



Ultra-Secure Communication Using Quantum Technology

For Prelims: [Quantum Communication](#), [Quantum Computing](#), [National Quantum Mission](#), [Post-Quantum Cryptography \(POC\)](#)

For Mains: Quantum Key Distribution Technology and its Significance Applications of Quantum Technology, National Quantum Mission, Other India's Initiative in Quantum Computing.

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Why in News?

Scientists from **IIT Delhi** and **DRDO** have successfully demonstrated an **ultra-secure communication system** using **entanglement-based free-space quantum secure communication**.

- This method uses **light particles (photons)** and the principle of **quantum entanglement** to transmit information through **air**, ensuring that **any attempt to intercept the communication is immediately detectable**.
- It marks a significant step forward in India's efforts to build quantum-secure networks under the [National Quantum Mission \(2023-2031\)](#).

What are the Key Highlights of DRDO-IIT-Delhi Breakthrough in Quantum Communication?

- Scientists demonstrated **entanglement-based Quantum Key Distribution (QKD)** over a **1 km free-space link**, **transmitting quantum keys** through **air**, recording a **secure key rate of 240 bps (bits per second)**, showing resilience to **atmospheric turbulence, detector noise, and artificial lighting**.
 - Earlier, in **2022**, India's first **intercity quantum link** (Vindhyachal-Prayagraj) was set up using commercial-grade fibre.
 - In **2023**, QKD was extended to **380 km** over standard telecom fibre (**QBER 1.48%**), followed by a **100 km demo** in **2024**.

What is Quantum Communication and Quantum Entanglement?

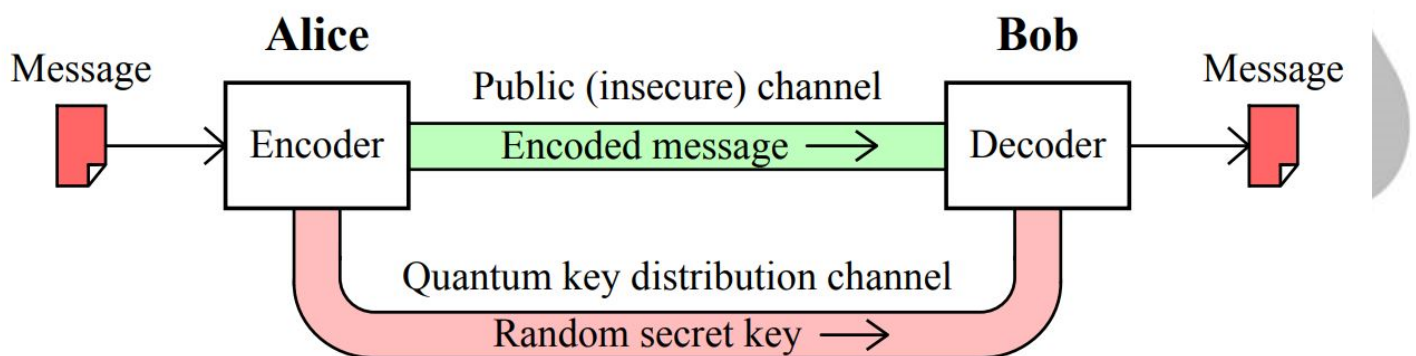
- **Quantum communication** is the **transmission of secure information** using **principles of quantum mechanics**, particularly **quantum entanglement**.
 - It includes protocols like **Quantum Key Distribution (QKD)**, **quantum teleportation**, and **dense coding** and techniques such as **free-space communication**, **quantum repeaters**, and **decoherence-free subspaces** to enable **secure, long-distance transmission**.
 - It holds strategic value for **defence and cybersecurity**.
- **Quantum Entanglement** is a phenomenon in quantum physics where **two or more particles become linked** in such a way that the **state of one instantly determines the state of the**

other, regardless of the distance between them.

- It **defies classical physics** and enables applications like **quantum communication, quantum cryptography, and quantum computing**.

What is Quantum Key Distribution (QKD)?

- **About: Quantum Key Distribution (QKD)** is a **secure communication method** that uses the principles of **quantum mechanics** to **generate and share cryptographic keys** between **two parties**.
- **Working:**
 - QKD uses **qubits (quantum bits)**, transmitted through **optical fibres** based on **total internal reflection**, to securely exchange encryption keys between two users.
 - Unlike classical bits, qubits are encoded on **photons** and are highly sensitive to disturbance.
 - QKD enables two distant users, who do not initially share a secret key, to generate a **common, random secret key**. These interactions must be **authenticated** using classical cryptographic methods.
 - If an eavesdropper tries to intercept the communication, it disturbs the qubits, causing **transmission errors** that alert the legitimate users. Thus, QKD transforms an authenticated classical channel into a **secure quantum channel**, ensuring **tamper-evident encryption**.



