

# MYSTERIOUS OF MODERN PHYSICS



# PLAN OF TALK

- Introduction
- Science
- Physics
- Two main branches of Physics
- Time line chart



# SCIENCE

- *Science* is a method of asking questions about **how the universe works**



# PHYSICS

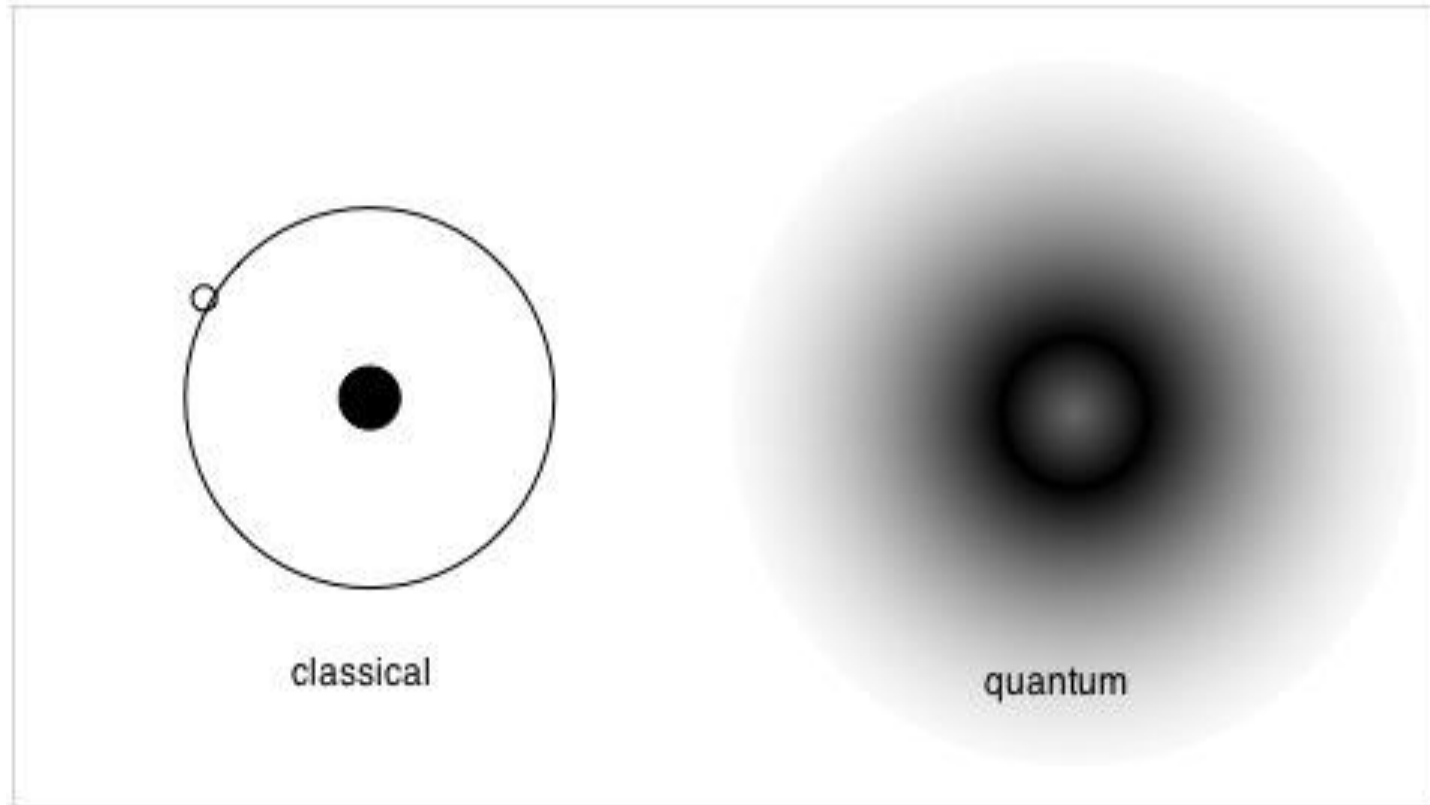
- Physics (from Greek term meaning **Nature**) is the study of **Nature Phenomena**
- To understand and predict **how nature works**



