Origin Of Quantum Mechanics

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- Planck's Quantum theory – provides an accurate explanation of blackbody radiation
- Photoelectric effect – experiments by Hertz in 1887
- theoretical support by Einstein in 1905

  Quantization of em waves – valid for light also
- *light itself is made of discrete bits of energy called* ***photons****,* each of energy $h\nu$*,* ν *frequency of the light*

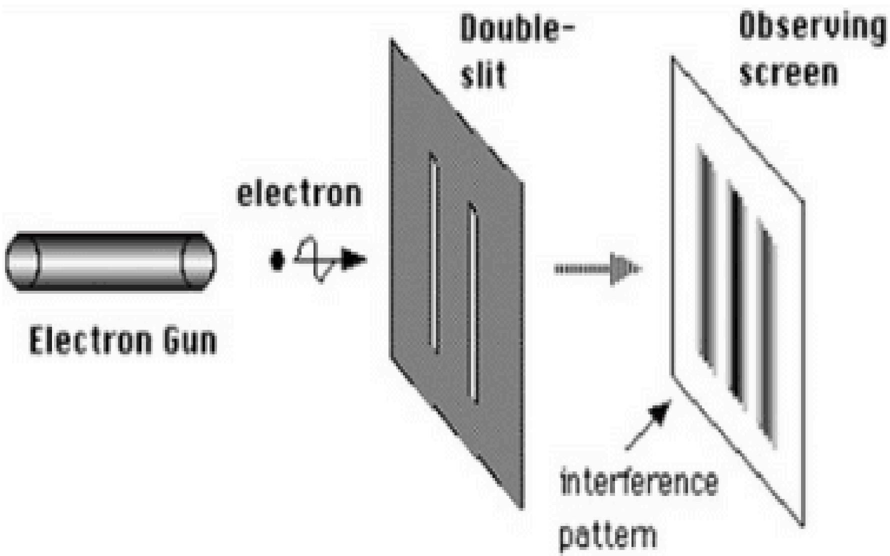
- Postulates of Planck and assumptions of Bohr - lacking the ingredients of a theory
- do not follow from the first principles of a theory.
- need to fit them within the context of a consistent theory - lead **Heisenberg and Schrödinger** to search for the theoretical foundation underlying new ideas.

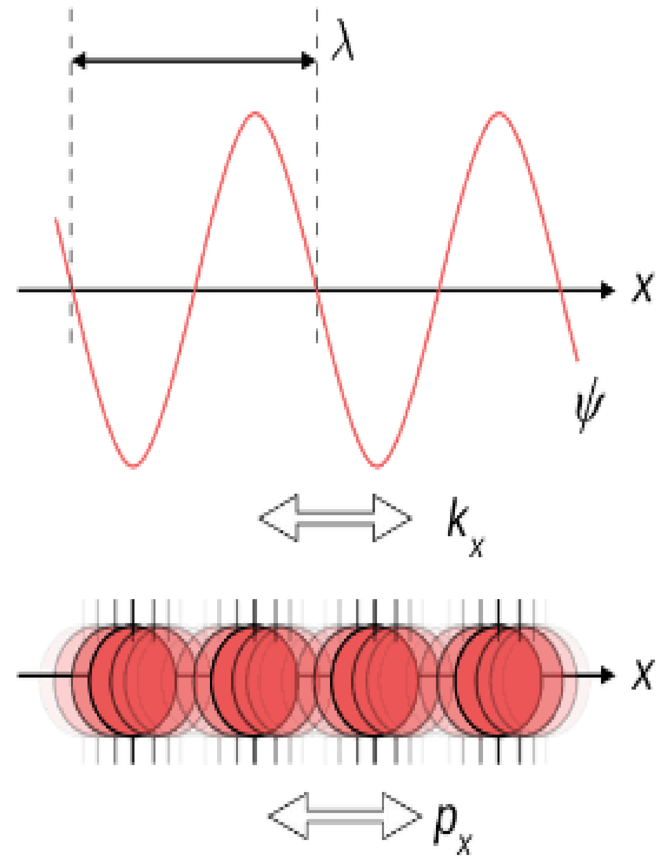
Applications of Planck's Quantum Theory Planck's quantum theory is the fundamental theory of quantum mechanics. So, it has applications in all those fields where quantum mechanics is being used. It has applications in electrical appliances, medical field, quantum computing, lasers, quantum cryptography etc.

