that is incredibly capable and self-sufficient. There are exceptional UK companies within every quantum vertical, and the potential economic benefits of such an outcome must not be underestimated by decision makers in government. It is therefore imperative that the government works together with end-users, incumbent corporations, and investors (including pension funds) to drive adoption and investment.

Perhaps the biggest challenge facing UK quantum start-ups is risk-willing capital, investors (public and private) willing to take that step beyond Series A investments, and support brilliant British businesses to take that next step to commercial success. Quantum has all the ingredients to be the next FinTech fairytale, a uniquely British story of innovation and global triumph, with the added benefit that quantum will be an enabler and force-multiplier for all industries and sectors.

# QFX

From the perspective of a UK quantum hardware SME, the next five years represent a critical transition period rather than an end state. This period will determine whether the UK becomes a country that manufactures and exports quantum technology, or one that primarily supplies upstream research, talent, and intellectual property to others.

Success in this timeframe means operational deployment of quantum sensing, timing, navigation, and precision measurement systems, alongside the emergence of repeatable, manufacturable quantum subsystems. Five years is not sufficient for fault-tolerant large-scale quantum computing to reach commercial maturity, but it is sufficient to cement sovereign capabilities and domestic manufacturing if policy is well aligned. The dominant challenges are translational rather than scientific. These include the gap between laboratory prototype and manufacturable product, fragmented access to capital-intensive infrastructure, and persistent shortages of experienced technical staff such as hardware-focused engineers, technicians, and experimental technologists.

The UK currently has one of the best ecosystems for quantum technologies in the world, owing to the foresight and coherent strategy of the UK National Quantum Technology Programme. Established in 2014 as the very first national-scale quantum programme across the globe, the NQTP has inspired most other industrialised nations to develop their own initiatives, resulting in today's highly competitive landscape.

We can maintain and selectively strengthen our global position only by focusing on areas of structural advantage: precision measurement, atomic physics, quantum sensing, timing, and network enabling subsystems. Attempting to compete head-on in megascale quantum computing infrastructure risks diluting impact. Sustained industrial support is fundamental to secure a future which takes the UK beyond just a source of ideas, where systems are designed, built and sold here, delivering enduring economic prosperity.

From government, this looks like mission-aligned procurement, shared translational infrastructure, and stable funding horizons. From private industry, this needs patient capital aligned to hardware timelines and long-term partnerships that allow SMEs to scale domestically.

Finance and funding, however, is only part of the picture. SMEs face acute shortages of skilled laboratory technicians and experimental engineers, alongside fragile domestic manufacturing supply chains with limited capacity and long lead times – a hardware focus is required. Government can play a pivotal role by investing in targeted education and training programmes that specifically foster hardware-based engineering talent. Strategic initiatives could include funding apprenticeships, supporting specialised university courses, and facilitating partnerships between industry and academia to ensure curricula remain relevant to emerging quantum hardware.

Additionally, government could implement streamlined visa policies to attract international experts and incentivise domestic career development in quantum hardware fields. This would help build a sustainable workforce and mitigate the risks posed by labour shortages, enabling SMEs to scale and innovate effectively within the UK.

The next five years will determine whether the UK ultimately captures industrial value from quantum technologies. Treating skills, manufacturing, and procurement as strategic assets is essential to building a durable UK quantum hardware sector.

**QFX is a UK-based SME developing and manufacturing enabling quantum hardware for networked quantum technologies and beyond. qfx.io**

# Lumino Technologies

Quantum technology promises to deliver a range of hugely consequential capabilities, including unbreakable security, sensing and time keeping with unparalleled sensitivity, and computing power able to solve the most intractable of problems. The key word is "promises". The reality may turn out very differently and the ability to deliver on that promise will depend on many factors, where government has a significant role to play.

## Where we are now

The UK has historically punched well above its weight in quantum technologies, notably establishing the first Quantum Hubs over 10 years ago, a model which has been emulated globally. Government has further provided industry support through a range of programmes via Innovate UK, including the Industrial Strategy Challenge Fund, which have been key in giving early start-ups and SMEs the funding they need to develop their R&D and grow. It is encouraging to see that this support has gradually adapted to the needs of industry as the field has matured, with government 'procurement' programmes such as Contracts for Innovation (formerly SBRI grants) providing demand signals to investors and the market more generally.

The hope is this matures further with government purchasing and deploying systems nationally, for example securing high-value assets and networks using Quantum Key Distribution (QKD), although this is hampered by the National Cyber Security Centre's (NCSC) position on the matter. The NCSC has long advocated against the use of QKD, and this is holding back the development of UK industry in the area; there is now significant global investment in quantum communication infrastructure, with initiatives such as EuroQCI (involving all 27 EU member states across terrestrial and space-based domains) alongside major programmes in China, Japan and other parts of Asia. The NCSC however views the opportunities from quantum networking favourably and notes the relevance of developing the underlying technologies. To support UK industry, the NCSC could play an equivalent role to the National Quantum Computing Centre (NQCC) and purchase a range of Quantum networking products (and other quantum-secure offerings), objectively and independently evaluate them, and assess their suitability.

## Changing course

Where the UK unfortunately seems to misstep, and the UK is not unique in this, is with a focus on quantum computing due to the general perception that it will unlock new opportunities and deliver significant social and economic benefits to the UK. Many private companies are engaging with quantum computing companies to explore these applications for drug discovery (e.g. Novo Nordisk), portfolio optimisation (JP Morgan Chase, HSBC), new materials (IBM) and many others, but without significant advances in logical qubit number or error correction techniques, these are medium to long term opportunities. Forging a path for interconnected quantum computers can accelerate these timelines, analogous to classical computing, where the full economic benefits were only unleashed once devices were networked together. The UK government has laudably committed £2bn to quantum technologies, but only £120M of that is set aside to quantum networking. The majority is earmarked for quantum computing development, for example through the flagship ProQure programme. Returning to the NCSC, it states "Extending classical networks to include new functionality that can only be provided by quantum components [and] inherently quantum networks, distributing entangled quantum states between quantum devices… have the most interesting applications" and "Local-state networking is an enabler for scaling-up of quantum computers, to help realise the economic potential they offer." Building out a quantum network in the UK that can distribute entanglement can offer the best of all worlds, utilising QKD as an initial use-case and laying the groundwork for networking quantum computers in the future.

The UK has an opportunity to play a leading role in quantum networking technologies in general and space in particular; the UK has now led two quantum space missions, SpeQtre (a joint programme between RALSpace and the Singapore company SpeQtral) and SPOQC (developed by the UK's Integrated Quantum Networks Hub), with two more in the pipeline (OPSAT VOLT led by Glasgow-based firm Craft Prospect) and QKDSat (strong UK involvement, including Lumino Technologies), and ground infrastructure coming into place (such as the Hub Optical Ground Station, or HOGS, at Heriot-Watt University) – no other country outside China has made such progress. The UK can build on past bilateral agreements with Canada and Germany, alongside multinational arrangements such as the UK's membership of ESA, to be a major player in this field.

There are other quantum technologies that work today and can make an immediate impact which are being overlooked. A clear example is those that tackle the problem of resilient position, navigation and timing (PNT) and over-reliance on satellite navigation signals (such as GPS, or GNSS more broadly), in fact another area where the UK is a leading figure globally, with its own government department under DSIT devoted to the area. Companies in the UK developing methods for timekeeping, transferring time securely and accurately, and inertial navigation would all benefit from increased levels of government support and can deliver capabilities that would provide immediate benefits to society.

The government is right to make long-term bets, but the distribution could be tweaked; quantum networking technologies will be needed to provide a quantum-analogue of today's internet, enabling connectivity across quantum devices. Developing equivalents to the National Quantum Computing Centre (NQCC) and ProQure but for quantum networking and PNT would be a great step in the right direction.

## Addressing gaps

Access to private investment is naturally a key requirement for companies to scale. The UK is in some ways in an awkward position with its proximity to Europe but of course sitting outside of it due to Brexit. This means the UK cannot access key EU initiatives which would align very well with British companies' capabilities, such as the Eagle-1 satellite QKD mission as part of EuroQCI. Those who have nonetheless been able to access capital often accept it with strings attached, such as the Spanish government's investment of €9.75m into nuQuantum conditional on setting up a subsidiary in the country. Given the current geopolitical climate and the importance of sovereign capability, more proactive utilization of the National Security Strategic Investment Fund in quantum technologies would safeguard the sector and help maintain the UK's position. In the next 5 years, it is likely we will see a period of consolidation, which has in many ways already begun, with for example the numerous acquisitions by IONQ, including the UK's own Oxford Ionics.

The UK government may need to play a more proactive role to ensure value capture is not by foreign investors or hyperscalers. Fortunately, the dialogue between government and industry is generally fairly strong, where for example the industry body UKQuantum plays a pivotal role in articulating the needs of companies in the field and that information is more often than not, listened to and acted upon.

Access to specific technical skills remains an outstanding problem, particularly for small companies who are less able to dedicate resources to upskilling new or existing staff members. As the restrictions on visas have tightened, it has narrowed the pool of suitable candidates, making recruitment now a significant headache for SMEs, many of whom are not in position to sponsor visas.

Relaxing visa requirements or making exceptions for key industries such as quantum would massively alleviate the problem. It must be emphasised, however, that as the industry matures, bringing many products to market will require not only physicists with quantum PhDs, but a range of skills which can be developed through apprenticeships such as manufacturing, electrical and electronic engineering and so on. The UK needs to do its bit to make these skills attractive and accessible to individuals early, starting in schools and colleges, and the government backed apprenticeships to develop technicians is a movement in the right direction.

**Lumino Technologies is developing novel solutions for free space optical and quantum communications. Founded in 2024, Lumino is building key components for the future quantum internet, including entangled photon sources, quantum receivers and low-cost optical ground stations to enable quantum networking applications.**

# Dr. Jonte Hance

Head of the Quantum Group, EPSRC Quantum Technologies Career Acceleration Fellow, & Senior Lecturer Newcastle University

Recent funding commitments from the UK Government on quantum procurement, and support for developing ready technologies for industrial and security use, are incredibly welcome. Unlike with AI research, where the UK was key to initial development, but mature ideas were snapped up by US companies, for quantum we need to see home investment and development to ensure the next generation of industrial quantum sensing tools, communications systems, and computational devices are designed and manufactured in the UK. We cannot stumble again when it comes to translating research into impact.

However, money towards procurement, while great, is not the only thing we need to make this vision of a strong UK quantum research-to-impact pipeline a reality. Building and retaining quantum and quantum-adjacent talent will also be crucial if we want to build on our current research achievements. Traditionally, building and retaining academic talent is something we have been good at. Despite only being the 20th-biggest country in the world by population, 4 of the world's top 10 universities by QS-rank are in the UK. However, such rankings tell us far more about how we used to be, than how we are currently. To build quantum talent, we need universities with strong physics (and engineering, and computing) departments, to train our next generation of quantum engineers. Therefore, it is horrifying that in a recent poll by the Institute of Physics, *Physics Matters: Funding the Foundations of Growth*, over a quarter of UK university physics department heads have stated that they expected their departments to face possible closure over the next two years. To retain quantum talent, we need an environment where researchers (be they originally from the UK or elsewhere) feel safe, stable, and able to build and develop their skills. PhD funding shortages and massive international surcharges, short-term postdoctoral contracts, massive visa fees and NHS surcharges, and an increasingly anti-immigration national rhetoric all undermine any sense of safety or stability that we need to attract and retain the best quantum talent, be it for initial research or industrial deployment.

