



# Fermi Energy in Quantum Physics

## Why in News?

Recently, **Fermi energy** has gained significant attention due to its wide range of **daily practical applications** in various fields, driven by the principles of **quantum physics**.

## What is Quantum Physics?

- Quantum physics is the branch of physics that deals with the **behavior and properties** of the smallest particles of matter and energy, such as **atoms, electrons, photons, and quarks**.
- Quantum physics reveals that these particles can **behave in strange and surprising ways**, such as being in **two places at once (superimposition), tunneling through barriers, or entanglement with each other over long distances**.
- Quantum physics also explains how atoms and molecules form the basis of all matter and **how light and other electromagnetic waves** are produced and interact with matter.
- Quantum physics impacts daily life through **electronics, computing, lasers, and optics**. It enables technologies like **MRI for medical imaging** and improves **renewable energy systems**.
  - **Quantum cryptography** ensures **secure communication**, while materials science and nanotechnology benefit from quantum principles.

## What is Fermi Energy?

- **About:**
  - Fermi energy is the energy of the highest occupied state of electrons in a material at **absolute zero temperature (-273° C or 0K)**.
    - Fermi energy determines **electron velocity in conduction**, as only electrons with energies close to the Fermi energy can participate in the conduction process.
  - Metals, such as **copper, aluminum, and silver, exhibit high Fermi energies**, even at extremely low temperatures.
  - The Fermi energy and fermionic behavior of electrons, governed by quantum mechanics, are responsible for various properties of metals, including their **reflectivity, electrical conductivity, and thermal conductivity**.
  - Fermi energy is measured by **Fermi level**.
  - Understanding Fermi energy is essential for comprehending the **fundamental behaviors** and applications of metals in our daily lives.
- **Importance for Quantum Physics:**
  - Fermi energy reveals the **wave nature** and **discrete energy levels of electrons in matter**.
  - Fermi energy determines various physical properties of materials, including **electrical and thermal conductivity, heat capacity, magnetism, and superconductivity**.
  - Fermi energy is relevant in natural phenomena and technological applications like **stars, nuclear reactions, lasers, transistors, and solar cells**.

**UPSC Civil Services Examination, Previous Year Questions (PYQs)**

**Prelims**

**Q. With reference to Visible Light Communication (VLC) technology, which of the following statements are correct? (2020)**

1. VLC uses electromagnetic spectrum wavelengths 375 to 780 nm.
2. VLC is known as long-range optical wireless communication.
3. VLC can transmit large amounts of data faster than Bluetooth.
4. VLC has no electromagnetic interference.

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

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

**Ans: (c)**

**Exp:**

- Visible Light Communication (VLC) systems employ visible light for communication that occupy the electromagnetic spectrum from 375 nm to 780 nm. **Hence, statement 1 is correct.**
- VLC is known as short-range optical wireless communication. Hence, statement 2 is not correct.
- Li-Fi, a kind of VLC, has a range of approximately 10 meters and it cannot pass through walls or any solid object.
- VLC can transmit large amounts of data faster than Bluetooth. The VLC uses visible light for communication to provide high speed internet up to 10 Gb/s while Bluetooth 4.0 promises speeds up to 25 Mb/s. **Hence, statement 3 is correct.**
- **VLC has no electromagnetic interference. The radio frequency (RF) based signals have the problem of interference** with other RF signals such as its interference with pilot navigational equipment signals in aircraft. Therefore, in the areas that are sensitive to electromagnetic radiation (such as aircrafts) VLC can be a better solution. **Hence, statement 4 is correct.**  
**Therefore, option (c) is the correct answer.**

**Q. Which one of the following is the context in which the term "qubit" is mentioned? (2022)**

- (a) Cloud Services  
(b) Quantum Computing  
(c) Visible Light Communication Technologies  
(d) Wireless Communication Technologies

**Ans: (b)**

**Explanation:**

- **Quantum Supremacy**
  - Quantum computers compute in 'qubits' (or quantum bits). They exploit the properties of quantum mechanics, the science that governs how matter behaves on the atomic scale.
- **Hence, option (b) is correct.**

**[Source: TH](#)**