# TWO MAIN BRANCHES OF PHYSICS

**Classical Physics**

**Modern Physics**



classical

quantum

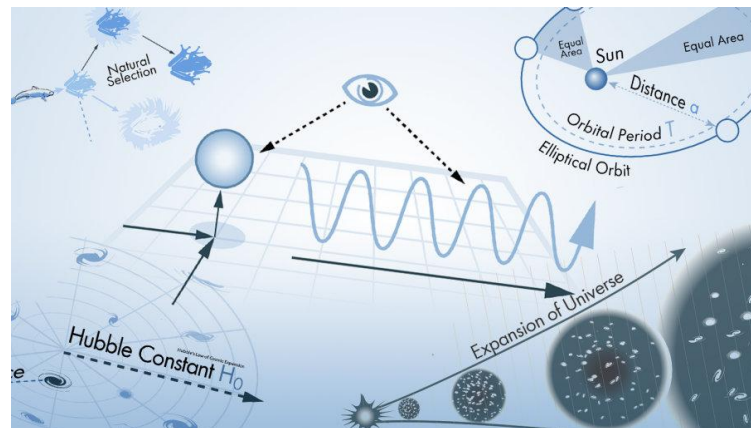
$h=0$

$h=\text{value}$



# CLASSICAL PHYSICS

- It deals with Newton's laws of motion( $x, v, a, p$ ), the law of gravitation, thermodynamics...
- Deterministic
- Continuity
- Macroscopic



$$h=0$$



# MODERN PHYSICS

- It is the branch of physics which deals with the theory of relativity and quantum mechanics.
- Undeterministic(Either one)
- Discrete
- Microscopic
- Max plank and Einstein are considered the father of modern physics
- The foundations of quantum physics were laid between 1896 and 1925



# Timeline chart:

**Democritus (470B.C)**



**Aristotle(384B.C)**



**Young's Double  
Slit  
Experiment(1801)**



**Dalton(1803)**



**J. J. Thomson(1897)**





**Planck's blackbody radiation law(1900)**

**Einstein photoelectric effect(1905)**

**Rutherford(1911)**

**Niels Bohr(1913)**

**Compton scattering  
1922**

**de Broglie(1924)**

**Schrödinger wave equation  
(1926)**

**Davisson and Germer experiment(1927)**

**G.P. Thomson Experiment(1927)**

**Heisenberg Uncertainty Principle(1927 )**

**MaxBorn (1927)**

# DEMOCRITUS

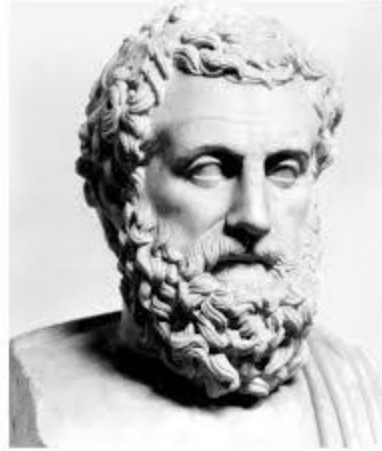


470-380 B.C.

- **Democritus** hypothesized that all **matter** is composed of **tiny** (1/2 fundamental particle) indestructible units.
- He named as **atoma**(In Greek **atoma-Indivisible or non-cuttable**)



# Aristotle



384–322 BC

- Everything was composed of four elements: earth, air, fire, and water (basic building block of matter).
- He completely disagreed with Democritus
- Democritus said  $\frac{1}{2}$  is the fundamental particle but Aristotle rejected it because he did not reach **Zero**

# DALTON

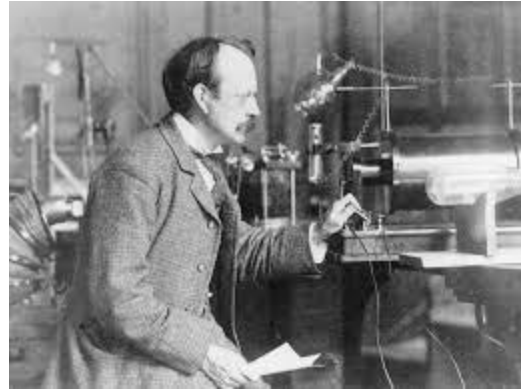


1766-1844

- In 1803, **Dalton** created the first chart of **atomic weights**.
- He proposed that all matter is made of tiny **indivisible** particles called atoms and they cannot be created, divided.
- Atoms of all element are **identical** .
- Atoms of same or different elements combine together to form **compounds**.



