



# Quantum Engine

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## Why in News?

Researchers have made a groundbreaking discovery by developing a **quantum engine**, referred to as the '**Pauli engine**,' which can **convert the energy difference between two quantum states** of a group of atoms into **useful work**.

- This innovation has the potential to advance our understanding of **quantum thermodynamics** and could have applications in the **development of more efficient [quantum computers](#)**.

## What are Quantum States and Quantum Engines?

### ▪ Quantum State:

- A **Quantum state** is a mathematical description of the **physical properties of a quantum system**.
  - In quantum mechanics, the **fundamental theory that describes the behavior of matter and energy at the smallest scales**, quantum states provide a complete specification of a system's properties, including its **position, momentum, energy, spin, and other observable quantities**.
- Quantum phenomena often defy our common sense and challenge our classical understanding of the world.
  - One of these phenomena is the difference between two types of quantum particles: **[bosons and fermions](#)**.
    - **Fermions are the building blocks of matter**, bosons are particles that carry the forces acting between them.
    - **Bosons are particles that can share the same quantum state**, while fermions are particles that **obey the Pauli exclusion principle**, which forbids them from occupying the same quantum state.
      - At low temperatures, **bosons can behave very differently than fermions** because an **unlimited number of them can occupy the same lowest energy level**, while fermions have to fill up **higher energy states**.
  - This energy difference between bosons and fermions has inspired researchers to design and build a **novel quantum engine** that can **convert this difference into useful work**.

### ▪ Quantum Engine:

- The **quantum engine or Pauli's engine** consists of a **gas of lithium-6 atoms** that are trapped in a combined **optical and magnetic trap**.
  - The gas can be tuned to **behave like bosons or fermions** by changing the magnetic field around it.
    - This is possible because the atoms can pair up into bosonic molecules or dissociate into individual fermionic atoms depending on the strength of the magnetic field.
- The engine operates in a four-step cycle and it opens up new possibilities for studying **quantum thermodynamics** and its implications for other fields of physics.

## Conclusion

- While the **quantum engine is still in the proof-of-concept stage**. One application of the quantum engine could be in **cooling the particles used in quantum computers**. Quantum computers require **extremely low temperatures to operate effectively**, and the quantum engine could potentially serve as a cooling mechanism for these particles, **similar to how an air-conditioner cools a room**.

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

**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 echnologies
- (d)** Wireless Communication Technologies

**Ans: (b)**

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