1.India's First Liquid Helium Cryogenic Facility – Sci & Tec

Union Minister of State for Science & Technology inaugurated a new Liquid Helium Facility, marking a milestone in India's capabilities in quantum science, cryogenics, advanced materials, and next-generation computing.

Overview of the Liquid Helium Facility

The Liquid Helium Facility has been inaugurated as a national research infrastructure asset, meaning it will serve universities, national laboratories, industry R&D units and advanced technology sectors. It represents a major step in strengthening India's cryogenics ecosystem, which is essential for next-generation scientific research.

Multi-Sector Support - The facility supports advanced research in -

Cryogenic Engineering - Enables development of technologies below –150°C, crucial for high-precision instruments.

Superconductivity - Allows testing of superconducting materials used in fusion reactors, power grids, particle accelerators, and MRI systems.

Quantum Computing & Quantum Sensing - Provides ultra-low temperatures required for qubit stability and error-free quantum operations.

Photonics & Optoelectronics - Helps in development of ultra-sensitive detectors and photonic circuits operating at cryogenic temperatures.

Healthcare Technologies - Supports MRI, radiology equipment, cryo-preservation, and cryo-EM research.

Green Energy Devices - Enables testing of superconducting energy storage systems, hydrogen technologies, and clean-energy prototypes.

Scientific Importance of the Facility

Critical Applications Enabled by Liquid Helium

Magnetic Resonance Imaging (MRI) - Superconducting magnets inside MRI machines require temperatures close to 4 Kelvin, which only liquid helium can provide.

Cryogenic Electron Microscopy (Cryo-EM) - Used in structural biology for mapping proteins, viruses, and biomolecules at atomic resolution.

Advanced Materials Characterisation - Helps study properties of materials at very low temperatures, such as electrical conductivity, magnetism, and quantum effects.

Efficient Helium Recovery System

The facility is equipped with a closed-loop helium recovery and liquefaction system, which

1. Reduces wastage of helium—a globally scarce resource.
2. Lowers operational costs by recovering and re-liquefying gaseous helium.
3. Expected to make cryogenic experiments nearly 90% cheaper, enabling more research at lower cost.
4. Enhances India's self-reliance in rare-gas supply for strategic sectors.

Liquid Helium — In Detail

A. Definition

Liquid helium is the liquid phase of helium gas, created by cooling gaseous helium to extremely low temperatures using compression–expansion cycles. Helium is the coldest known substance that can exist in liquid form under normal pressure.

Physical Properties of Liquid Helium

Extremely Low Temperature -Liquefies at −269°C (4.2 K) at atmospheric pressure—the lowest boiling point among all known elements. Can exist as superfluid helium (Helium-II) below 2.17 K, a phase with zero viscosity and extraordinary heat conductivity.

Very Low Density - One of the least dense liquids, enabling use in sensitive scientific experiments where minimal thermal and mechanical disturbance is required.

Low Viscosity - Exhibits the ability to flow without friction, making it ideal for precision cooling in quantum and particle physics.

Chemically Inert and Non-Toxic - Safe for controlled use in industrial, laboratory, and medical environments. Does not react with other chemicals, ensuring purity of experiments.

Major Uses of Liquid Helium

Medical Sector

MRI Machines - Superconducting magnets in MRI scanners are cooled using liquid helium to maintain zero electrical resistance. Essential for ensuring stable imaging performance in hospitals.

Particle Accelerators & High-Energy Physics - Used in CERN-type accelerators, synchrotrons, and detector systems for

1. Cooling superconducting magnets
2. Maintaining beam stability
3. Enabling ultra-low temperature experiments

Quantum Computing - Qubits in quantum computers (e.g., superconducting qubits) require temperatures near 10–20 millikelvin, achievable only using helium-based dilution refrigerators. Enables error-free quantum superposition and entanglement.

Space Science & Astrophysics - Infrared sensors in satellites and space telescopes require liquid helium to reduce background thermal noise. Helps improve accuracy of astronomical observations.

E. Material Science and Nanotechnology - Used in experiments dealing with superconductors, topological materials, spintronics, and low-temperature magnetism. Crucial for semiconductor research where noise reduction is essential.

F. Cryogenics Industry - Supports cryogenic pumps, cryo-coolers, cryogenic storage systems, and hydrogen-related technologies (green hydrogen production, storage, and transport).

Strategic Importance for India

A. Reducing Dependence on Imports - India imports most of its liquid helium, making research costly and vulnerable to global supply fluctuations. Establishing a domestic facility helps reduce import bills and strengthens scientific sovereignty.

B. Building a National Cryogenics Ecosystem - Enables training of scientists and engineers in cryogenics—an area where India has had limited specialised manpower. Attracts global collaborations in superconductivity, quantum technologies, and hydrogen economy.

C. Supporting National Missions - The facility directly supports

1. National Quantum Mission (NQM)
2. National Supercomputing Mission (NSM)
3. Health mission for advanced diagnostic technologies
4. ISRO space science missions
5. Green hydrogen and clean-energy technologies

Conclusion

The Liquid Helium Facility is a landmark development for India's scientific, technological, and healthcare ecosystem. Its advanced cryogenic capabilities will accelerate progress in quantum technologies, superconductivity research, space science, and high-precision medical diagnostics. By incorporating helium recycling, the facility also strengthens India's resource security and reduces dependence on imported liquid helium. Overall, it represents a major step toward India's goal of becoming a global leader in low-temperature science and high-technology innovation.

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