Quantum technologies will have a massive impact on all our lives over the next 5 years – from the positive, like imaging and sensing modalities which can improve healthcare outcomes, identify methane leaks, or enable navigation when outside of GPS range; to the negative, like the breaking of previously-impenetrable cryptography protocols through Shor's algorithm leaving essential communications vulnerable to nefarious actors. To leverage the positive, and mitigate the negative, the UK needs to invest in its quantum workforce. Not just at PhD level, but around wider quantum literacy, and quantum-supporting roles in engineering and programming, we need the best people. Procurement commitments are brilliant, but they are only one part of ensuring the quantum talent pipeline we need in order to avoid being left behind again.

# Professor Matthias Keller

Professor of Experimental Physics
(Physics and Astronomy), University of Sussex

Over the past decade, the UK has built one of the world's most coherent quantum technology ecosystems, combining scientific excellence with deliberate efforts to drive commercialisation that delivers transformative technology leadership and economic growth. I have been involved in the UK National Quantum Technologies Programme (NQTP) since its launch in 2014. Through work spanning optical atomic clocks, ion-photon interfaces for quantum networking and distributed quantum computing, and participation in multiple Quantum Technology Hubs and Innovate UK programmes, I have seen first-hand how the UK has built one of the most coherent quantum ecosystems, connecting fundamental research through to early-stage commercialisation.

In my own work, research into integrating optical fibres into ion traps evolved into a commercial optical atomic clock, supported initially through the Sensors and Metrology Hub and later through Innovate UK funding. This technology has clear applications in improving resilience to disruption of GNSS signals. Similarly, my investigations into ion-cavity systems as a platform for fundamental quantum optics have become enabling technologies for scalable quantum computing architectures and quantum networks. These examples illustrate the strength of the UK's approach in creating a pipeline from curiosity-driven research to translational development. However, whilst the UK quantum technology sector remains strong and world-leading in many respects, it faces rapidly increasing pressures that must be addressed to sustain its long-term success.

## Quo Vadis Quantum Technology

The next five years will be defined less by discovery and more by deployment, consolidation, and early adoption. Early deployment of quantum sensing and timing technologies into real-world systems, greater involvement of system integrators and large industrial players, and consolidation in quantum computing, driven by programmes such as ProQure and similar international initiatives, will accelerate the next phase of quantum in the UK.

There is a strong reason for optimism: the National Quantum Strategy sets an ambitious goal to secure 15% of the global quantum market and 15% of global private investment by 2033. Quantum is also rightly recognised as a high-potential frontier technology within the UK's Modern Industrial Strategy, with the potential to drive transformative economic growth. However, this opportunity is not guaranteed. The next five years will determine whether the UK converts early leadership into long-term industrial strength.

The United States combines large-scale private capital with federal support, and China, Germany and other European nations are scaling coordinated efforts. Without continued and targeted investment, UK innovators will increasingly be forced to seek funding and growth opportunities overseas. This creates a real risk that intellectual property, talent, and economic value will migrate out of the UK. The UK has historically been strong at invention but weaker at capturing long-term economic value. Quantum technology represents an opportunity to avoid repeating this pattern.

## From innovation to market: the role of government and industry

The UK has been highly effective at supporting early-stage innovation, particularly through programmes delivered by Innovate UK, including Contracts for Innovation and other translational funding schemes. These programmes play an important role, but in practice they are often short in duration and not well aligned with the timelines required for deep-tech development. It can be difficult to deliver meaningful technical progress within funding windows of less than a year. As a result, the impact of these programmes can only be limited.

More fundamentally, innovation funding alone is not sufficient. The UK now needs to move decisively toward supporting scale-up of companies, using government as an early adopter, particularly in defence, healthcare, infrastructure, and transport creating clear demand signals that give confidence to private investors. Public investment should be used to leverage significantly greater private investment. Without this, there is a real risk that high-potential UK companies relocate to countries offering stronger scale-up support.

## The Ups and Downs of Quantum Technology Research

While the trend toward commercialisation of quantum technologies is set to continue, there are concerning indications that investment in fundamental research is stagnating or declining. Examples include the cancellation of the second phase of the STFC Quantum Technologies for Fundamental Physics programme and low funding for responsive-mode UKRI research. This is particularly troubling, as it was precisely this type of blue-sky research that enabled the emergence of the quantum technology sector in the first place.

Restricting the flow of new concepts, ideas, and techniques into the quantum technology ecosystem risks undermining the long-term sustainability of the UK industry. In my view, this represents one of the most significant challenges facing UK quantum research. This risk is further amplified by a funding focus on large-scale collaborations such as the Quantum Technology Hubs or Centres, which can inadvertently leave promising emerging topics and early-career researchers behind.

## The Future Quantum Technology Workforce

A further, system-wide challenge is the shortage of highly skilled quantum technology professionals. Rapidly increasing demand in both industry and academia, combined with historically low numbers of physics students, quantum PhD candidates, and postdoctoral researchers – and the long training period required – has led to a depletion of suitable candidates in the labour market. This problem is exacerbated by UK immigration restrictions and intense international competition for talent. Initiatives such as Centres for Doctoral Training are important and will help train the next generation of researchers. For example, the University of Sussex co-leads the 'QIST' EPSRC CDT with the University of Bristol.

However, more needs to be done to make academic careers more attractive and sustainable to retain UK-trained talent, and to attract international expertise. Encouragingly, steps are being taken to address these challenges, including efforts to make physics degrees more attractive and to improve funding for quantum-technology training. At the same time, quantum technologies require a much broader workforce than is sometimes assumed. Progress will depend not only on physicists, but also on engineers, software developers, technicians, systems integrators, and others, and this is recognised in the UK Quantum Skills Taskforce report (2025). New training routes, including integrated 'engineering for quantum' pathways, will be necessary if the UK is to retain the talent and sovereign capability needed to compete globally.

Beyond the need for highly specialised quantum professionals, increasing awareness and understanding of quantum technologies across other industrial sectors is becoming increasingly important. Through the development of CPD modules and online and distance-learning courses, UK universities are leading efforts to disseminate the potential benefits of quantum technologies across the wider UK industrial base.

## Conclusion: a moment of opportunity

There is now a clear opportunity to translate this into economic growth, technological leadership, and strategic capability. The recognition of quantum technology as a frontier technology within the UK's industrial strategy is both important and encouraging. However, the UK must invest in scaling its companies by acting as an early adopter of quantum technologies. To further drive its innovation potential, it must not neglect the fundamental research base but sustain investment in curiosity-driven research; and attract and retain the talent required to deliver. Failure to act risks repeating a familiar pattern of developing world-leading technologies but capturing only a fraction of their long-term value. The UK has already demonstrated leadership in quantum technologies. The next decade will determine whether it can also lead in industrial scale, market capture, and technological sovereignty.

# Dr. Thomas Hird

Assistant Professor in Quantum Technologies
School of Physics & Astronomy, University of Birmingham

The UK holds a leading position in quantum technologies, supported by sustained public investment and a growing base of commercial activity. Research groups across the country produce internationally renowned results, and government programmes span training, research and commercial activity. This work provides a solid foundation to build upon and places the UK in a strong position internationally.

Some of the future challenges in quantum technologies lie in translating existing research into systems that society and industry can deploy at scale. There are risks that advances and innovations could remain confined to laboratories, prototypes or short-term demonstrations with limited paths to established use cases.

Quantum development depends on three connected requirements. First, enabling technologies and supply chains (such as lasers, cryostats, and FPGAs) must receive sustained attention. Secondly, fundamental research must continue; long-term capability depends on a pipeline of discoveries. Thirdly, the sector needs skilled technicians, engineers and operators who support experiments, production and deployment. These roles underpin research groups and emerging companies alike.

Without parallel investment across research, people and translation activity, the UK risks weak economic return, and reduced strategic benefit. Scientific leadership alone does not guarantee industrial impact, secure supply chains or workforce development. A balanced approach remains essential across the whole quantum programme.

Over the next five years, the UK must continue as a global leader across the full range of quantum technologies. Strength in sensing, timing, communications, networking and computing must remain a national priority.

A key shift during this period needs to involve demonstrations in real-world settings. Systems should address practical problems in areas such as navigation, infrastructure monitoring, secure communications and measurement. These deployments need to deliver measurable value. Laboratory demonstrations alone will not provide a sufficient marker of progress.

Hybrid quantum-classical systems will play a central role. Many applications depend on quantum components integrated into existing infrastructure. Control, data processing and reliability often rely more on engineering and classical systems than on the quantum element itself. Integration, therefore, becomes a consistent challenge rather than a specific research problem.

Over the next 5 years, some workforces should be working with quantum-enabled technologies as part of routine activity. Many users will not require deep training in quantum physics; instead, making use of robust technologies, clearly defined interfaces and standard operating procedures. This transition marks an important step to broader adoption across the UK economy.

Global competition now focuses less on research output alone and more on system ownership, manufacturing capacity, and workforce depth. Other countries invest heavily in domestic supply chains, integrated facilities, and long-term deployment programmes. These actions shape market access and strategic influence.

UK success depends on retaining capability across the full development chain. Research excellence provides influence at early stages, but progress stalls when system integration, fabrication, or large-scale deployment occurs elsewhere. Overseas acquisition of UK-developed technologies can shift skills and production out of the country. Preventing this outcome requires stronger support for scale-up and retention rather than reliance on the export of early research results.

The UK's international position also depends on domestic adoption. Having the ability to deploy quantum technologies within infrastructure sectors shapes standards and operational norms. These early applications, therefore, play a critical role in sustaining international standing.

The main challenge in quantum networking research lies in moving from controlled laboratory systems to reliable network integration. Experiments often rely on bespoke hardware, custom software, and constant monitoring by researchers. We have the opportunity now to make use of shared test platforms, including fibre and satellite links and establish clear interface definitions between systems. Without these foundations, scaling networked quantum systems remains slow and difficult to integrate.

A second challenge involves expertise within research groups. Quantum networking experiments depend on expertise spanning optics, electronics, software control, vacuum systems, and systems engineering. Career structures within higher education offer limited routes for technicians and research engineers to progress, retain expertise, and move between projects without leaving the sector.

Higher education faces wider structural pressures linked to funding and incentives. Grant structures often prioritise short-term novelty over engineering maturity and long-duration system development. This focus can discourage work on reliability, integration, and maintenance, despite these factors determining performance outside the lab.

A separate constraint on long-term capability arises from the shortage of specialised physics teachers across secondary education. Limited teaching capacity reduces uptake of physics at GCSE and A-level and narrows entry routes into technical, engineering, and science roles. This effect appears most strongly outside established research clusters and contributes directly to future skills shortages. This shortage of physics teachers also limits future physics literacy across the population, reducing understanding of these emerging technologies and restricting the number of informed users, technicians, and decision makers needed for widespread adoption. Continuing and further developing the concerted effort to stabilise and expand physics teaching capacity directly supports apprenticeships, technician training, and future research capability.

