

# THE RACE FOR QUANTUM TECHNOLOGY IN ASIA

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The race to harness the power of quantum technology has become a significant focus for countries worldwide. In recent years, Asia has emerged as a key player in this race, with countries such as China, Japan, and Singapore making substantial investments in quantum Research and Development (R&D). It has been considered the ally of new-age technologies like Artificial Intelligence (AI) and Machine Learning (ML).

Quantum technology refers to the practical application of principles derived from quantum mechanics, a branch of physics that describes the behaviour of matter and energy at the smallest scales, such as atoms and subatomic particles.<sup>1</sup> Quantum technology harnesses these principles to develop devices and systems with capabilities that go beyond what is achievable using classical physics.

Key components of quantum technology include:

- **Quantum Computing:** Utilises quantum bits, or qubits, which can exist in multiple states simultaneously due to phenomena such as superposition and entanglement. Quantum computers have the potential to solve certain problems much faster than

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1. "What is Quantum Computing?", *IBM*. Accessed on April 12, 2024.

classical computers, particularly in areas such as cryptography, optimisation, and simulation.

- **Quantum Cryptography:** Relies on the principles of quantum mechanics to create secure communication channels. It utilises properties such as the uncertainty principle and the no-cloning theorem to ensure that any attempt to intercept the communication is detectable, providing a higher level of security compared to classical cryptography.<sup>2</sup>
- **Quantum Sensing and Metrology:** Employs quantum properties to develop highly sensitive sensors and measurement devices. Examples include quantum-enhanced imaging, atomic clocks, and magnetometers, which offer superior precision and accuracy compared to their classical counterparts.<sup>3</sup>
- **Quantum Communication:** Involves the transmission of quantum information over long distances using quantum states as carriers. Techniques such as quantum teleportation and quantum key distribution enable secure and efficient communication networks resistant to eavesdropping.
- **Quantum Materials and Devices:** Explores novel materials and devices engineered to exhibit quantum properties for various applications. This includes quantum dots, superconductors, and topological insulators, which hold promise for advancements in electronics, photonics, and energy storage.<sup>4</sup>

The ‘quantum race’ refers to the global competition among countries, research institutions, and companies to achieve breakthroughs in quantum technology and gain a competitive advantage in shaping future technological landscapes. This race is significant for several reasons:

**Technological Leadership:** Success in the quantum race can establish a country or organisation as a leader in emerging quantum

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2. Alexander S. Gillis, “What is Quantum Cryptography?”, *Tech Target*, January 2022, [techtarget.com](https://techtarget.com). Accessed on April 12, 2024.
  3. L.J.Fiderer and D. Braun, “Quantum Metrology with Quantum-Chaotic Sensors”, *Nat Commun* 9, 1351, 2018, <https://doi.org/10.1038/s41467-018-03623-z>. Accessed on April 12, 2024.
  4. Robert Cava, “Quantum Materials”, *Chemical Reviews*, March 10, 2021, Introduction: Quantum Materials | Chemical Reviews (acs.org). Accessed on April 13, 2024.

technologies. Being at the forefront allows for the development of foundational intellectual property, setting standards, and influencing the direction of future technological advancements.

**Economic Growth:** Quantum technology has the potential to drive economic growth by creating new industries, products, and services. Countries and companies investing in quantum research and development aim to capitalise on these opportunities, fostering innovation, job creation, and revenue generation.

**National Security:** Quantum technology has implications for national security, particularly in areas such as cryptography, communication, and defence. Nations are investing in quantum research to enhance their capabilities in securing communications, protecting sensitive information, and developing advanced defence systems.

**Scientific Discovery:** The pursuit of quantum technology advances our understanding of fundamental physics and expands the boundaries of scientific knowledge. Breakthroughs in quantum computing, for example, may lead to insights into complex phenomena, such as materials science, chemistry, and the nature of the universe.

**Global Collaboration:** While there is competition in the quantum race, there is also collaboration among researchers, institutions, and countries. International partnerships facilitate knowledge exchange, resource sharing, and collective progress in overcoming common challenges, accelerating the development and adoption of quantum technologies worldwide.

**Addressing Societal Challenges:** Quantum technology has the potential to address pressing societal challenges, including healthcare, climate change, and energy sustainability. Quantum computing, for instance, could revolutionise drug discovery, optimise renewable energy systems, and simulate complex environmental systems to inform policy decisions.

**Ethical and Policy Considerations:** The quantum race raises ethical and policy considerations related to privacy, security, and governance. As quantum technologies become more powerful, policy-makers need to address issues such as data privacy, encryption

standards, and regulation to ensure responsible development and deployment.

