



Nobel Prize in Physics 2022

For Prelims: Nobel Prize Physics 2022, Quantum Mechanics, Quantum Entanglement

For Mains: Application of Quantum Mechanics

Why in News?

The [Nobel Prize in Physics for 2022](#) was awarded to **John F. Clauser, Alain Aspect and Anton Zeilinger** for their work in [quantum mechanics](#) by the **Royal Swedish Academy of Sciences**.

- In 2021, the [Nobel Prize in Physics](#) was awarded to **Syukuro Manabe and Klaus Hasselmann (jointly)** for their research on climate models and to **Giorgio Parisi** for his work on the interplay of disorder and fluctuations in physical systems.
- The [Nobel Prize for 2022 in Physiology or Medicine](#) was awarded to Svante Pääbo for his research in the field of genomes of extinct hominins and human evolution.

What is Quantum Mechanics and Quantum Entanglement?

- Mechanics is the branch of physics that **deals with the movement and interaction of various bodies. Mechanics has two parts - classical and quantum.**
 - **Classical or Newtonian mechanics** is the mathematical study of the motion of **macroscopic objects** and the forces that affect them.
 - **Quantum mechanics** is a subfield of physics that describes the **behavior of particles — atoms, electrons, photons** and almost everything in the **molecular and sub molecular realm.**
 - One important difference in the behaviour of quantum systems, when compared to classical rigid bodies, is the **concept of entanglement.**
- **Quantum entanglement** is a phenomenon by which a pair of subatomic particles are **allowed to exist in a shared state where they have complementary properties**, such that by measuring the properties of one particle, one can automatically know the properties of the other particle.
 - This is true regardless of how far apart the two particles are transported.
 - Quantum entanglement was **first elucidated by Erwin Schrödinger** in 1935, leading to his well-known **cat paradox.**

What is Bell Inequality?

- In the 1960s, **John Stewart Bell** developed the mathematical inequality - Bell Inequality which states that if there are **hidden variables**, the correlation between the results of a large number of measurements will **never exceed a certain value.**
 - Quantum mechanics predicts that a certain type of experiment will violate Bell's inequality, thus resulting in a stronger correlation than would otherwise be possible.

What is the Experiment?

- The laureates have been awarded for their experiments with **entangled photons** (quantum entanglement), establishing the **violation of Bell inequalities**, and pioneering **quantum information science**.
- John F. Clauser developed John Bell's ideas, leading to a practical experiment which supported quantum mechanics by clearly violating a Bell inequality **implying that quantum mechanics cannot be replaced by a theory that uses hidden variables**.
- Alain Aspect **developed the setup**, using it in a way that closed an important loophole.
 - He was able to switch the measurement settings after an entangled pair had left its source, so the setting that existed when they were emitted could not affect the result (as some loopholes remained after John Clauser's experiment).
- Anton Zeilinger was chosen for his **innovative use of entanglement and Bell pairs** both in research and application such as **quantum cryptography**.
 - His research group demonstrated a phenomenon called **quantum teleportation**, which makes it possible to **move a quantum state from one particle to the one at a distance**.

How is the Experiment Significant?

- The development of experimental tools has laid the foundation for a new era of technology based on quantum information.
- It will help in utilising the **special properties of individual particle systems to construct [quantum computers](#), improve measurements, build quantum networks, establish secure quantum encrypted communication ([quantum cryptography](#)) and precise timekeeping** as is done in **[atomic clocks](#)**.

UPSC Civil Services Examination Previous Year Question (PYQ)

Prelims

Q. Who among the following scientists shared the Nobel Prize in Physics with his son? (2008)

- (a) Max Planck
- (b) Albert Einstein
- (c) William Henry Bragg
- (d) Enrico Fermi

Ans: (c)

Q. Nobel Prize winning scientist James D. Watson is known for his work in which area? (2008)

- (a) Metallurgy
- (b) Meteorology
- (c) Environmental protection
- (d) Genetics

Ans: (d)

Mains

Q1. The Nobel Prize in Physics of 2014 was jointly awarded to Akasaki, Amano and Nakamura for the invention of Blue LEDs in the 1990s. How has this invention impacted the everyday life of human beings? **(2021)**

Q2. Discuss the work of 'Bose-Einstein Statistics' done by Prof. Satyendra Nath Bose and show how it revolutionized the field of Physics. **(2018)**

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