Addressing these challenges requires aligned investment in infrastructure, education, and stable career pathways within academia.

The next major advances in quantum technology will emerge from work at the intersection between quantum systems and classical infrastructure. Key areas of progress include photonic integrated circuits and hybrid platforms that link atomic systems, photonics, and semiconductor devices. These areas address practical limits in control, stability, and integration. Improvements here directly affect performance, cost, and deployability across networking, sensing, and computing. Progress in these areas depends less on new physical effects and more on system architecture and integration.

Future breakthroughs will arise through repeated engineering cycles rather than single experimental demonstrations. Research groups and companies need the ability to collaborate, build, test, fail, and rebuild before moving to scale production. Manufacturing capability plays a central role, since reproducibility and component quality define system reliability. Collaborations and access to facilities allow all teams to move beyond prototypes. Reliable, sustained operation matters more than peak laboratory performance once systems leave controlled environments.

The funding approach needs to reflect this shift. Programmes should allow for both shared infrastructure and long-term platform co-development as well as short-term demonstrator projects. Support for testbeds and integration facilities creates lasting capacity across the sector. This approach spreads benefits across multiple technologies and organisations, while reducing duplication. A focus on infrastructure enables sustained progress from research through deployment.

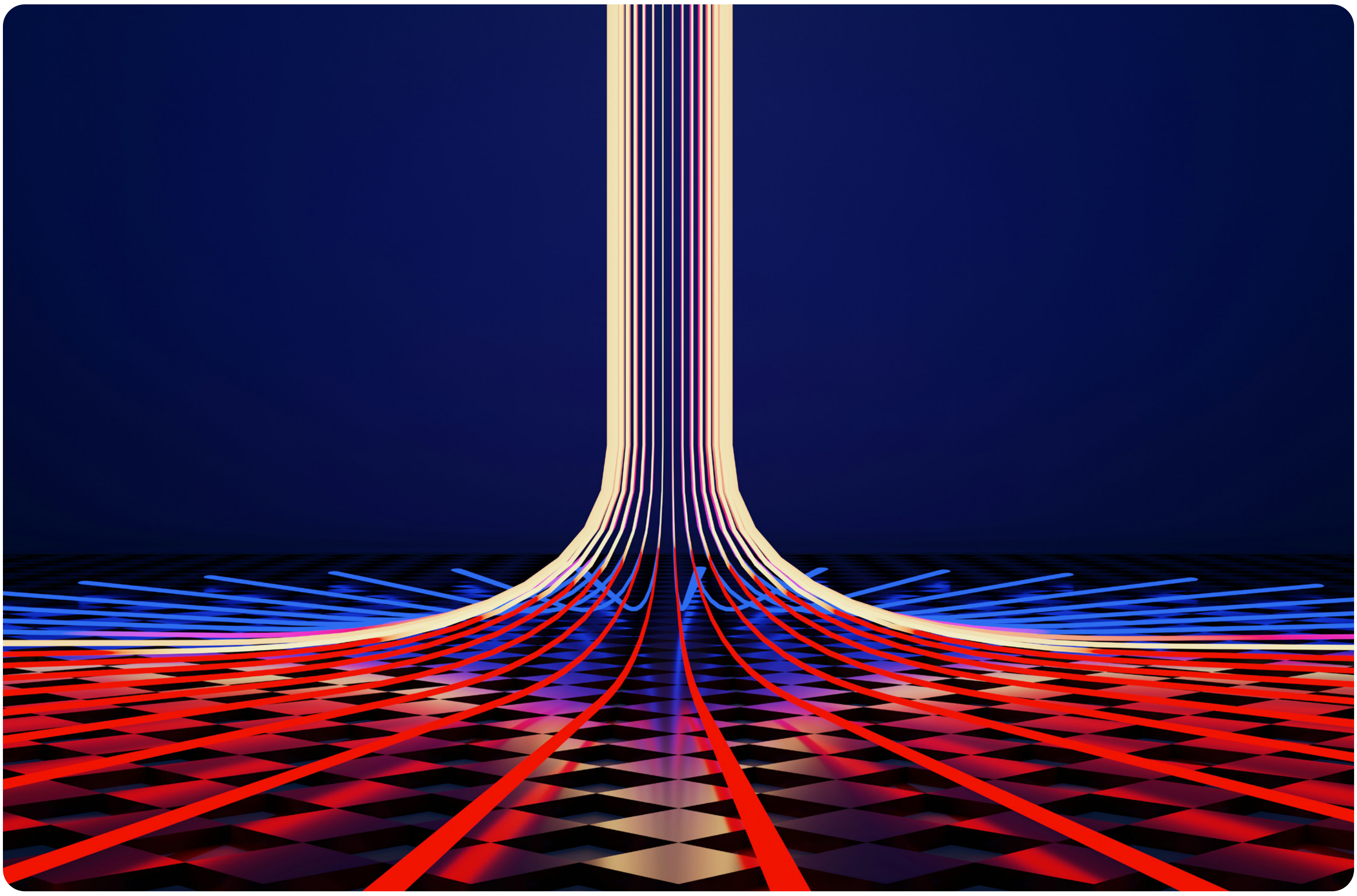
Policy coordination across government departments is of the utmost importance. Education, research, defence, infrastructure, and digital policy all intersect with quantum technologies. Stronger alignment would improve skills planning, infrastructure investment, and adoption pathways. Targeted action to address shortages in physics teachers and technical education supports the long-term workforce pipeline. Funding mechanisms should reward engineering maturity, reliability, and integration work alongside scientific novelty. This shift encourages activities required for deployment rather than short-lived demonstrations.

Manufacturing access and supply chain capacity present growing constraints on progress across quantum technologies. Many research groups and early-stage companies depend on components with long lead times and limited domestic availability. This reliance slows development, increases cost, and makes system reliability harder to develop. Expanded access to shared fabrication and testing facilities could reduce some of these barriers and support repeatable production. In parallel, enhanced apprenticeship programmes at higher technical levels would help staff these facilities and laboratories with skilled personnel who specialise in operation, assembly, and maintenance. These pathways support workforce growth beyond doctoral training routes and strengthen long-term capability once systems move into routine deployment.

Private industry support needs to begin earlier in the development cycle. Companies gain value through collaboration with research groups on system design, manufacturing constraints, and operational requirements, rather than engagement only at late commercial stages. Industry should invest in shared facilities, workforce training, and co-developed platforms where commercial outcomes depend on reliability and scale. Long-term partnerships help align research direction with practical needs and reduce the gap between laboratory performance and field operation. A stronger role for industry in training programmes and apprenticeships would also support skills transfer and workforce stability across the sector.

Staffing and retention present persistent challenges across quantum technologies research and higher education. Research groups often depend on a group of highly trained researchers, engineers, and technicians, yet universities struggle to retain these individuals beyond short-term contracts. Fixed-term posts dominate technical and early career research roles, which interrupts continuity and drives experienced staff toward industry or roles outside the sector. This loss of skilled personnel slows projects, increases the training burden, and weakens institutional memory.

To conclude, the UK is at a point where its scientific strength and excellence must now translate into durable capability. Continued success in quantum technologies depends on decisions taken across research funding,



workforce development, education, infrastructure provision, and adoption policy. Progress requires stable investment in systems that operate reliably outside research laboratories, supported by clear use cases and long-term demand. These steps shape economic return, skills retention, and international influence.

As quantum technologies move into routine applications, the sector will progress beyond the current requirement that participation necessitates a doctorate in physics. A broader workforce becomes possible once systems reach a level of reliability and repeatability that supports standard procedures, defined interfaces, and reliable performance. This shift depends on sustained deployment and real-world demonstrations. Without these conditions, attempts to widen participation risk placing unrealistic demands on training and staffing.

Delivering these outcomes will require coordination across government, higher education, and industry. Investment in enabling technologies, technical careers, education, and shared infrastructure reinforces each stage of the pathway from research to deployment. With consistent focus on reliability, adoption, and people, the UK can strengthen its quantum ecosystem and secure lasting benefits from the excellent scientific position it has built.

# Dr. Aleksey Kozikov

Lecturer, Newcastle University

## Quantum Communication in the UK: Turning Research Strength into Strategic Capability

The United Kingdom has established a strong and internationally recognised position in quantum technologies, underpinned by sustained investment, a coordinated National Quantum Technologies Programme and a globally competitive academic base. Within this broader landscape, quantum communication represents one of the most immediate and strategically consequential areas, particularly in the context of secure information transfer, critical infrastructure resilience and an increasingly complex geopolitical environment.

However, the next five years will be decisive. Without targeted intervention, the UK risks repeating a familiar pattern seen in previous technology cycles: generating world-leading research while failing to capture long-term industrial and strategic value. Quantum communication is now at a stage where this transition from scientific leadership to deployment capability must be actively managed.

My perspective is shaped by experimental research on quantum light sources, including single-photon and entangled-photon emitters, for quantum key distribution (QKD). This work operates at the interface between fundamental quantum optics and real-world communication systems. From direct experience working with industry partners, this interface exposes a persistent and practical challenge: the gap between laboratory demonstration and deployable technology.

### Strategic importance and near-term relevance

Quantum communication occupies a distinct position within the quantum technology landscape. Unlike quantum computing, where large-scale practical advantage remains an emerging prospect, elements of quantum communications are approaching operational readiness. QKD systems, in particular, have reached a level of maturity that allows for real-world testing and early-stage deployment.

This creates a narrow, but critical window of opportunity. The UK has the capability to lead in the development of secure communication infrastructures that are resilient to future cryptographic threats. However, this leadership will not materialise automatically. It requires deliberate alignment between research, industry and policy.

Secure communications is no longer a purely technical issue. It is a matter of national resilience. Existing cryptographic systems, while currently robust, face long-term uncertainty in the presence of scalable quantum computing. At the same time, vulnerabilities in classical infrastructure, such as satellite navigation spoofing and interception of communication channels, highlight structural weaknesses that cannot be addressed through incremental improvements alone. Quantum communications provides a fundamentally different security paradigm, but its adoption depends on decisions being made now.

### From laboratory capability to deployment

The central challenge in quantum communications is not the absence of scientific progress, but the difficulty of translation.

At the device level, the development of reliable, scalable and manufacturable quantum light sources remains a critical bottleneck. While laboratory demonstrations routinely achieve high performance, translating these results into systems that are stable, reproducible and compatible with existing infrastructure is significantly more demanding. This is particularly evident in the development of sources suitable for deployment outside controlled environments, where robustness and long-term operation become decisive factors.

At the systems level, integration with fibre networks, free-space links and satellite platforms introduces further complexity. In my own work, this requires close collaboration with industrial partners who are able to test emerging technologies under realistic conditions. These collaborations are essential, but they also highlight a persistent gap: academic systems are often not designed with deployment constraints in mind, while industry requires solutions that meet stringent performance, reliability and cost criteria.

Bridging this gap requires sustained support for translational research, work that is neither purely fundamental nor fully commercial, but essential for converting scientific advances into operational capability.