Asia, including countries such as China, Japan, South Korea, and Singapore, plays a significant role in the global quantum race, contributing to advancements in quantum technology through research, investment, and collaboration. The following section highlights Asia's contribution:

**Research and Development:** Asian countries have made substantial investments in quantum R&D, establishing world-class research institutes and laboratories focussed on quantum science and technology. These institutions conduct cutting-edge research in areas such as quantum computing, quantum communication, and quantum sensing, contributing to advancements in the field.

- **Government Initiatives:** Governments in Asia have launched strategic initiatives to support quantum research and innovation. For example, China has implemented its National Laboratory for Quantum Information Sciences and the Quantum Exascale Computing Initiative, aiming to achieve breakthroughs in quantum computing and secure communication.<sup>5</sup> Japan has also invested in quantum technology through programmes like the Quantum Leap Flagship Programme, focussing on quantum computing and simulation.<sup>6</sup>
- **Industry Collaboration:** Asian companies, particularly in the technology and telecommunications sectors, are actively engaged in quantum R&D. Companies in countries like China and Japan are partnering with research institutions and universities to advance quantum technologies and explore potential applications in areas such as finance, healthcare, and cyber security.
- **Education and Talent Development:** Asian countries are investing in education and talent development to cultivate a skilled workforce in quantum science and engineering. Universities in Asia offer specialised programmes and courses in quantum information science, attracting students and researchers

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5. Jeffrey Lin, "China is Opening a New Quantum Research Supercenter", *Popular Science*, October 10, 2017, popsci.com. Accessed on April 13, 2024.

6. "Japanese Joint Research Group Launches Quantum Computing Cloud Service", April 13, 2023, NICT - National Institute of Information and Communications Technology. Accessed on April 14, 2024.

from around the world. Additionally, initiatives such as summer schools, workshops, and training programmes contribute to building a vibrant quantum ecosystem in the region.

- **International Collaboration:** Asian countries participate in international collaborations and partnerships to advance quantum research and share knowledge and resources. Collaborative efforts include joint research projects, exchange programmes, and participation in global initiatives such as the Quantum Internet Alliance<sup>7</sup> and the Quantum Flagship programme of the European Union (EU).
- **Commercialisation and Innovation:** Asian countries are exploring opportunities to commercialise quantum technologies and drive innovation in the private sector. Start-ups and venture capital firms in Asia are investing in quantum start-ups and technologies, aiming to bring quantum-enabled products and services to the market and capture opportunities in emerging industries.

The strategic importance of quantum technology lies in its potential to revolutionise various aspects of computing, communication, cryptography, and sensing. Quantum technology leverages the principles of quantum mechanics to enable capabilities that are not achievable with classical technology. Given below are some key aspects of the strategic importance of quantum technology.

### *Quantum Sensing*

Quantum sensors offer high-precision measurement capabilities, surpassing the limits of classical sensing technologies. Applications include quantum metrology, gravitational wave detection, magnetic field sensing, and medical imaging. Quantum sensors have potential applications in navigation, environmental monitoring, healthcare, and defence.

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7. "Building a Global Quantum Internet Made in Europe", Quantum Internet Alliance. Accessed on April 14, 2024.

### *Strategic Competitiveness*

Nations and companies investing in quantum technology aim to gain a competitive edge in various sectors. Leadership in quantum technology can enhance economic competitiveness, drive innovation, and shape global technological standards. Quantum technology is considered a strategic asset with implications for national security, defence, and intelligence.

### *Scientific Discovery*

Quantum technology enables researchers to explore fundamental questions in physics, chemistry, and materials science. Advancements in quantum science led to new discoveries and insights into the nature of quantum phenomena. Quantum research contributes to the advancement of scientific knowledge and drives interdisciplinary collaborations.

### *Global Leadership*

The race for quantum technology reflects broader geopolitical dynamics, with countries vying for leadership in science and technology. Leadership in quantum technology can influence geopolitical power dynamics and shape the balance of influence in the global arena. Countries investing in quantum research and development aim to establish themselves as leaders in the next generation of technology.

## **QUANTUM PROFILE OF THE STATES**

### *China*

China has made significant advancements in quantum technology, particularly in quantum computing and quantum communication. China has been investing heavily in quantum computing research and development. In 2020, it unveiled the Jiuzhang, a quantum computer claimed to perform a calculation in minutes that would take the world's fastest classical supercomputers tens of thousands of years.<sup>8</sup> However, it is essential to note that there is an ongoing debate

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8. Jeff Pao, "China Unveils Faster Hight-Based Quantum Computer", *Asia Times*, October 13, 2023. Accessed on April 14, 2024.

and scepticism within the scientific community about the practicality and true quantum nature of some of China's quantum computing achievements.

