AI-Based Quantum Computing

Prelims - *Current events of national and international importance |*

General Science.

Why in News?

Recently, researchers from China reported significant progress on this front by developing a way to rapidly and reliably create large arrays of neutral atoms.

- **Quantum computing –** It is a technology that utilises the ***principles of quantum mechanics*** to solve complex problems much faster than traditional classical computers.
- It harnesses the unique behaviour of quantum physics, such as superposition, entanglement, and quantum interference and applies it to computing**.**
- **Qubit –** It is also known as quantum bits.
- It is the basic unit of information in quantum computing as bits plays in classical computing.
- Classical bits are binary and can hold only a position of 0 or 1, but qubits can have a ***superposition of all possible states.***
- **Building quantum computers –** It requires assembling large array of qubits with no effect.
- Neutral atoms, like rubidium atoms, can be trapped and controlled by small laser beams called optical tweezers which serve as qubits in quantum computing.
- Arranging thousands of atoms accurately is crucial for performing complex operations and error corrections.
- **Challenges in building –** Perfectly placing atoms in large arrays is difficult because they are loaded randomly, often with missing sites.
- Assembling defect-free arrays involves moving atoms one by one or row by row, making the process slow and prone to errors.
- **AI-based building –** It quickly moves thousands of atoms at the same time, precisely controlling their positions and phases using laser holograms.

- AI use the ***Hungarian algorithm*** to find the ideal pairing of loaded atoms with a target position to organise them efficiently.
- It minimised the total distance of the atoms to move, also preventing any collisions during the rearrangement.
- Each movement of atoms was divided into 20 small steps to prevent heating and loss.
- It generated a hologram that simultaneously moved all atoms smoothly, precisely controlling their positions and light phases to avoid disturbances.

*• **Holograms** are real-world virtual 3D pictures generated by the interference of light beams that reflect real-world physical objects.*
• It is a photographic method that uses a laser to capture 3D objects and then recreates them as accurately as possible initially recorded item.

- **Experimental AI model –** Rearranging the atoms, whether 1000 or 10000, took the same time.
- The scientists assembled 2D arrays of up to 2,024 atoms free of any defects in about 60 milliseconds, substantially faster and more scalable.
- It is a convolutional neural network trained on simulated laser holograms, which quickly generates accurate holograms to guide atoms smoothly with minimal loss.
- The experiment used a high numerical aperture lens to tightly focus laser beams, acting like tweezers to trap and move atoms.
- A high-resolution camera captured the positions of the atoms and calculated their movements in real time.
- It created a cartoon-style animation of Schrödinger's cat thought experiment by arranging 549 atoms within a 230 × 230 micrometre grid.
- **Significance -** It opens new paths toward building scalable quantum computers.

Reference

The Hindu| AI-Based Quantum Computing

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