Black Body Radiation :

According the temperature, all objects emit electromagnetic radiations. Objects having low temperature emit radio or microwaves (low frequency waves) while objects having high temperature emit visible or ultraviolet light or even higher frequency radiations. A black body is an idealized object that can absorb all electromagnetic radiation which comes in contact of it. After this it starts emitting thermal radiation in a continuous spectrum according to its temperature. The radiation which a black body emits is called black body radiation. Stars almost behave like black body.

What is Wave Particle Duality?





Electrical 4 U

Schrödinger's wave mechanics

- generalization of the de Broglie postulate.
- more intuitive than matrix mechanics
- describes the dynamics of microscopic matter by means of a ***wave equation****, called the Schrödinger equation*
- *instead of the matrix eigenvalue problem of Heisenberg, Schrödinger* obtained a differential equation.
- The solutions of this equation yield the energy spectrum and the wave function of the system under consideration.
- square moduli of the wave functions are *probability densities.*

Dirac's formulation

- Schrödinger's *wave formulation and Heisenberg's matrix approach—were shown to be equivalent.*
- *P A M Dirac*
- *general* formulation of QM - deals with kets (state vectors), bras, and operators.
- The representation of Dirac's formalism in a *continuous basis—the* position or momentum representations— Schrödinger's wave mechanics.
- As for **Heisenberg's matrix formulation**, representing Dirac's formalism in a *discrete basis*

Group Velocity And Phase Velocity Relation:
When group velocity increases, proportionately phase velocity will also increase. When phase velocity increases, proportionately group velocity will also increase.

Uncertainty principle

In quantum mechanics, the uncertainty principle (also known as Heisenberg's uncertainty principle) is any of a variety of mathematical inequalities[1] asserting a fundamental limit to the accuracy with which the values for certain pairs of physical quantities of a particle, such as position, x, and momentum, p, can be predicted from initial conditions.

Heisenberg's Uncertainty Principle

uncertainty in momentum

$$\Delta x \Delta p \geq \frac{h}{4\pi} = \frac{\hbar}{2}$$

uncertainty in position

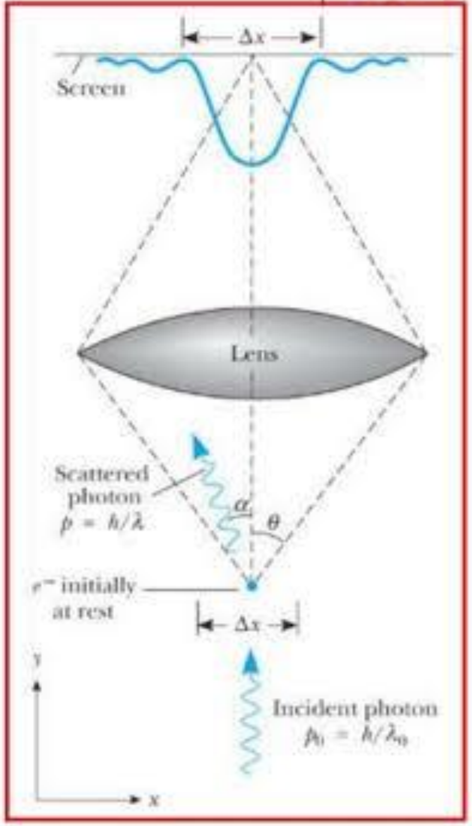
The more accurately you know the position (i.e., the smaller Δx is), the less accurately you know the momentum (i.e., the larger Δp is); and vice versa

Gamma ray microscope

At the moment the light is diffracted by the electron into the microscope lens, the electron is thrust to the right. To be observed by the microscope, the gamma ray must be scattered into any angle within the cone of angle 2A. In quantum mechanics, the gamma ray carries momentum, as if it were a particle.

Physical Origin of the Uncertainty Principle Heisenberg (Bohr) Microscope

- The measurement itself introduces the uncertainty
- When we "look" at an object we see it via the photons that are detected by the microscope
  - These are the photons that are scattered within an angle 2θ and collected by a lens of diameter *D*
  - Momentum of electron is changed
  - Consider single photon, this will introduce the minimum uncertainty




Thank you