Moiré Materials and Superconductivity

Source: TH

Why in News?

A recent ***Nature* study** found that **moiré materials** made from semiconductors can also be superconducting, a property **previously** thought to be exclusive to graphene.

What are the Key Facts About Moiré Materials?

- **About:** Moiré materials are materials having **unique properties** due to the **interference pattern** formed when **two repetitive structures are overlaid at a slight angle.**
- **Creation of Moiré Materials**: Moiré materials are created by **stacking two layers of a two-dimensional (**2-D) material, such as tungsten **diselenide**, and **twisting one layer** at a small angle (3.65º).
  - The **twist** between the layers creates a **unique moire pattern** that gives rise to **new electronic behaviors n**ot present in individual layers.
- **Electronic Properties**: The twist in layers creates **flat bands** in the electronic structure, where **electrons** move slowly with nearly **constant energy.**
  - This slow movement boosts **electron-electron interactions,** crucial for superconductivity.
- **Research on Tungsten Diselenide (tWSe_2)**: **tWSe_2,** a semiconductor moiré material, demonstrated **superconductivity** at a transition temperature of approximately –**272.93º C,** comparable to that of **high-temperature superconductors.**
  - The superconducting state in tWSe_2 was found to be **more stable** than in other moiré materials.
- **Comparison with Graphene Superconductors: Graphene**-based moiré materials achieve superconductivity through **electron-lattice interactions** and **flat band formation,** while **tWSe_2** relies on **electron-electron interactions,** making it more stable and potentially more robust.
  - Electron-lattice interactions are the interactions between **electrons and the atomic lattice** (the arrangement of atoms) in a material's crystal structure.
- **Significance of Findings**: **Stable superconductivity** at low temperatures enables practical applications in quantum computing **and electronics**.
  - It can aid in **designing new materials** for future technologies.

Note: Superconductivity is the property of certain materials to conduct **direct current (DC) electricity without energy loss** when they are **cooled below a critical temperature (Tc).**

- These materials also **expel magnetic fields** as they transition to the superconducting state.
- Superconductivity was discovered in **1911 by Heike Kamerlingh-Onnes.** For this discovery, he won the **1913 Nobel Prize in Physics.**
- E..g., **MRI machines** use an alloy of **niobium and titanium.**

Read more: Allotropes of Carbon

UPSC Civil Services Examination Previous Year Question (PYQ)

Prelims

Q.Which one of the following is the context in which the term "qubit" is mentioned?

(a) Cloud Services

(b) Quantum Computing

(c) Visible Light Communication Technologies

(d) Wireless Communication Technologies

Ans: (b)