## Infrastructure, supply chains and access

A further constraint on progress lies in access to specialised infrastructure and supply chains. Quantum communications research depends on components that are often difficult to source, have long lead times or are subject to international restrictions. These challenges are not merely logistical; they directly affect the pace and direction of research.

If the UK is to maintain its position, it will need to strengthen domestic capabilities in key areas of the supply chain, particularly in photonics, precision manufacturing and advanced materials. Without this, even strong research programmes will struggle to scale.

## Workforce and technical capability

The development of quantum technologies is also constrained by the current structure of the workforce. At present, highly trained researchers (PhD students and postdoctoral researchers) are frequently required to undertake technical and operational tasks that do not fully exploit their expertise. This is not an efficient use of highly specialised skills and limits overall research productivity.

There is a clear need for a broader and more structured technical workforce, including skilled laboratory technicians and engineers. Higher-level apprenticeship programmes could play a significant role in addressing this gap. Such programmes would not only improve the efficiency of research environments, but also create accessible entry points into the quantum sector for individuals who do not follow traditional academic pathways.

This is not simply a workforce issue. It is a strategic requirement. A sustainable quantum ecosystem must extend beyond academia and include a diverse range of technical and engineering roles.

## Role of government and industry

The future of quantum communications in the UK will depend on a balanced and clearly defined relationship between public investment and private sector engagement.

Government support remains essential, particularly for fundamental research and early-stage development. However, long-term success cannot be built on public funding alone. A quantum sector that is overly dependent on government grants will struggle to achieve commercial viability.

Industry must take a more active role in deployment and adoption. In the case of quantum communications, this includes telecommunications providers, infrastructure operators and sectors with high security requirements. These organisations will ultimately determine whether quantum technologies transition from demonstration to widespread use.

Government policy should therefore focus on enabling this transition. This includes:

- Supporting large-scale demonstration and testbed environments
- Facilitating the development of standards and interoperability frameworks
- Using targeted procurement to reduce early-stage risk
- Ensuring that regulatory frameworks do not hinder deployment

At the same time, it is essential that industry assumes responsibility for integration and scaling. The role of government is to enable capability, not to substitute for market demand.

## UK position in a competitive global landscape

The UK remains a leading nation in quantum communications research, but this position is not guaranteed. Significant investments are being made internationally, particularly in Europe, North America and Asia, with increasing emphasis on deployment and infrastructure.

Maintaining leadership will require a shift in focus. Research excellence alone is no longer sufficient. The UK must demonstrate the ability to deploy, integrate and scale quantum communication systems in real-world environments.

There is a clear opportunity to lead in areas such as satellite-based quantum communications and integrated photonic platforms. These areas build directly on existing strengths and have strong potential for global impact. However, realising this opportunity will require sustained investment, coordination and a willingness to move beyond pilot projects.

## Future directions and emerging opportunities

Future breakthroughs in quantum communications are likely to emerge from advances in device engineering, materials and system integration. In particular, progress in scalable photonic technologies, robust quantum emitters and hybrid communication architectures could significantly accelerate deployment.

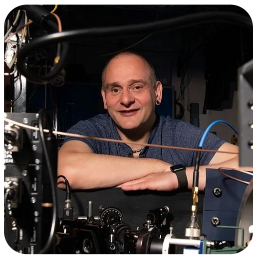
Importantly, these advances will occur at the interfaces between disciplines. Supporting them will require flexible funding mechanisms that encourage collaboration between academia and industry, and that allow for rapid iteration between fundamental research and applied development.

Quantum communications is entering a critical phase. The scientific foundations are strong and the UK is well positioned to lead. However, leadership will depend on the ability to translate research into operational systems.

The next five years will determine whether the UK establishes itself as a leader in secure quantum communications or remains primarily a source of high-quality research. Achieving the former will require coordinated action across government, industry and academia, with a clear focus on deployment, capability and long-term resilience.

The opportunity is significant, but it will not realise itself without deliberate action.

# Professor Winfried Hensinger



Professor of Quantum Technologies, University of Sussex and Chairman of Universal Quantum

## How can we secure and consolidate UK economic success in the development of quantum computing?

Practical quantum computers have the potential to solve extremely complex problems much faster than their classical counterparts, and to disrupt sectors such as finance, drug discovery, and materials science, thereby changing the way we work and live. The uptake of quantum computing in different sectors within the UK makes its potential economic impact clear: according to a report by Oxford Economics, quantum computing is predicted to create 148,000 UK jobs by 2055 and ca. £12.9 billion to GDP. Quantum-driven productivity gains could increase by 33% across key industries and 8% economy-wide.

These projections are rooted in the UK's historic and existing world-leading capabilities and landmark breakthroughs in quantum computing that have emerged from its universities and successful startups; and these successes have been enabled by proactive government funding into research and innovation. The importance of quantum technologies as a whole for the UK's economy and security has long been recognised by the UK Government and led to strategic investment into research and innovation over the last decade through UK's pioneering National Quantum Technology Programme (NQTP) that was initiated in 2013.

Quantum computing provides a significant opportunity for the UK, but its continued development and future adoption is at a critical juncture. Several strategic levers exist that, if deployed correctly, will enable the economic potential of quantum computing and quantum technologies in the UK to be maximised.

In the below I provide a set of recommendations that if followed will help to drive economic growth while capitalizing on the UK's strong potential in the development of this technology.

### Assisting growth by leveraging mobile capital via sovereign investment

The US are assisting the development of a sovereign quantum computing sector by making significant equity investment into key US quantum computing companies including Quantinuum and IonQ. Other countries, such as France, have similar programs supporting their promising home-grown quantum computing companies. The European Union also provides investment for companies from member countries. This does not only strengthen quantum computing companies, providing reason for them to grow naturally where they have been founded, but most importantly, it stimulates the growth of a new industry sector and it makes these companies more attractive for private investment.

While a similar supportive approach has been outlined by Rachel Reeves, many companies or dedicated quantum technology venture capital funds see little or no support from the British Business Bank even though it has  a sign-posted role by Government of supporting home-grown fast-scaling companies. The British Business Bank has funded some UK companies while not engaging with others, it is perceived in the sector as lacking strategic vision, coordination or understanding of the quantum computing technology and sector. This places the UK at a strategic disadvantage, reduces UK's ability to attract mobile capital from overseas and may result in promising UK firms moving overseas.

The UK needs to urgently reform its approach to enable equity co-investment into all promising UK quantum technology or quantum computing companies.
The British Business Bank should really facilitate co-investment for all promising UK quantum companies and open a dedicated quantum division for that purpose. The recent investments into Oxford spin-out companies Quantum Motion and Oxford Quantum Circuits constitute a positive development. However, the British Business Bank should help grow the whole ecosystem here in the UK rather than just investing into two Oxford spin-out companies. This would help to grow ecosystems across the UK and help deliver economic growth all across the UK rather than just focussing on

a single region. The British Business Bank should use a transparent way to engage, setting clear structures for co-investment such as a significant ticket sizes of co-investors, quality of co-investing funds, sovereign capability importance and regional balance. The current approach is not effective in helping to grow the UK economy and it reduces the level of mobile capital that is being attracted to the UK.

It is also worthwhile to consider whether pension funds can invest in disruptive technologies such as quantum computing as this might help leverage  more private capital to the UK and assure to retain promising UK companies to stay here in the UK.

As companies scale up and undergo further funding rounds, the capital needs will grow and funds will need to write bigger cheques with a more advanced funding round. A lot of companies seriously consider moving their home base to the USA as venture capital funds located there are capable of providing sufficient capital contributions within relevant capital raises. The ability to generate large enough capital raises here in the UK will play a critical role in keeping promising companies here in the UK. This makes the provision of functioning sovereign investment tools even more important.

## A regional approach driving innovation all across the UK

Many regions across the UK have potential for significant economic growth because of impressive potential in commercialising academic achievements and driving economic growth. Government should help catalyse regional economic growth cluster wherever there is merit across the UK. Promising regions are spread all across the UK and examples include the wider Bristol area with growth resulting from the development of quantum photonics, both from university and company side, Sussex with significant growth resulting from quantum computing and subsystems manufacturing along with university innovation and spin-outs, London via the biomedical imaging hub, quantum computing manufacturers and universities such as UCL and Imperial, Oxford via the quantum computing hub, the university and a number of quantum computing manufacturers, and Glasgow, via the presence of a quantum hub and university innovation and relevant quantum technology companies.

This growth of quantum economic centres has happened organically over many tens of years and has been accelerated with the emergence of UK's National Quantum Technology Program in 2014. In order to efficiently grow an industry sector in the UK,  it is important to capitalize on these regions and provide a set of local support mechanisms to help grow these ecosystems.

## The role of the NQCC

The key role of the NQCC should be to nurture the UK quantum computing sector, act as the first customer acting to independently verify the system specifications. A secondary role should be to help educate customers and to provide suitable incentives for partnerships of different stakeholders (e.g. partnerships of hardware and software companies) that strengthen UK's overall quantum computing capabilities. A key role of the NQCC should be to strengthen the vulnerable UK ecosystem, provide topical and coherent funding for academic stakeholders to address critical research challenges where existing funding mechanisms may not be suitable for or where natural funding gaps appear within the transition from one grant to another. The NQCC should also play a role in showcasing UK quantum computing capability.
In order to initiate growth all across the UK I propose a "hub and spoke" model for the NQCC. Such a model would leverage regional strengths in quantum computing across the UK, thus enhancing nationwide economic growth and diversification. Here, Harwell would remain the central hub and primary connection point, while government funding would simultaneously encourage regional concentrations of quantum excellence wherever there is merit.

## Mechanisms to drive growth of ecosystems

EPSRC's recent call for a Quantum Commercialisation Centre is an important step to provide a focussed approach to streamline commercialisation of promising academic breakthroughs. However, it efficacy may be limited by a single location that may  not provide easy access for many potential stakeholders. It is hard to imagine that a PhD student working in Glasgow may find a commercialisation centre located at the other end of the country particularly helpful, beyond attending a course or conference there. Commercialization of research is best learnt on the job as part of  an accelerator program or with a local mentor and support system in place. As such, this investment should be supplemented with local centres associated with the key relevant regional ecosystems. Similarly as for the NQCC, a hub and spoke model could provide for regional coverage assuring that effective commercialisation takes place wherever there is merit across the UK.

## A holistic approach

In order to grow a quantum technology industry sector, it is important to have a wholistic approach. The government quantum computing procurement program is a step in the right direction by enabling UK quantum computing manufacturers to showcase their technologies with government acting as the first customer. Indeed these quantum computing manufacturers are living proof how academic breakthroughs at certain UK universities have been commercialized highly successfully.
In order to create an efficient innovation pipeline for these leading UQ quantum computing companies it is

important to maintain and strengthen the underlying academic research which powers the innovation funnel of the company. If we force such research group to access funding via a drip feed of standard research grants, regular EPSRC grants and other miscellaneous funding schemes, the overhead in overseeing such a diversity of funding streams may result in a slow-down of relevant innovation and in turn reduce UK's ability to retain its leadership position in the development of quantum technologies. One should consider creating critical mass research hubs which are associated with promising quantum companies. Such university hubs would provide an innovation pipeline, while also training future staff for the sector.