# J. J. THOMSON

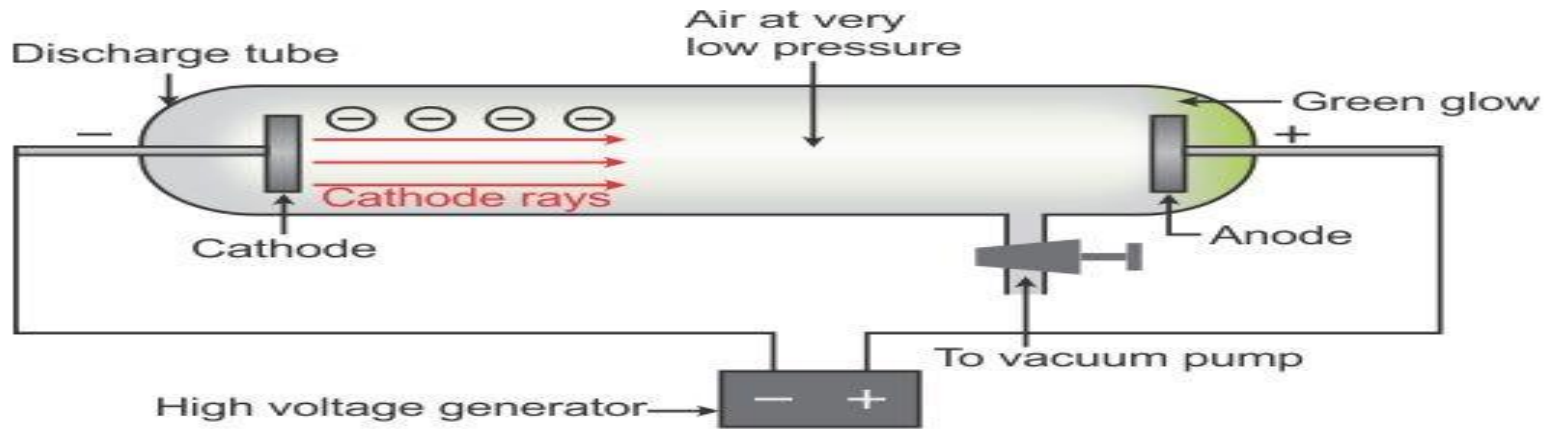


1856-1940

- In 1897, J.J. Thomson discovered the **electron**.
- **Johnstone Stoney** named this charge 'electron' in 1891.
- **J.J. Thomson** concluded that atoms must balance positive(+ve ) and negative(-ve) particles
- Thomson proposed the model of an atom to be similar to that Christmas pudding(**Plum pudding model**)

He discovered 1<sup>st</sup> Subatomic particle

# J.J. Thomson's Experiments



Production of cathode rays  
**Cathode Rays Discharge Tube**

- **J.J. Thomson's** experiments with cathode ray tubes showed that all atoms contain tiny negatively charged subatomic particles or electrons
- He proposed that atom consists of 2-bits(+ve and -ve)

