Superconductivity at Room Temperature

Why in News

Recently, **researchers have created a material that is superconducting** at room temperature, however, it **only works at a pressure of 267 Gigapascals** (GPa), which is equivalent to **about three-quarters of pressure at the centre of Earth** (360 GPa).

Key Points

- **Material Used:** A **mixture of carbon, hydrogen and sulfur** was put in a microscopic niche carved between the tips of two diamonds **(diamond anvil)** and laser light was used on them to **trigger chemical reactions.**
- **Process:**
    - As the experimental **temperature was lowered, resistance** to a current passed through the material **dropped** to a vanishingly small value below the **critical temperature** (Tc).
    - The **transition of the sample to become superconductive** occurred the best at **transition temperature of around 15°C at 267 GPa.**
- **Verification:** To verify that this phase was indeed a superconductor, the group ascertained that the **magnetic susceptibility** of the superconductor was that of a **diamagnet.**
    - A **superconducting material kept in a magnetic field expels the magnetic flux out** its body when cooled below the critical temperature and **exhibits perfect diamagnetism.**
    - It is also called the **Meissner effect** which simply means that **magnetic lines do not pass through superconductors** in a magnetic field.
- **Superconductors:**
    - A superconductor is a material that can **conduct electricity or transport electrons from one atom to another with no resistance.**
    - No heat, sound or any other form of energy would be released from the material when it has **reached critical temperature** (Tc), or the temperature at which the material becomes superconductive.
        - The critical temperature for superconductors is the **temperature at which the electrical resistivity of metal drops to zero.**
    - **Prominent examples** include **aluminium, niobium, magnesium diboride,** etc.
- **Applications:**
    - From magnetic resonance imaging (MRI) machines, low-loss power lines, ultra powerful superconducting magnets to mobile-phone towers.
    - Researchers are also experimenting with them in high-performance generators for wind turbines.
- **Limitations:**
    - Their usefulness is still **limited by the need for bulky cryogenics** (production of and behavior of materials at very low temperatures) as the common superconductors **work at**

atmospheric pressures, but only if they are kept very cold.

- Even the most sophisticated ones like **copper oxide-based ceramic materials** work only below −140°C.

- **Significance of the Research:**
    - If researchers can stabilise the material at ambient pressure, **applications of superconductivity at room temperatures could be achieved** and will be within reach.
    - Superconductors that work at room temperature could have a **big technological impact, for example in electronics that run faster without overheating.**

Diamagnetism

- It is a **very weak form of magnetism** that is **induced by a change in the orbital motion of electrons** due to an applied magnetic field.
- This magnetism is **non-permanent and persists only in the presence of an external field.**
- The **magnitude of the induced magnetic moment is very small,** and its **direction is opposite to that of the applied field.**

Meissner Effect

- When a **material makes the transition from the normal to the superconducting state,** it **actively excludes magnetic fields** from its interior and this is called the Meissner effect.
- This constraint to zero magnetic fields inside a superconductor is **distinct from the perfect diamagnetism which would arise from its zero electrical resistance.**

Source: TH