## Maintaining the people funnel

Government has already expanded on relevant doctoral training centres. Government has also awarded top-up stipends to attract the very best students to carry out a PhD in the field. These are extremely important measures enabling a people funnel for a fast-growing sector. It will be very important to keep up the momentum and further increase training provisions to satisfy the growing demand of the sector.

## Generating economic prosperity on a limited budget

Quantum computing is a once in a generation opportunity for the UK. Government has recognized the importance of the sector and has provided sufficient levels of funding to help capitalize on its vast potential. Rather than aiming for more funding which is unrealistic in the current economic climate, we should spend more focus on optimizing delivery mechanisms for accelerated economic growth. This White Paper has identified how minimal improvements to the relevant delivery mechanisms can result in accelerated economic growth in the UK.


**About Winfried K. Hensinger**

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- Head, Sussex Ion Quantum Technology Group, University of Sussex
- Deputy Director and Sussex Lead, EPSRC Centre for Doctoral Training in Quantum Information Science and Technologies, University of Sussex and University of Bristol
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# Dr. Carrie Weidner

## Senior Lecturer, University of Bristol

### Introduction

Quantum technologies sit at an interesting crossroads. In many ways, the most mature "second revolution" technologies, primarily in quantum sensing and timekeeping, are moving out of the laboratory and into the commercial sphere; these technologies hold promise in mitigating the £1 billion/day hit to the UK economy that would arise if there was a country-wide outage to satellite-based GPS systems. On the other hand, some of the most promising applications of quantum technologies lie in computing, which remains firmly stuck in the noisy, intermediate-scale era. However, there is an undeniable race for the first fault-tolerant quantum computer, in no small part due to the political implications of, e.g., a bad actor being able to break RSA encryption. As a result, quantum technology is a sensitive area of research, and it is of utmost importance that the UK maintain and build upon its leadership in this area. This piece will provide insight into how this can be achieved, but it is based on an academic perspective, and it's important to note that mine is only one perspective of many.

### Who am I?

My position is one of someone educated in the US, with experience working as a post-PhD academic in the EU and UK. I came to the University of Bristol as a Lecturer in 2022, and I am currently Senior Lecturer in Quantum Engineering Technologies, a position held between the Schools of Physics and Electrical, Electronic, and Mechanical Engineering. I maintain strong academic collaborative ties to the US and EU, and I have also worked closely with US and UK partners in the quantum industry. I actively collaborate with researchers across the UK. I am Director of the outgoing Quantum Engineering Centre for Doctoral Training (CDT) at Bristol, and until recently, I served as Interim Director of the Quantum Information Science and Technologies CDT that sits between Bristol and Sussex. I teach undergraduates and postgraduate taught students, and I supervise multiple Bachelor's, Master's, and PhD students as a part of my research group, which sits at the intersection of cold atom physics and quantum engineering. My research is primarily focused on atom-based sensing of inertial forces and electromagnetic fields, although I also have efforts in robust quantum control, quantum physics education, and atom-photon enabled neuromorphic computing. Finally, I am co-work-package lead for the Inertial Sensing work package of the EPSRC Quantum Enabled Positioning, Navigation, and Timing Hub, where I also sit on the Management Board.

### Where do you see quantum technology in the UK in five years?

The UK punches well above its weight in the quantum sphere, and this is a result of sustained investment in both blue-sky, curiosity-driven research and applied technology development within academia and industry. If this level of investment continues into 2030 and beyond, we should see continued advancement within quantum technologies that maintains or even advances the UK's position within the global quantum economy. However, this does not come without its challenges. One must consider the critical roles that will be played by academia and industry within this space, as well as the unique challenges faced by these. In my view, academia exists to pursue lower TRL implementations of quantum technologies, bringing them into maturity, wherein commercial exploitation can occur. As such, while it is critical to fund the industrial sector, continued innovation requires academic work, and useful technology often springs from pure, curiosity-driven research, research that often also serves to develop early-career academic talent that later moves into senior academic or industrial leadership positions. The UK must thus ensure that it funds curiosity-driven research and lower-TRL quantum technology research to maintain its strong foundation.

### What are the biggest challenges facing your research or company?

This leads to the challenges that academics in quantum technologies face, and by definition, the next three paragraphs will read as somewhat critical. However, this must be seen as constructive criticism from a passionate immigrant who loves her adopted country. That is, we are doing well, but we can do better. It is also worth noting that I recognise that many of these issues may lie outside the remit of readers of this whitepaper, but I include them so that readers have a holistic view of the issues faced by me, my academic peers, and researchers in my group.

First, we must ensure that robust and sustainable funding mechanisms exist, and time from grant application to decision must be reduced; the current year-plus time from submission to funding decision for the EPSRC New Investigator Award harms our youngest and thus most vulnerable (but often our most motivated and original) young researchers. UKRI and other funding organizations could experiment with modified lottery-based mechanisms that reduce reliance on expensive and time-consuming panel reviews, e.g., following a first round of peer review wherein the reviewers mark an application as fundable or not fundable, successful proposals are chosen via lottery. Funding must also continue for curiosity-driven research inside and outside of quantum technologies. Many of our brightest minds in physics develop their skills working in fields outside of quantum technologies before moving into quantum, and we must continue to foster these students.

We must ensure that our ECRs are sufficiently well-paid. PhD students effectively live in poverty, as well as in a limbo between student and professional; other countries treat PhD students like employees, and the UK should consider doing the same. PhD students should be paid at least minimum wage, but they should also pay taxes on those wages. This will make a PhD a lucrative option for a home-fee-paying student (especially one who cannot rely on their families for funding) who would otherwise consider a graduate scheme, which will increase competitiveness for PhD slots and ensure that the best students continue to PhDs, as well as improving diversity within academia, both culturally and socioeconomically. For international students, time as a PhD student should count towards indefinite leave to remain in the UK, and ATAS decisions should be quicker. We must also ensure that UK universities continue to be seen as world-class educational institutions in order to attract the best talent from our allies overseas. Finally, I am a huge proponent of the cohort-driven CDT-type model, as I think that cohort-based learning and networking is a critical component of a PhD. However, the UK government should ensure this does not come at the cost of "traditional" PhDs, especially for universities that do not have ready access to a pool of quantum CDT students.

## What access challenges have you experienced regarding staffing over the past few years?

My main staffing challenges involve the recruitment and retention of the folks that make up the spinal cord of my research group: postdoctoral researchers. A good postdoc is worth their weight in gold and while academic wages will likely never compete with industry, the pay should be good enough that some of our best domestic PhD students are inclined to stay in academic roles; a minimum salary of £40k/yr should be standard. Currently, almost all our best students go into industry roles, and many work for companies outside of the UK; to avoid this academic brain drain a UK postdoctoral role should be seen as desirable for (at least some of) these students. There is also potential utility for making permanent, non-postdoctoral technician roles more of a norm at universities; these roles will allow individuals with master's and PhDs who do not have "traditional" academic aspirations but who enjoy the academic setting to find secure employment. These roles also ensure continuity between students and postdocs in research groups, something that is critical to sustained success within the academic setting, where, by definition, students and postdoctoral researchers are transient. Somewhat anecdotally, I know of at least three individuals at the University of Bristol who would be excellent candidates for such a role; all these individuals would likely welcome such an opportunity.

## What support is required from the government and from private industry, and (related to this) what access challenges have you experienced regarding manufacturing in the last few years?

None of the problems I mentioned in the previous section are unsolvable, but they do require financial commitments from government. Indeed, as I stated previously, the UK is in a very good position—that of a world leader within quantum. The UK is home to a fantastic number of talented researchers and innovators within academia and industry, and government and industry must do their part to foster both its existing and up-and-coming talent. Government must act to mitigate the challenges that I have listed, and industry must work with academia to identify commercially viable technology and methodology as it matures within UK R&D spaces.

For my colleagues and me, the biggest issue we face regarding sourcing the equipment and consumables needed to do our research has been that of finding cost-effective, reliable, and trusted suppliers with reasonable lead times and prompt technical support staff.

Critically, given the current geopolitical state of play, as well as quantum technology's increasingly sensitive nature, both government and industrial sectors must work towards sovereign supply chains for the infrastructure and equipment that is instrumental to quantum technologies. These include CMOS-compatible manufacturing for integrated photonics and electronics, as well as laser light sources, optical fibre, bulk optics, and nonlinear crystals. Photons, in particular, will play a critical role within any practical implementation of quantum technologies, and we must have domestic sources for the kit that makes them tick. However, photonics does not tell the whole story. The NQCC's recent investment in trapped ions and neutral atoms following an initial thrust towards superconducting qubits indicates that there are a variety of quantum systems that show immense promise. We must ensure that researchers have access to the atomic species required for the generation and utilisation of warm and cold atoms, ions, and molecules, including alkali metals like rubidium and caesium, as well as more exotic (and fun) species like strontium, ytterbium, and barium. These systems require a foundation of vacuum and cryogenic technologies, and cryogenics (which require a reliable source of helium) are also the backbone of superconducting technologies.

## Where do you anticipate the next breakthrough coming from outside your own research, and how should it be funded?

Finally, I want to end this piece with some excitement. There is no end to the cool technologies that my peers and colleagues in academia are developing, and I am extremely impressed by what UK industry continues to achieve. It is extremely difficult for me to predict what the next "big breakthrough" in quantum technologies will be, especially if I am asked to look outside of the remit of my own work, but I think that the cold and ultracold molecule work being done by the incredible groups in Durham and Imperial College London (among many others around the world) is some of the most promising in terms of long-term technological maturity. Molecules are difficult to corral and control, but they hold so much promise for quantum information. On a similar note, I think that if they can be controllably implemented and interlinked, vacancy centres like NV centres in diamond offer protected qubits and incredible sensors with promising size and scalability. The field of integrated quantum photonics developed in no small part due to the efforts of Bristol researchers (where I am showing my bias!) is also one with incredible promise in terms of scalability and utility across all spheres of quantum technology, from computation to networking and sensing.

In terms of who should fund this work, I think that, in general, government should fund lower-TRL work, assist in funding mid-TRL work that is moving out of the lab, and industry/venture capital should fund higher-TRL work that is at or nearing the stage of being a commercial product. As such, I think the next big breakthroughs are likely to come out of government-funded academic laboratories, and the next big impacts will be made by industry partners in quantum computing and sensing who are increasing the number of logical qubits in their systems or bringing practical quantum sensors to market.

Clearly, it is difficult to choose just one breakthrough, and it is rare that a day goes by where I don't hear about a new paper or industrial breakthrough that doesn't floor me with its innovation and originality. Quantum is such an exciting space in which to work, and it holds so much promise. Those working in this space are increasingly controlling the most fragile but promising pieces of our world, and this should never cease to amaze and inspire. In such fraught times, the excitement of quantum is palpable and inspiring.

# KETS Quantum

## Where do you see quantum technology in the UK in five years?

The UK has real strengths in quantum research and several areas of early commercial promise. In five years however, the challenge will be whether those strengths have translated into deployed capability, globally significant companies, and retained economic value. The current trajectory of the industry suggests these outcomes are challenging to achieve.