China launched the world's first quantum communication satellite, Micius (or Mozi), in 2016.<sup>9</sup> This satellite enabled experiments in Quantum Key Distribution (QKD), a secure form of communication using quantum principles. China has been actively working on expanding its quantum communication network, with the goal of creating a global quantum communication infrastructure for secure communication.

China has been investing in fundamental research in quantum mechanics, quantum information theory, and related fields. It has established research institutes and universities dedicated to quantum science and technology, such as the Chinese Academy of Sciences (CAS) and the University of Science and Technology of China (USTC).

The Chinese government has included quantum technology as a priority in its strategic plans, such as the Made in China 2025 initiative<sup>10</sup> and the Quantum Science Satellite Programme.<sup>11</sup> These initiatives aim to propel China to the forefront of quantum technology research and development globally.

Moreover, China actively collaborates with international partners in quantum research while also competing with other countries, particularly the United States. There is a race among the major powers to achieve breakthroughs in quantum technology due to its potential implications for national security, economic competitiveness, and scientific advancement.

### *Japan*

Japan also has a significant presence in the field of quantum technology, although its approach and focus may differ from those of China or other countries.

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9. "Micius Quantum Communication Satellite", *Aerospace Technology*, August 2016, aerospace-technology.com. Accessed on April 15, 2024.

10. Scott Kennedy, "Made in China 2025", *CSIS*, June 1, 2025, csis.org. Accessed on April 15, 2024.

11. Jacob Aron, "China Launches World's First Quantum Communications Satellite", *New Scientist*, August 16, 2016. Accessed on April 15, 2024.

Japan has a long history of excellence in science and technology research, and quantum technology is no exception. Japanese universities and research institutions, such as the University of Tokyo, Kyoto University, and National Institute of Informatics, are actively engaged in quantum research across various disciplines, including quantum computing, communication, sensing, and cryptography.

Japan is making strides in quantum computing research and development. It has several research initiatives and collaborations aimed at advancing quantum hardware, algorithms, and applications. Japanese companies like NEC, Fujitsu, and Toshiba are investing in quantum computing projects and exploring its potential for various applications, including optimisation, simulation, and cryptography.<sup>12</sup>

Japan is also involved in research and development related to quantum communication and cryptography. Efforts are underway to develop secure communication networks based on QKD and other quantum cryptographic protocols. Japan's National Institute of Information and Communications Technology (NICT) is actively working on quantum communication technologies.

Japan collaborates with other countries and participates in international initiatives to advance quantum technology. Collaborative projects with the European countries, the United States, and other partners allow Japan to leverage expertise, resources, and knowledge sharing in the field of quantum science and technology. The Japanese government recognises the importance of quantum technology for future innovation and competitiveness. It has launched strategic initiatives and funding programmes to support quantum research and development, such as the Moonshot Research and Development Programme, which includes quantum technology as one of its focus areas.<sup>13</sup>

Japan possesses significant expertise and capabilities in quantum technology, with ongoing research efforts aimed at advancing quantum computing, communication, and related fields. While perhaps not as prominently featured in the media as other countries,

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12. Berenice Baker, "The Japanese Government Wants 10M Quantum Computer Users by 2030", *IOT World Today*, April 4, 2022, [iotworldtoday.com](https://www.iotworldtoday.com). Accessed on April 14, 2024.

13. "The Moonshot Research and Development Program: Challenging Research and Development Towards the Future", *North America Analysis*, October 18, 2019, [openaccessgovernment.org](https://openaccessgovernment.org). Accessed on April 15, 2024.



Japan's contributions to the global quantum landscape are noteworthy and contribute to the broader advancement of quantum science and technology.

### *South Korea*

South Korea has been steadily building its capabilities in the field of quantum technology. South Korea has been investing in quantum R&D across various institutions and universities. Organisations such as the Korea Institute of Science and Technology (KIST), Korea Advanced Institute of Science and Technology (KAIST), and the Institute for Basic Science (IBS) have been actively involved in quantum research, including quantum computing, communication, and sensing.

South Korea has been focussing on advancing quantum computing technologies. Research efforts aim to develop quantum hardware, algorithms, and software tailored to specific applications. Companies like Samsung Electronics have been exploring quantum computing as part of their long-term research and development strategies.

