



# Superconductivity

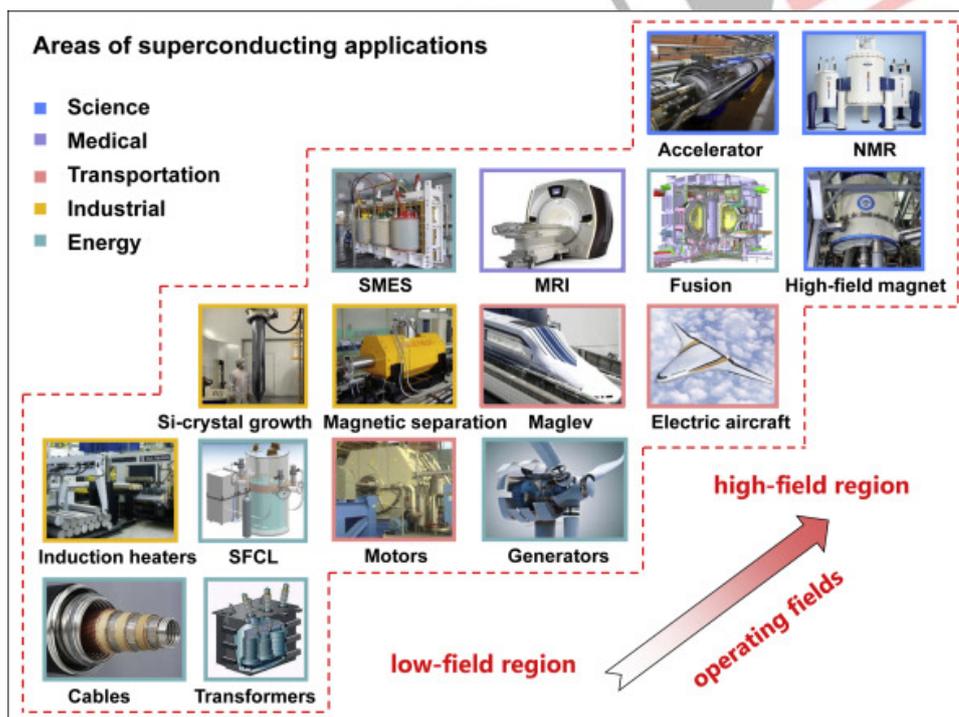
## Why in News?

Recently, physicists at the University of L'Aquila in Italy have recently made a breakthrough by achieving a **full microscopic understanding of the superconductivity of Mercury** for the first time.

- Superconductivity was first discovered in mercury, **yet scientists required 111 years to explain how it becomes superconducting.**

## What is Superconductivity?

- **Superconductivity:**
  - **Superconductivity** refers to a state when a material can conduct electricity without any resistance. It is observed in many materials when they are cooled below a **critical temperature.**



- **Superconductivity of Mercury:**

- **About:**

- In 1911, Heike Kamerlingh Onnes discover superconductivity in mercury.
    - Onnes had invented a way **to cool materials to absolute zero** - the lowest temperature possible.
    - Using his technique, he found that at a very low temperature, called the threshold temperature, **solid mercury offers no resistance to the flow of electric current.** It was a watershed moment in the history of physics.

- **Various Methodologies:** Superconductivity of mercury is explained by various methodologies:
  - **The BCS Theory:**
    - In BCS (**Bardeen-Cooper-Schrieffer**) superconductors, **vibrational energy released by the grid of atoms encourages electrons to pair up**, forming so-called Cooper pairs.
    - These Cooper pairs can move like **water in a stream, facing no resistance to their flow, below a threshold temperature.**
      - These could explain why mercury has such a low threshold temperature (around  $-270^{\circ}\text{C}$ ).
  - **Spin-Orbit Coupling:**
    - Spin-orbit coupling (SOC) is the way an **electron's energy is affected by the relationship between its spin and its momentum.**
    - SOC gave a better view of the phonons' energies and explain why mercury has such a **low threshold temperature (approx.  $-270^{\circ}\text{C}$ ).**
  - **Coulomb Repulsion:**
    - Another factor was the Coulomb repulsion (a.k.a. 'like charges repel') between two **electrons in each pair.**
    - The superconducting state is determined by a balance between an attractive interaction between electrons, mediated by phonons, and the repulsive Coulomb interaction (electrostatic repulsion between negative charges).

## What is Mercury?

- Mercury is a **naturally occurring element that is found in air, water and soil.**
- Released into the atmosphere through natural processes such as weathering of rocks, volcanic eruptions, geothermal activities, forest fires, etc.
- Mercury is also **released through human activities.**
- It is the only metal which **remains liquid at room temperature.**

## UPSC Civil Services Examination Previous Year Question (PYQ)

**Q. Due to improper/indiscriminate disposal of old and used computers or their parts, which of the following are released into the environment as e-waste? (2013)**

1. Beryllium
2. Cadmium
3. Chromium
4. Heptachlor
5. Mercury
6. Lead
7. Plutonium

**Select the correct answer using the codes given below:**

- (a) 1, 3, 4, 6 and 7 only  
(b) 1, 2, 3, 5 and 6 only  
(c) 2, 4, 5 and 7 only  
(d) 1, 2, 3, 4, 5, 6 and 7

**Ans: (b)**

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