The main risk is not lack of science, but lack of scale. Without stronger commercial pull-through, the UK risks remaining stronger in research than in deployment, while relying increasingly on overseas suppliers for critical capabilities.

In quantum security, the UK has world-leading technical capability, but if deployment remains weak, commercial leadership will not be retained and the economic potential of this sector will be lost.

On the current trajectory for quantum-safe communications, in five years a small number (1-2) of non-domestic large communications primes and systems integrators are likely to offer limited quantum-safe products, representing much of the commercial market.

Bespoke and small-batch systems may continue to serve academic and publicly funded research settings, but volume commercialization is unlikely to have been achieved from within a UK base. It is likely that UK startups in the sector, along with their IP, will have been acquired by international firms, or shut down.

## What are the biggest challenges facing your research or company?

The principal challenge is not technical feasibility, but the absence of a clear domestic adoption pathway.

This is particularly critical in quantum-safe communications. It is welcome that DSIT and UKRI continue to support research, development, and early-stage commercialisation through the National Quantum Technologies Programme. However the current National Cyber Security Centre position on Quantum Key Distribution has had the effect of suppressing private market capital into quantum-safe hardware development - the very capital required to develop appropriate technologies to meet the UK's security objectives. Thus early R&D support for quantum security technologies is valuable, but its impact is severely limited since the direction of broader procurement guidance and deployment policy counteract it.

There is also uncertainty around when the volume commercial quantum-safe communications market will mature, which makes fundraising difficult and slows product development. The absence of a clear pathway to first customers is a greater constraint than the underlying technical challenge. The absence of a government-backed quantum-safe communications transition timeline, particularly ahead of 2030, adds to that uncertainty. Industry is unlikely to move quickly enough on its own if demand remains fragmented.

## Do you believe the UK will maintain its current position in the global market?

The UK currently has strong capabilities in several quantum areas, but its position is far more secure in research than in commercial deployment.

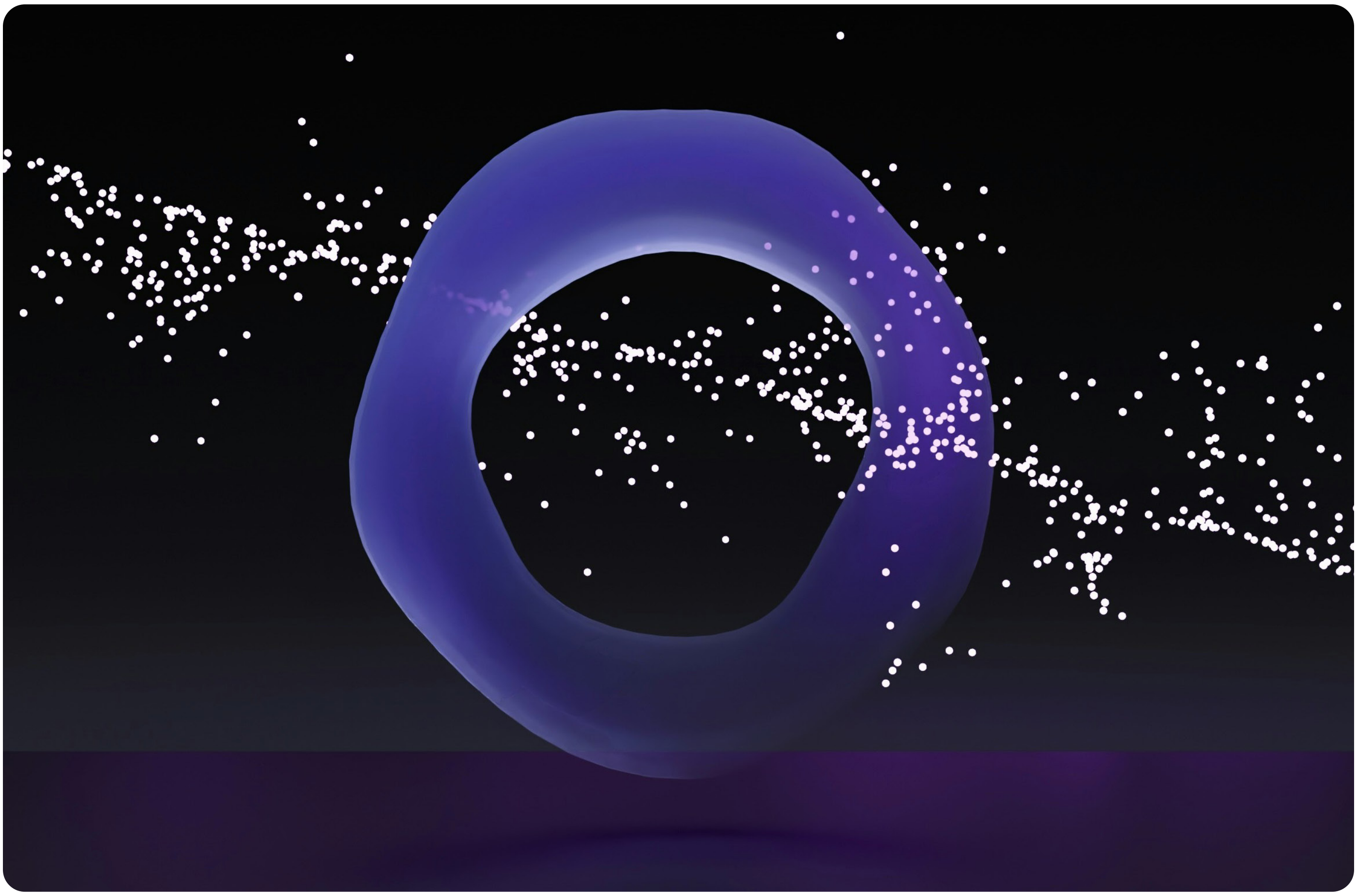
In quantum-safe hardware and broader quantum communications, the UK does not currently hold a major global market position, despite being home to world-leading expertise and critical IP in this area. That commercial market remains led by companies in Switzerland, Israel, the EU, the USA, and Asia.

The UK's quantum security expertise is widely recognised, but current funding and deployment levels remain below the scale seen in the EU and parts of Asia, by orders of magnitude. If the policy environment does not change, the likely outcome is that the UK will not capture any significant global market position in quantum security.

More critically than the obvious lost economic opportunity this represents - this will leave the UK increasingly dependent on overseas providers for secure communications infrastructure, which has clear implications for sovereignty, resilience, and national security.

## What support is required from the government and from private industry?

Alignment across government is important. Early stage funding for research and commercialisation is useful, but it comes up against suppressed commercial uptake if



deployment guidance signals hesitation. The issue is not that one department is wrong and another is right; it is that the overall policy signal on quantum security is not yet coherent.

A more balanced policy position can acknowledge that quantum-safe hardware is not yet a universal solution and identify the challenges to be overcome, while also recognising its significant future potential and strategic importance to UK sovereign security.

That approach would give private capital the confidence to continue investing in UK quantum security companies rather than treating the technology as closed off.

In practice, it would allow UK industry to build evidence from real-world pilots and address open issues in a structured way, and avoid prematurely foreclosing a strategically important capability for future secure communications infrastructure.

Broader efforts to mobilise UK pension capital into domestic scale-ups are welcome, but they are not enough on their own. The British Business Bank should be empowered to lead, not just follow, investment rounds in technologies of strategic importance to the UK. In quantum, where multiple technical pathways need to advance in parallel, the UK cannot wait to "pick winners" only after the threat becomes fully acute.

A portfolio approach is needed now, backing a range of both offensive and defensive capabilities so that sovereign capability and defence-in-depth are in place before the risk crystallises.

Finally, quantum-safe hardware should be treated as a strategic national capability, with the government acting as an early customer. The EU's EuroQCI programme (a €193m public funding programme for quantum-safe networking deployment) is an example of how public funding can support both infrastructure and sovereign supply chains. The UK should adopt a comparable approach through NSSIF, procurement, and targeted support until the volume commercial market is sufficiently mature. A feasibility study for this was undertaken in 2023 however the project has stalled. This would de-risk private investment, and support companies to build products that meet real-world requirements around assurance, interoperability, and security, which the UK has the capability to do.

## Where do you anticipate the next breakthrough coming from outside your own research, and how should it be funded?

In quantum networking, significant progress is expected in entanglement distribution, particularly in link performance and interoperability. This is a foundational capability underpinning secure communications, quantum repeaters, distributed computing, and sensing. However, the UK has critical gaps in such enabling technologies, most notably quantum memories and repeaters. These are essential for scaling quantum networks and achieving long-distance communications, yet research activity in these areas remains limited domestically, despite their centrality to the UK's stated ambitions.

Addressing this requires a coordinated national effort: attracting leading international researchers, substantially increasing targeted R&D funding, and ensuring clear pathways to commercialisation. Without this, the UK risks falling further behind in the security infrastructure required to operate safely in a quantum-enabled world.

## What access challenges have you experienced regarding staffing and manufacturing over the past few years?

As with deep-tech industry as a whole, the quantum sector faces persistent challenges in building a diverse and scalable workforce.

The first issue is talent access. The UK quantum sector still draws heavily from PhD and postdoctoral pipelines, which narrows the pool of candidates and makes it harder to access people from less advantaged socio-economic backgrounds. Geographic clustering around Oxford, Cambridge, Bristol, and London also reinforces recruitment through established academic networks. The second issue is diversity. As highlighted in the UK Quantum Skills Taskforce report, women remain significantly underrepresented in quantum roles and in senior positions. This is not just a social issue; it reduces the available talent pool and weakens the sector's long-term resilience.

Manufacturing access is also a major constraint. Key capabilities such as photonic integrated circuit fabrication, advanced packaging, and bespoke microelectronics remain prohibitively expensive for start-ups. The result is slower iteration, higher capital intensity, and greater dependence on external suppliers.

## Are higher-level apprenticeship programs for lab technicians necessary for lab staffing?

Higher-level apprenticeships for lab technicians would provide some benefit, but their overall impact on quantum companies is likely to be modest given the relatively small number of such roles required.

A more critical gap is the "missing middle" in quantum organisations: mid-level technical, operational, and commercial roles that bridge the gap between academic research and executive leadership. These roles are essential for scaling companies, driving commercialisation, and building a resilient workforce.

Filling this gap would not only accelerate commercial outcomes but also broaden access into the sector, improving diversity and long-term sustainability.

# Dr. Joschka Roffe

EPSRC Quantum Technologies Fellow,
Quantum Software Lab, University of Edinburgh

## Where do you see quantum technology in the UK in five years?

The past decade has seen runaway proliferation of AI technology from scientific concept to society-wide deployment. Quantum technologies are poised for a similar revolution. Recent progress in quantum error correction has established a clear route to the manufacture of scalable, fault-tolerant quantum computers—think of this as the transistor moment of quantum. By 2030, I see that quantum computers will be pushing the limits of what is possible classically, with early applications emerging that promise exponential speedups over conventional approaches and the creation of entirely new multi-billion-pound markets. In parallel, the same period will see material benefits of quantum sensing and communications deployed across sectors including healthcare and finance.

Building on our existing strengths in quantum technology across academia and industry, the opportunity is there for the taking: the UK can establish full-stack capability, from algorithm design to hardware manufacture, and in doing so establish sovereign capability and workforce that will stand the test of time.

