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Superconductivity of Mercury

*This article covers "Daily current events "and the topic is about '**Superconductivity of Mercury**' which is in news, it covers the "scientific innovations and discoveries" In GS-3, and the following content has relevance for UPSC.*

For Prelims: Superconductor, Superconductivity of mercury
For Mains: GS-3, Science and technology

Why in News:
A recent discovery by a research team provides a clear picture of Mercury's superconductivity.

About superconductor:
When a substance gets colder than a critical temperature, it is said to become a superconductor because it gives no resistance to the electric current.

Superconductors come in a variety of common forms, including those made of **aluminum, magnesium diboride, niobium, copper oxide, yttrium barium, and iron pnictides.**

HOW MERCURY BECOMES A SUPERCONDUCTOR (SUPERCONDUCTIVITY OF MERCURY)

- Mercury's superconductivity was discovered in 1911 by **Dutch physicist Heike Kamerlingh Onnes.**

- The threshold temperature, which he discovered, is the point at which solid mercury presents no resistance to the flow of an electric current.
- **Solid mercury presents no resistance** to the flow of electric current below a very low temperature known as the threshold temperature.

HOW MERCURY IS ABLE TO BECOME SUPERCONDUCTING: *BARDEEN-COOPER-SCHRIEFFER (BCS) THEORY EXPLANATION*

- Since the ideas of the Bardeen-Cooper-Schrieffer (BCS) hypothesis could account for the superconductivity of mercury, scientists categorized it as a conventional superconductor.
- Although the BCS theory has been used to explain superconductivity in a variety of materials, scientists have never fully grasped how it works in mercury, the earliest superconductor.
- Utilizing cutting-edge theoretical and computational techniques, the researchers discovered that mercury exhibits anomalies in all physical parameters pertinent to conventional superconductivity.

BCS's explanation:

- In BCS superconductors, the atom grid's vibrational energy induces electron pairing, leading to the formation of so-called Cooper pairs.
- Below a certain temperature, these Copper couples can flow without resistance like water in a stream.
- The team's simulations provided a clearer picture of how superconductivity develops in mercury by taking into account some elements that physicists had previously ignored.
- For instance, the researchers were able to explain why mercury has such a low threshold temperature (about -270°C) when they took into consideration the relationship between an electron's spin and momentum.

Recent Development:

- A research team in their article that was published in the journal Physical Review B, a team of Italian researchers addressed this gap.
- Modern theoretical and computational methods were applied by the researchers, who discovered that mercury exhibits anomalies in all the physical characteristics necessary for conventional superconductivity.
- The threshold temperature of **mercury superconductivity** was determined theoretically, and it was predicted to be within 2.5% of the measured value.

Considerations of both recent and historical factors:

- The team's simulations provided a clearer picture of how superconductivity develops in mercury by considering several elements that were previously ignored (such as Cooper Pairs).
- When the researchers took into account the connection between an electron's spin and momentum, for instance, they were able to explain why mercury has such a low threshold temperature (of about -270°C).

Mercury and the Coulomb repulsion:

- Similar to this, the team discovered that in mercury, one electron in each pair had a greater energy level than the other.
- Apparently, this information reduced the Coulomb repulsion (in which charges repel one another) between them and promoted superconductivity.
- In this way, the team has clarified how mercury can behave as a superconductor below its critical temperature.
- Their techniques and findings imply that we might have overlooked analogous anomalous properties in other materials, opening the door to previously unrecognized ones that can be utilized for better and more innovative real-world applications.

Applications:

- These are utilized in the memory section of computers as well as in submarine detection and underwater communication.
- utilized in medical diagnostics, such as in nuclear magnetic resonance imaging equipment and other magnetic imaging systems (NMR).
- utilized for train levitation at high speeds.
- Magnetic cardiograms, based on magnetic fields produced by electric currents in the heart, can be obtained using SQUIDS (Superconducting Quantum Interference Devices).

Way Ahead:

- This creates opportunities to examine other materials for superconductivity, which exhibits comparable odd phenomena in other materials.
- It can be used to develop fresh and improved real-world applications.

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