- **Types of QKD:**
 - **Prepare-and-Measure QKD:** One party **prepares photons in specific quantum states**, and the **other measures them**. Any interference alters the state, revealing intrusion.
 - **Entanglement-Based QKD:** A **source generates entangled photon pairs** and **sends one to each party**. The entangled nature ensures that the **measurement outcomes are correlated and secure**.

What is the National Quantum Mission (NQM)?

- **About:** The **National Quantum Mission (NQM)** is a strategic national initiative aimed at **advancing India's capabilities in quantum technologies**.
 - It is one of the **9 key missions under the PM-STIAC** (Prime Minister's Science, Technology, and Innovation Advisory Council).
 - It seeks to position India as a **global leader in quantum science** by fostering innovation in **quantum communication, quantum computing, and precision sensing**.
 - It was approved by the Union Cabinet **in 2023** for the period **2023-24 to 2030-31**.
- **Significance:** Crucial for advancing India's position in the global quantum race, with applications in **defence, cybersecurity, space, banking, and telecommunications**.
- **Key Objectives:**
 - **Quantum Computing:** Develop **intermediate-scale quantum computers** with **50-1000 physical qubits** using platforms such as **superconducting**

and photonic technologies over the next eight years.

- **Secure Quantum Communication:**
 - Enable **satellite-based quantum communication** between Indian ground stations over distances exceeding **2000 km**.
 - Facilitate **long-distance secure quantum links** with **international partners**.
 - **Quantum Sensing and Metrology:** Develop **high-sensitivity magnetometers** and **atomic clocks** to enhance precision in **navigation, communication, and timing applications**.
 - **Thematic Hubs (T-Hubs):** Establish **four T-Hubs** at premier academic and national R&D institutions focused on:
 - [Quantum computation](#)
 - [Quantum communication](#)
 - Quantum Sensing & Metrology
 - Quantum Materials & Devices
- **Key Initiatives Under NQM:**
- **DRDO Initiatives:** DRDO is developing and testing **quantum-resilient security protocols** and **quantum-safe symmetric and asymmetric cryptographic algorithms** to protect defence and strategic communications.
 - **SETS (Society for Electronic Transactions and Security):** Under the Principal Scientific Adviser (PSA), SETS is advancing **Post-Quantum Cryptography (PQC)** research and has implemented PQC for **FIDO authentication** and **IoT security** applications.
 - **C-DoT (Centre for Development of Telematics):** Under the Department of Telecommunications (DoT), C-DoT has developed cutting-edge solutions, including **Quantum Key Distribution (QKD)**, **Post-Quantum Cryptography**, and **Quantum-Secure Video IP Phones**.



NATIONAL QUANTUM MISSION

Aims to put India among the top six leading nations involved in the R&D in quantum technologies

■ Presently, R&D works in quantum technologies are underway in the US, Canada, France, Finland, China and Austria ■

■ **Duration:** 2023-24 to 2030-31

■ **Nodal Ministry:** Ministry of Science & Technology

■ **Highlights of the Mission:**

- Four Thematic Hubs (T-Hubs) in different domains across the country
- Wide-scale applications ranging from healthcare and diagnostics, defence, energy and data security

- Strengthening of indigenously building quantum -based computer
- Help develop magnetometers with high sensitivity in atomic systems and atomic clocks
- Support design and synthesis of quantum materials

A huge boost to National priorities like digital India, Make in India, Skill India, Stand-up India, Start-up India, Self-reliant India and SDGs

Quantum Technology

■ Works by using the principles of quantum mechanics (the physics of sub-atomic particles), including quantum entanglement and quantum superposition ■

Quantum Superposition

The ability of a quantum system to be in multiple states simultaneously

While digital computers store data as bits (the ones and zeros of binary), quantum computers use qubits that exist as one, zero or both at the same time

This superposition state creates a practically infinite range of possibilities, allowing for fast simultaneous and parallel calculations

Quantum Entanglement

It means the two members of a pair (Qubits) exist in a single quantum state

If you change the properties of one of them, the other changes instantly

This can be used to create a secure encryption key in quantum cryptography

If an eavesdropper tries to intercept the transmission, the entangled state of the particles will be disturbed, making the attempt detectable



Related Government Initiatives on Quantum Technology

- [Quantum-Enabled Science & Technology \(QuEST\)](#)
- [National Mission for Quantum Technologies and Applications \(NM-QTA\)](#)
- [Quantum Key Distribution \(QKD\) solution.](#)
- [Quantum Key Distribution Link Demonstrated: Latest update | Drishti IAS English](#)

Drishti Mains Question:

Examine the key objectives and initiatives under the NQM and their strategic importance for India.

UPSC Civil Services Examination Previous Year Question (PYQ)

Prelims

Q. Which one of the following is the context in which the term "qubit" is mentioned?

- (a) Cloud Services
- (b) Quantum Computing
- (c) Visible Light Communication Technologies
- (d) Wireless Communication Technologies

Ans: (b)

Mains

Q. “The emergence of the Fourth Industrial Revolution (Digital Revolution) has initiated e-Governance as an integral part of government”. Discuss. (2020)

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