

Quantum Technology for Securing Maritime Communications

For Prelims: Indian Navy, Quantum mechanics, Semiconductor, <u>Internet-of-Things</u>, machine learning, <u>Robotics, Artificial intelligence.</u>

For Mains: Quantum Technology, Significance and Challenges.

Why in News?

RRI (Raman Research Institute) has inked a **Memorandum of Understanding (MoU)** with the <u>Indian</u> Navy on <u>Quantum Technologies</u> to develop secure maritime communications.

- RRI is an autonomous institute of the Department of Science and Technology (DST).
- Under this agreement, RRI's Quantum Information and Computing (QuIC) lab will lead the research
 efforts towards developing Quantum Key Distribution (QKD) techniques that the Indian Navy
 could leverage in the nation's efforts towards securing free space communications.

Note

- Quantum Technology is a field of science and engineering that deals with the study and application of quantum mechanics principles.
 - Quantum mechanics is the branch of physics that describes the behavior of matter and energy at the atomic and subatomic level.
- There are Four domains of Quantum Technology:
 - Quantum communication
 - Quantum simulation
 - Quantum computation
 - Quantum sensing and metrology

What is Quantum Communication?

- Quantum Communication:
 - Quantum communication is a subfield of quantum technology that focuses on the development of secure communication systems that use the principles of quantum mechanics.
 - Quantum communication uses a fundamentally different approach to encryption.
 - The most common example of quantum communication is QKD, which allows two
 parties to generate an encryption key that is virtually uncrackable.
- Mechanism of Quantum Communication:
 - **Encoding Information:** Information is encoded onto quantum bits (qubits), which can exist in **multiple states simultaneously.**

- This property is known as superposition.
- Transmitting Information: The encoded qubits are transmitted over a quantum communication channel, such as a <u>fiber optic cable</u> or a free-space link.
 - The qubits are typically transmitted one at a time.
- **Receiving Information:** The receiving party measures the qubits using a quantum measurement device.
 - The measurement process collapses the superposition state of the qubit to a single state, revealing the encoded information.
- Detecting Eavesdropping: One of the key features of quantum communication is that
 any attempt to eavesdrop on the communication will disturb the quantum state
 of the qubit, making it immediately detectable.
 - This is known as the "no-cloning theorem" and is a fundamental principle of quantum mechanics.
- Establishing a Secret Key: By exchanging a sequence of qubits, the transmitting and receiving parties can establish a secret key that can be used for secure communication.
 - This key can be used with conventional encryption algorithms to **ensure the confidentiality and integrity** of transmitted information.

How Can Quantum Technology be useful In Maritime Communication?

Secure Communication:

 Quantum encryption can be used to ensure secure communication between ships and shore stations, making it difficult for hackers to intercept or eavesdrop on the communication.

High-speed Communication:

- Quantum technology can enable faster communication between ships and shore stations by using quantum entanglement to transmit information instantaneously over long distances.
 - This could be **particularly useful for communication in remote areas** where traditional communication methods are limited.

Precision Navigation:

- Quantum sensors can be used to improve navigation accuracy by measuring the Earth's magnetic field with high precision.
- This could help ships navigate through narrow channels, avoid obstacles, and improve overall safety.

Improved Weather Forecasting:

 Quantum computers can be used to run complex simulations of weather patterns, which can provide accurate and timely information to mariners about impending storms or other dangerous weather conditions.

Way Forward

- Implementing quantum communication technologies, such as QKD at scale is a major challenge as they are still in the early stages of development and implementation.
 - **Pilot projects can be established** to test the technology in real-world settings and refine the implementation process.
- Quantum communication technologies are expensive to develop and deploy. Adequate funding for R&D could lead to more cost-effective solutions.
- Quantum communication technologies are not yet standardized, making it difficult for different systems to communicate with each other.
 - **Standards and protocols can be developed** to enable different quantum communication systems to communicate with each other

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