## Do you believe the UK will maintain its current position in the global market?

The National Quantum Technologies Programme, launched by Sir Peter Knight in 2014, has laid the foundations for a quantum-enabled UK economy. Through the creation of the UKRI Quantum Technology Hubs and a network of Centres for Doctoral Training, it has established both a world-leading research base and a strong talent pipeline. The recently opened National Quantum Computing Centre (NQCC) is a global flagship, housing ten quantum computers across five distinct qubit platforms: no comparable facility worldwide brings together so many quantum computers under the same roof!

Maintaining this position, however, will depend on translating scientific leadership into commercial scale. The UK has faced similar inflection points before. In both semiconductor manufacturing and AI, early leadership in foundational science did not translate into sustained industrial prominence, leaving us reliant on external providers for critical technologies. Quantum presents an opportunity to break from this pattern, but only with decisive and coordinated action.

The UK has been highly successful in fostering quantum computing start-ups, with more than one hundred companies now based here. The challenge emerges at the transition from start-up to scale-up, where access to growth capital can fall short of requirements. As a result, we have seen several successful UK-founded companies relocate to the USA, where deeper pools of late-stage investment are available. Government procurement programmes, such as the recently announced Innovate UK ProQure initiative, play an important role in signalling confidence and attracting further investment. Building on this, further measures could include dedicated scale-up investment funds for quantum companies, potentially developed in partnership with European collaborators. Such mechanisms would help ensure that UK-founded companies can grow from startup to public trading while remaining anchored in the UK.

An increase in investment capital is part of the solution, but measures should be put in place to ensure this is correctly directed. One of the UK's greatest strengths is the breadth of its quantum ecosystem. With multiple hardware approaches and a rich software and theory landscape, the UK is well hedged against uncertainty in which technologies will ultimately prove dominant. Yet this diversity also creates a challenge: as the field matures and clear winners begin to emerge, the ability to pivot quickly will be crucial.

This is where rigorous, data-driven evaluation becomes essential. At the Quantum Software Lab in Edinburgh, working with colleagues at the NQCC, our work focuses on developing robust frameworks for the characterisation and benchmarking of quantum computing devices. By establishing clear standards and performance metrics, we aim to enable informed, evidence-based decisions across the ecosystem to ensure effort can be directed at the quantum technologies that will bring the greatest returns.

## What are the biggest challenges facing your research or company?

A persistent challenge for university research groups is the lack of job security and clear career pathways for early-career researchers. The UK has built an excellent network of doctoral training centres, producing a strong pipeline of talent in quantum technologies and other priority areas. But to fully benefit from this, we need to ensure there are enough opportunities, with competitive pay and stability, to keep these graduates in the UK. The issue is most acute at the postdoctoral level, typically the first step after a PhD. Postdoctoral researchers are a critical part of any research group. They drive experiments, develop new methods and theory, and provide much of the day-to-day momentum behind research progress. In many ways, they are the engine room of scientific innovation. Yet despite their critical role, near-all postdoctoral roles in the UK are employed on short-term contracts—sometimes as low as six months and rarely more than a few years—with salaries that compare badly to other careers requiring similar levels of training. The incentives to remain are weak, and many of the most capable researchers leave the UK.

It does not have to be this way. The UK can be the best place in the world to build a scientific career in quantum technologies, but that requires taking early-career stability seriously. Improving pay and providing longer-term security would go a long way. The benefits are clear: stronger retention of UK-trained talent, more stable and effective research groups, and the ability to build the long-term capability needed to tackle genuinely hard problems.

There is also a clear commercial benefit. Postdoctoral researchers sit at exactly the right point between deep technical expertise and practical experience. They are often the people who go on to found spinouts and translate research into real products. Supporting them properly is not just about academia, it is an investment in the entire quantum ecosystem.

## Outside of your own research, where do you anticipate the next breakthrough, and how should it be funded?

Outside of quantum, the defining technological development of the past decade has been the development of AI tools. The impact on scientific research has already been substantial. In the near term, the most immediate benefit is the speed with which code can be written and, by extension, the rate at which new theories and designs can be tested. Further applications include automated calibration of experimental devices and AI-assisted theorem proving. Large language models are not yet at the point of making meaningful, original contributions to quantum theory, but more advanced agentic approaches may well change this in the years ahead. The way we do science is changing, and remaining competitive in the quantum technology sector will require us to integrate these new capabilities into our standard research workflows.

Doing so effectively will require government support for data centre infrastructure and the resources to develop sovereign AI models capable of powering research agents without dependence on external providers. Government funding streams should be created towards research into the integration of AI methods into quantum computing and technologies programmes, treating this not as a peripheral concern but as a core component of the UK's quantum strategy.

Equally important is education. From school level through to university, we must prepare the next generation for an AI-enabled workforce. The benefits of this new technological era will accrue to those who understand how to deploy these tools effectively and cost-efficiently, and we must ensure that future generations are equipped with the necessary skills.

## Is there a need for higher-level apprenticeship programs for lab technicians?

Yes, and this is a meaningful gap in the current skills landscape. The traditional route into quantum technology is an undergraduate degree in a STEM subject followed by a more specialised postgraduate qualification. This has served the sector well during the period in which it has been predominantly research driven. However, as the quantum industry grows, so will the demand for highly skilled lab technicians capable of operating and maintaining complex quantum hardware: cryogenic systems, vacuum equipment, precision optics, RF electronics, and more. Higher-level apprenticeship programmes are well suited to meeting this need, offering a more scalable and inclusive route into the sector than one that routes all talent through full academic degrees. Such programmes should be designed in partnership between universities, quantum companies, and further education providers to bring in talent from a wider demographic.

## What specific support is needed from the government and from private industry?

**Support for Fundamental Science.** The National Quantum Technology Programme has been a flagship initiative, and government funding must scale in step with the expected growth of the sector. This means continued and expanded long-term investment in fundamental research at universities and research institutes through National Hubs, Centres for Doctoral Training, and PhD studentship schemes. Alongside this, technology transfer should be actively supported through collaborative industry-academia funding streams and staged procurement programmes, ensuring that the industry remains grounded in scientific innovation whilst moving progressively towards practical deployment.

**Support for the Quantum Industry.** The UK hosts a large and growing number of quantum technology companies, but access to capital at later stages remains materially constrained relative to the opportunities available in the USA. The availability of later stage capital should be improved through continued support for government procurement exercises, in addition to exploring Europe-wide collaboration to provide access to a venture ecosystem that is world leading.

**Reforming Career Pathways for Quantum Researchers.** The current system of short-term contracts for early-career researchers is not fit for purpose and is actively undermining our ability to attract and retain world-leading talent. A government review is required to examine how career pathways for post-doctoral and early-career researchers can be reformed, so that building a career in quantum technologies in the UK is a genuinely secure and attractive prospect. Without this, the talent pipeline that underpins both our research base and our commercial sector will continue to leak at precisely the point where it matters most. This review should also explore the creation of alternative routes into the quantum industry, for example through apprenticeship programmes.

**Infrastructure for AI enabled science.** The integration of AI into quantum research workflows requires deliberate investment in the underlying infrastructure that makes sovereign capability possible. Government funding directed towards UK-based data centre capacity and the training of accessible, publicly governed AI models would equip research communities with tools whose priorities align with public research goals.

# Dr. Nick Chancellor

Lecturer, Newcastle University

## Where do you see quantum technology in the UK in five years?

Since my area is quantum computing and simulation I will focus there rather than quantum in general. I do think there will be great advances in sensing, timing, communication etc... but others are better placed to estimate where those areas will be. As far as computing, I think we will still be in the late NISQ era, but with substantial progress toward fault tolerant operation, and laboratory proof-of-principle in this direction being produced. I think there are still room for substantial theoretical advances in quantum error correction and these advances will play an important role in the path toward utility-scale fault tolerance. I believe the first genuinely useful niche applications of quantum computing/simulations will have started to materialise. A potential early area for a win here is analogue quantum simulation, for example in cold-atom Rydberg systems. I also think that strong secondary impacts from quantum-inspired algorithms will start to be felt, for example the use of advanced tensor network simulations to solve problems. Further indirect impacts will have come from the fact that quantum has changed the way in which many in computing think about solving their problems, for example working on quadratic rather than linear optimisation. I think there will be an increasing emphasis on co-locating quantum devices in HPC environments, and devices will begin to be included as parts of the offerings within the UK HPC infrastructure.

I do not see one underlying technology emerging as a single overall "winner" but rather a focus of different device types toward tasks which suit their strengths. For example, superconducting circuit technologies are able to produce many samples from distributions very quickly, but may be subject to errors, making them well suited to machine-learning and possibly optimisation related tasks. On the other hand atom and ion technologies have much slower operations, which allow time for corrections to be calculated, and make them more suited to work toward fully error-corrected computation. As such I believe the UK would do well to continue to support a broad portfolio of quantum-computing-related research, both in theory and experiment

## What are the biggest challenges facing your research or company?

Consistency of funding has been an issue for us, not so much the amount which is available but the timing. For example we completed a very successful InnovateUK feasibility study project with an industrial partner which was eager to follow up on the next steps, only to find that no quantum calls were available for us to apply to. Calls also often come with short notice, meaning that consortia have to be put together quickly and this ability, rather than the quality of the work often seems to determine what gets funded.

Being able to recruit internationally is also a challenge, in particular at a postgraduate level. Based on cost, Universities are often only able to fund home students, so we have no choice but to turn away very talented international applicants. Having more routes to fund postgraduates would be useful.

## Do you believe the UK will maintain its current position in the global market?

Yes, assuming the UK continues or increases the support for quantum technologies programs and retains its strength in university research. I think the UK can maintain its current position. I think the biggest threat the UK faces here is overseas companies and academic institutions being able to lure away quantum talent. I think the best way to avoid this is to make sure the UK is an attractive place for both industry and academics with the quantum sector, at all career stages. Part of this involves making sure that UK academic institutions are attractive places to work (not just in terms of available research funding, but also other factors such as workloads and salaries). This also should not just focus on making sure they are attractive to the top researchers, but also to early career researchers who will become the next stage of research leaders and smaller groups which drive steady progress in a way which is often invisible outside of science. My general view is that the biggest threat to the success of quantum technologies in the UK is the current academic climate, many universities are in a very precarious financial position and that impacts both the quality of outputs from current staff (and the ability to retain them) and the ability to recruit new workers to expand the quantum efforts.

## What support is required from the government and from private industry?

The government needs to continue to provide funding for diverse academic research within quantum, which will underpin advances in quantum technologies, in addition to funding institutions such as the National Quantum Computing centre. While quantum will inevitably become more application-focused, the underpinning research which drives the field will still have to go forward in an academic setting. As I mentioned previously, a huge indirect factor here will be the UK ensuring that UK academia is competitive and attractive for relevant talent, this means making sure that universities have stable funding, and are operating in a supportive environment. Supporting businesses so that the UK quantum industrial landscape is attractive is also important, but my impression is that this is something the UK also does well.

