

WRAP Exams · wrapexams.com

Prelims PYQ, Mains model answers, and copy evaluation. Write to the desk for this paper, a doubt, or the AI waitlist.

ask@wrapexams.com · +91 85951 84903 · wrapexams.com

Q5

Discuss the work of 'Bose-Einstein Statistics' done by Prof. Satyendra Nath Bose and show how it revolutionized the field of Physics. (150 Words, 10 Marks).

UPSC Civil Services Mains 2018 · GS III · 10 marks · Indian Economy

Indian Economy and issues relating to planning, mobilization of resources, growth, development and employment.

Core demand of the question

- State what Satyendra Nath Bose did with Planck's law and photons
- Explain Bose-Einstein statistics and bosons
- **Show how that work changed later physics:** condensate, lasers, and the **boson** family

Revision summary

Satyendra Nath Bose derived Planck's law by treating photons as indistinguishable quanta.

Einstein extended the counting to atoms; the result is Bose-Einstein statistics.

Bosons have integer spin and may occupy one quantum state; fermions cannot.

The theory predicted Bose-Einstein condensation, confirmed in 1995, and underpins lasers and many-body quantum fluids.

Force-carrying particles in the Standard Model, including the **Higgs boson**, sit in that **boson** class.

Introduction

In 1924 **Satyendra Nath Bose**, then at the University of Dacca, re-derived **Planck's law** of black-body radiation by counting **indistinguishable photons**, not by classical waves alone. **Albert Einstein** saw that the same counting could apply to material particles. The joint idea became **Bose-Einstein statistics**. It split the quantum world into particles that may share a state and particles that may not, and it still structures lasers, superfluids and the **Higgs boson**.

Body

Bose's work

- Planck had an energy formula for heat radiation; Bose gave it a **pure quantum-statistical** proof by treating light quanta as identical particles and counting the ways they occupy energy cells.
- Bose sent the English paper to Einstein after an Indian journal delay; Einstein translated and extended it to **atoms with integer spin**.
- The method dropped the classical assumption that particles are **distinguishable**, which was the key break from Maxwell-Boltzmann counting.

Bose-Einstein statistics

- Particles with **integer spin** (0, 1, 2, ...) follow Bose-Einstein statistics and are called **bosons**, a name given by Paul Dirac.
- Many bosons **may occupy the same quantum state**; there is no **Pauli exclusion** for them.
- Photons, gluons, W and Z bosons, and the Higgs particle are bosons; composite nuclei with integer spin also behave as bosons.
- **Fermions** (half-integer spin: electrons, protons, neutrons) follow Fermi-Dirac statistics and cannot share a state. Matter structure depends on that contrast.
- Einstein predicted that a gas of bosons cooled near absolute zero would collapse into one ground state: the **Bose-Einstein condensate (BEC)**.

How the field of physics changed

- **Quantum statistics became a third pillar beside wave mechanics and matrix mechanics:** whole fields (quantum optics, condensed matter, particle classification) use the **boson/fermion** split.
- **Lasers and masers** rest on many photons in one mode, which Bose counting allows.
- Superfluid helium and related macroscopic quantum fluids are **boson** phenomena at low temperature.
- **BEC** was produced in dilute alkali gases in **1995** (Cornell, Wieman, Ketterle; Nobel Prize 2001), confirming the 1920s prediction in the laboratory.
- The **Standard Model** names force carriers as bosons; the 2012 Higgs discovery at CERN is a **boson** story whose name traces to Bose's statistics, not to a Higgs-Bose joint paper.
- **Indian physics gained a foundational credit in the world syllabus:** Bose-Einstein, not only applied nuclear or space work.

Flow diagram

SN Bose photon counting -> Planck law derived
 SN Bose photon counting -> Einstein atoms
 Einstein atoms -> Bose-Einstein statistics
 Bose-Einstein statistics -> Bosons share a state
 Bosons share a state -> Lasers BEC Higgs family

Conclusion

Bose counted indistinguishable photons and repaired Planck's law. Einstein generalised the count to atoms. Bose-Einstein statistics defined bosons, predicted the condensate, and still frames lasers, superfluids and the **boson** family in particle physics. That is a revolution in how the field classifies matter and light.

Facts & figures

Bose 1924

Paper on Planck's law using photon statistics; Einstein communicated and generalised it in Zeitschrift fur Physik.

Boson

Integer-spin particle that obeys Bose-Einstein statistics; named by Dirac after S. N. Bose.

BEC

Bose-Einstein condensate: macroscopic occupation of one quantum state by a cold boson gas; laboratory realisation in 1995.

Pauli exclusion

Rule that fermions cannot share a quantum state; bosons are not bound by it, which is the statistical contrast.

Higgs boson

Standard Model scalar boson observed at CERN in 2012; the boson label follows Bose-Einstein classification of integer-spin particles.

WRAP Exams · Write. Read. Analyse. Practice. · <https://wrapexams.com/upsc/mains-answers/gs-3/2018/discuss-the-work-of-bose-einstein-statistics-done-by-prof-satyendra-nath-bose-and-show-how-it-revolutionized-the-field-of-physics-150-words-10-marks/> · ask@wrapexams.com · wrapexams.com