South Korea is also investing in quantum communication and cryptography. Research initiatives focus on developing secure communication protocols based on quantum principles, such as QKD. This includes collaborations between academia, industry, and government agencies to advance quantum communication technologies. Its government has recognised the strategic importance of quantum technology and has launched initiatives to support its development. Programmes like the Quantum Information Research Support Project provide funding and resources to researchers and institutions working in quantum science and technology.<sup>14</sup>

Korea also actively collaborates with international partners in the field of quantum technology. Collaborative projects and partnerships with countries like the United States, European Union, and other Asian nations allow South Korea to leverage expertise and resources for advancing quantum research and development. South

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14. James Dargan, "A Brief Overview of Quantum Computing in South Korea In 2023", *The Quantum Insider*, July 28, 2023, [thequantuminsider.com](https://thequantuminsider.com). Accessed on April 15, 2024.

Korea is also focussed on building a skilled workforce in quantum technology. Universities offer programmes and courses in quantum science and engineering to train the next generation of researchers and professionals in the field.

Furthermore, it is making significant strides in quantum technology, with research efforts spanning quantum computing, communication, cryptography, and other related areas. South Korea's contributions to the advancement of quantum science and technology are noteworthy and contribute to the broader international landscape.

### *India*

India has been steadily increasing its focus on quantum technology and is investing in research and development in this field. Indian academic institutions and research organisations have been actively engaged in quantum research. Institutions like the Indian Institutes of Technology (IITs), Indian Institute of Science (IISc), Tata Institute of Fundamental Research (TIFR), and the Centre for Quantum Technologies (CQT) at the Indian Institute of Science Education and Research (IISER) are conducting research in quantum computing, communication, cryptography, and other related areas.

India is making efforts to develop quantum computing technologies. Research initiatives focus on both hardware and software aspects of quantum computing. The Indian government has established the National Mission on Quantum Technologies and Applications (NMQTA) to accelerate research and development in quantum computing and related areas.<sup>15</sup>

India is also exploring quantum communication and cryptography technologies. Research efforts aim to develop secure communication protocols based on quantum principles, such as QKD. Collaborative projects among academia, industry, and government agencies are working to advance quantum communication technologies.

The Indian government has recognised the strategic importance of quantum technology and has launched initiatives to support its development. In addition to the National Mission on Quantum Technologies and Applications (NMQTA), other initiatives include

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15. Amitabh Sinha, "What is the Rs 6,000 Crore National Quantum Mission, and What it Means for Science in India", *Indian Express*, April 27, 2023. Accessed on April 15, 2024.

funding for quantum research projects through agencies like the Department of Science and Technology (DST) and the Defence Research and Development Organisation (DRDO).

India collaborates with international partners in quantum research and development. Collaborative projects and partnerships with countries like the United States, European Union, and other nations allow India to leverage expertise and resources for advancing quantum technology. Indian universities are incorporating quantum science and technology into their academic programmes. Efforts are being made to train a skilled workforce in quantum technology through specialised courses, workshops, and research programmes.

### **ROADMAP FOR INDIA'S QUANTUM LEAD**

India has immense potential to excel in quantum technology. It needs to focus on several key areas to realise its goals. These key areas include R&D expenditure. India ought to allocate a substantial portion of its resources towards the advancement of quantum science and technology. This covers financing for theoretical and experimental research as well as joint ventures with educational establishments and business associates., India must prioritise creating a skilled workforce with expertise in quantum science and technology. To do this, scientists, engineers, and technicians with knowledge of quantum computing, quantum cryptography, and related subjects must be trained. Building quantum laboratories infrastructure for quantum technologies such as metrology, computing, and communication is fundamental to develop India's quantum capabilities.

Encouraging industry-academia collaboration is also an important aspect. The effective development and commercialisation of quantum technologies depend on this collaboration. India ought to promote collaborations among academic institutions, research centres, and business enterprises to expedite advancements in this domain. Moreover, India should work to establish a favourable atmosphere for start-ups and entrepreneurship in the field of quantum technology. This entails offering capital, guidance, and regulatory support to enable quantum companies to prosper and introduce cutting-edge goods and services to the market. Moreover, to encourage the advancement and uptake of quantum technologies,

the Indian government should create initiatives and policies. This might include financial support for quantum technology initiatives, tax benefits for businesses engaged in the field, and incentives for R&D expenditures. Lastly, to advance quantum science and technology, India should take a leading role in international consortiums and collaborations. This entails working together to exchange resources, knowledge, and skills with top research institutes, universities, and businesses worldwide.