I see private industry as playing the role of exploring and developing direct applications of quantum technologies, as well as scaling up the advances which are made in the laboratory. I do believe caution should be taken in relying too much on private industry, particularly startups, as their incentives are not always well aligned to national priorities and they can pivot quickly based on the funding environment and are strongly effected by hype cycles. For this reason, while the government can and should leverage private industry in developing quantum technology, care should be taken in making assumptions on what industry will or will not do and at what specific times. This is part of why the academic institutions involved in quantum need to be protected. While quantum computing and simulation will probably move to be a more industrial topic in the next five years, the underpinning work in universities is crucial (this will even be true when the field fully matures, some important work will not be economical to perform industrially).

## Outside of your own research, where do you anticipate the next breakthrough, and how should it be funded?

I think this is by-definition hard to predict, but two areas which I would watch are analogue quantum simulation for condensed matter physics, where devices are now starting to be able to exceed what can be done in simulation. The second is quantum inspired algorithms, making use of the tools which have been used to disprove quantum advantages directly in quantum computing. Neither of these are considered "mainstream" areas, so they underscore the need to fund a broad portfolio of academic research within the space of quantum computing and simulation. Ensuring that the basic science which supports quantum applications remains well funded is also essential.

## What access challenges have you experienced regarding staffing and manufacturing over the past few years?

My work is theoretical and numerical so I do not have manufacturing needs, as for staffing, I think the biggest issue I have faced is being able to provide a stable and continuous contract for postdocs. Much of my funding has come through small projects which offer short contract extensions. I think this is part of a broader conversation about how academic research is supported. While this hasn't been an issue for me yet, I do worry how immigration policy changes could reduce my future ability to recruit postdocs internationally, something which is crucial for many groups.

## Are higher-level apprenticeship programs for lab technicians necessary for lab staffing?

I do not perform laboratory research but from talking to colleagues who do work in experimental physics, it seems that maintaining the expertise within their labs is a real challenge. In particular, a steady stream of postgraduate students is needed so that the current students can train the new students before they leave. I could see this problem being alleviated by having technicians with higher level expertise on non-fixed-term contracts. Apprenticeship programs to train such technicians would be one component of this, but also ensuring that they are actually employed and maintained at relevant institutions would also be important, especially given how difficult the financial situation is at many institutions. Getting such a program to work may also require developing a new long-term funding mechanism. My impression is that funding, not availability of candidates, is what currently limits the number of staff technicians at academic institutions, but this impression may be wrong. Any program like this will need a holistic approach to ensure that the technicians are trained in what is needed and can be retained.

# Dr. Jessica Wade

Assistant Professor in Functional Materials, Imperial College London

## Where do you see quantum technology in the UK in five years?

Within five years, we expect to see a significant increase in investment into quantum sensors and a corresponding rise in the number of sensor-based spin-outs emerging from UK universities. Quantum sensors should be deployed at meaningful scale in key sectors including healthcare, environmental monitoring, navigation and defence, where the technology is already closest to operational readiness. Quantum computers will begin to see early use in finance, optimisation, drug discovery, and energy applications — including, for example, the identification of new materials for batteries and solar panels — and we anticipate that government departments and public institutions, including the Bank of England, will be among the early adopters. International collaboration is likely to remain patchy, shaped by a rapidly evolving geopolitical landscape, the bedding-in of the new Trusted Research approach, and the lag caused by delayed strategic decision-making. On the institutional side, we expect the NQCC's purpose to become clearer and its strategy more focused, accompanied by greater public awareness of what quantum technologies actually do.

## What are the biggest challenges facing your research or company?

The most pressing challenge is finding skilled and enthusiastic researchers who can clear ATAS and visa requirements. Clearance often takes so long that the candidate has accepted another role elsewhere by the time it is granted. Retaining existing talent is equally difficult against the backdrop of global competition: higher salaries and longer contracts are readily available overseas, and the gap between academic and industry pay makes it especially hard to keep brilliant people in universities. Beyond people, we face the challenge of opening access to quantum for those outside physics — engineers and others without formal quantum training who could otherwise contribute to the field. Funding access is a further constraint, both for discovery and early-stage science and for researchers operating outside the EPSRC quantum hub framework, and we continue to need better access to fabrication and characterisation infrastructure of the appropriate quality.

## Do you believe the UK will maintain its current position in the global market?

In some areas — most notably sensing, timing and basic research — yes; in others, including computing and communications, less so.

## What support is required from the government and private industry?

Government support in a number of areas would build further confidence in the sector and help to unlock complementary investment from industry. The first is open, accessible, up-to-date and state-of-the-art infrastructure, co-identified with other critical technologies such as semiconductors, AI and engineering biology, and developed alongside innovators. Linked to this is the need for rapid prototyping and scale-up space, supported by local government. There is also a clear case for backing closer academic and end-user engagement to enable sector-specific development and field trials, and for improving coordination across what remains a fragmented quantum landscape — particularly within defence.

Clearer guidance is needed on visa routes and indefinite leave to remain, on supply chains, and on the definition of sovereignty — especially in the context of "sovereign capability." Further clarification of the "own, collaborate, access" framework as it applies to quantum technologies would help, ideally accompanied by a taxonomy, drawn up with government support and technical advice from the sector, indicating which technologies, platforms or areas of research sit in each category. Better coordination of UK photonics activities and stronger linkages between quantum and adjacent areas — semiconductors, PNT, AI — would also pay dividends.

Long-term funding commitments matter a great deal: a ten-year pledge to the NQCC, for example, would make it considerably easier to attract and retain talent. Support is also needed to help existing enabling technology capabilities, such as electronics and software, work effectively with the quantum community — including access to finance that accommodates the low initial yields characteristic of early-stage development. Finally, a sustained commitment to funding the discovery and early-stage science that underpins future quantum technologies is essential.

## Outside of your own research, where do you anticipate the next breakthrough, and how should it be funded?

We expect significant breakthroughs to emerge from several areas, all of which fall squarely within the remit of discovery-led science funding through the research councils. These include room-temperature superconductors; nuclear clocks; molecular sensors and qubits, whose rich internal structure enables new interactions to be exploited but which are correspondingly harder to control; and higher-frequency, higher-temperature superconducting qubits, which would enable computing without the need for dilution fridges.

## What access challenges have you experienced regarding staffing and manufacturing over the past few years?

On staffing, the chief concerns are the quality and diversity of the eligible applicant pool and delays to research programme starts caused by ATAS and visa checks. Overseas PhD student fees remain a major barrier, deterring many of the world's strongest scientists from coming to the UK and representing a significant missed opportunity to attract and retain top talent. On the manufacturing and equipment side, key challenges include access to stable, rugged, high-performance lasers and the persistent difficulty of integration and packaging.

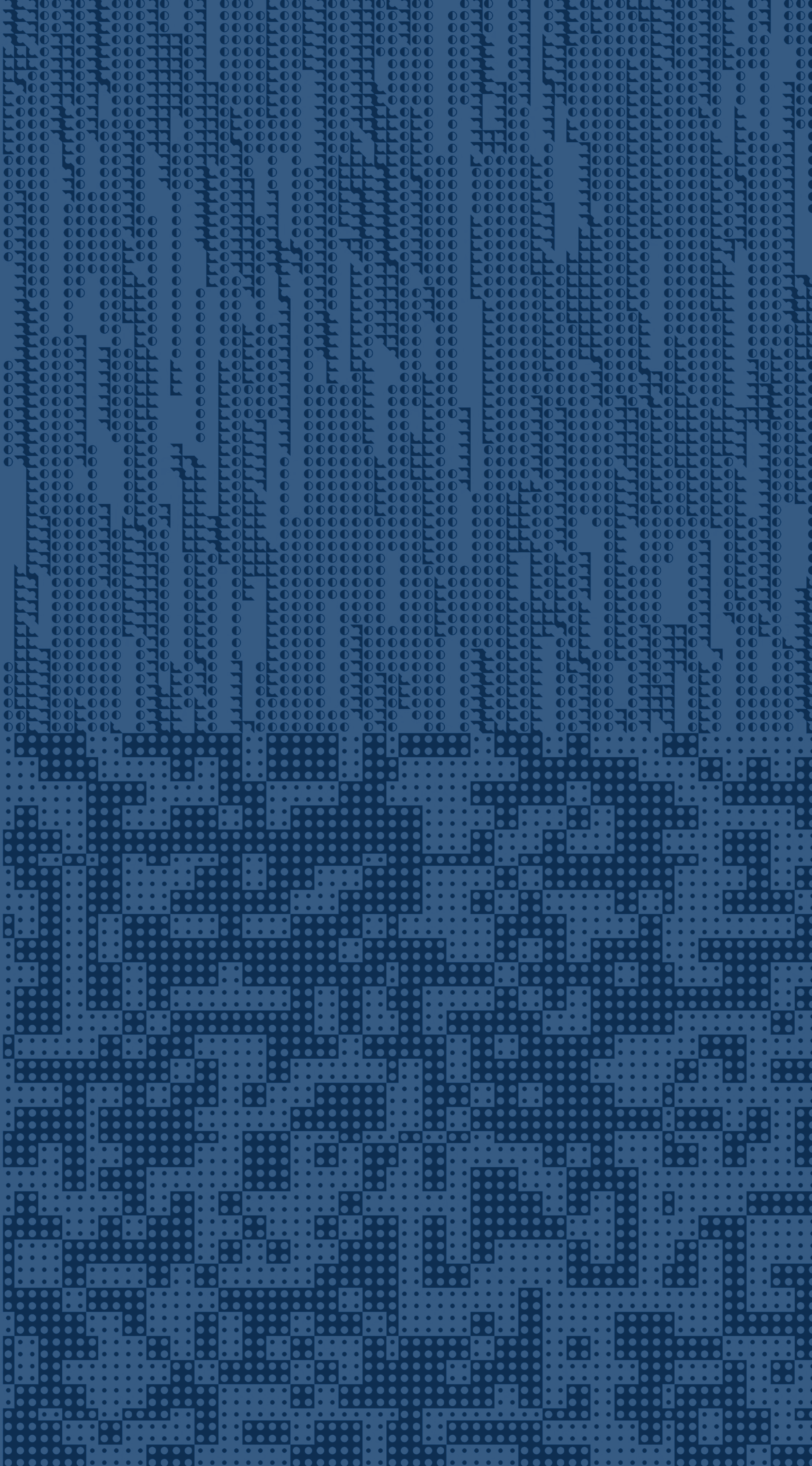
## Are higher-level apprenticeship programs for lab technicians necessary for lab staffing?

Yes. Higher-level apprenticeships, engineering microcredentials and broader upskilling opportunities are needed to build the quantum workforce. It is worth noting that most of the skills involved are not unique to quantum, and apprenticeship programmes should be designed to help technicians and engineers upskill in areas such as vacuum technology, radio frequency and microwave electronics, electrical engineering, design and precision engineering, additive manufacturing, materials and cryogenics. These skills will transform their employability not just in quantum but across a range of related fields including AI, engineering biology, telecoms and semiconductors. STFC and EPSRC are well placed to support this work. Alongside it, we need to rethink technical career pathways in both universities and industry, and to work with the Technician Commitment to formalise and optimise training opportunities so that they are accessible, sustainable and scalable.

COMPUTING FIELDS

CLASSICAL

QUANTUM



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