# ERNEST RUTHERFORD

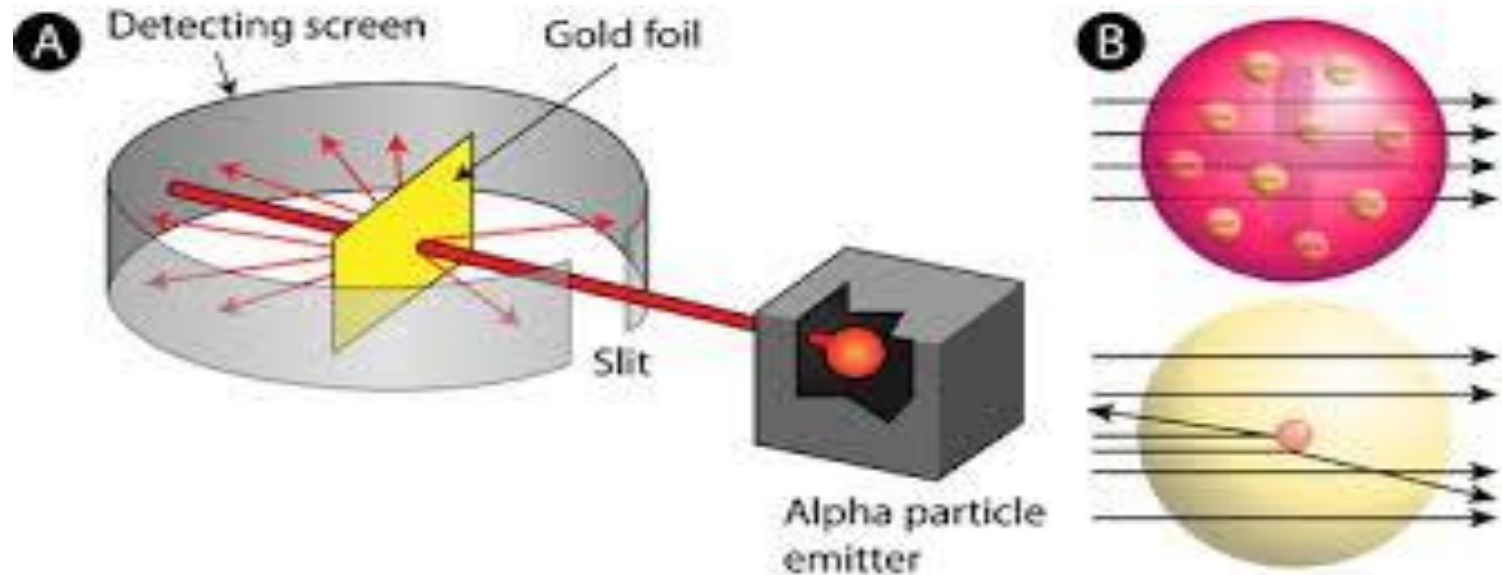


1871-1937

- He is known as **father of nuclear physics**.
- In 1911, he was the first to discovered the **nucleus**.
- He proposed the model of an atom known as the **Rutherford atom model**.
- In 1919 **Rutherford** had **discovered the proton**.  
(pro means First).



# Gold foil experiment



- When he shot a beam of alpha particles at a sheet of **gold foil**
- Most of the fast moving  $\alpha$ -particles passed straight through the gold foil.
- Some of the  $\alpha$ -particles were deflected by the foil by small angles.
- Surprisingly one out of every 12,000 alpha particles appeared to rebound.
- He concluded that a **tiny, dense nucleus** was causing the deflections.

<https://youtu.be/kHaR2rsFNhg>



# YOUNG'S DOUBLE SLIT EXPERIMENT



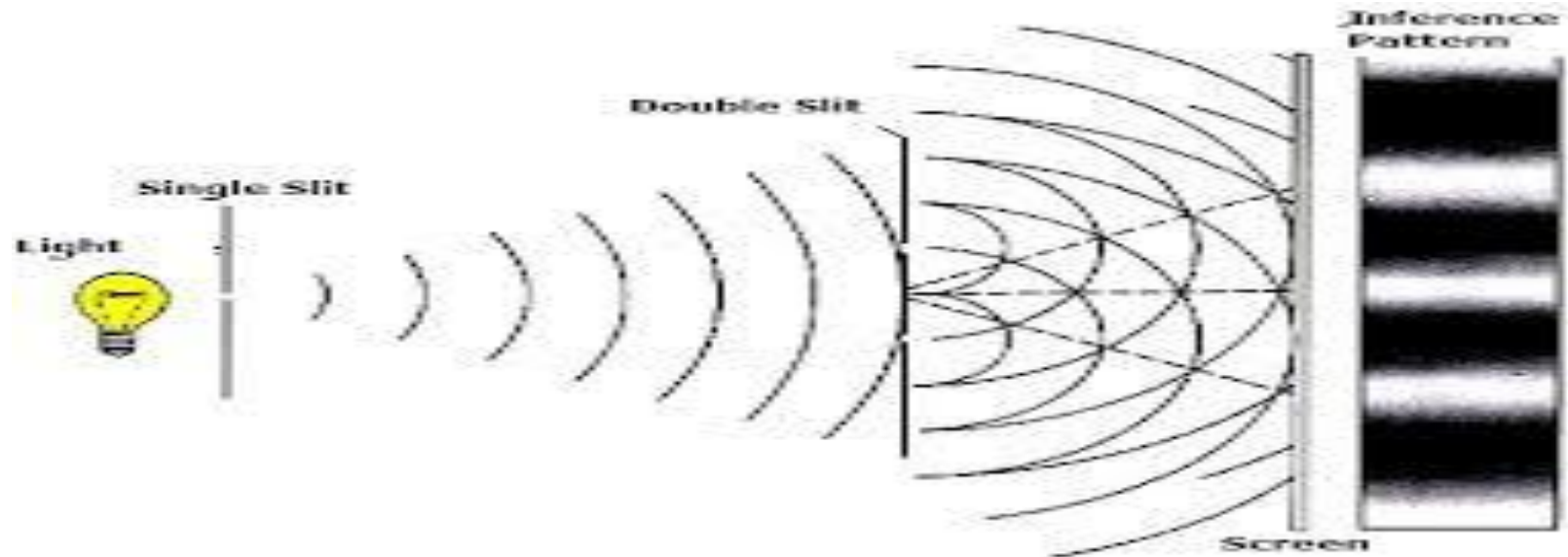
1773-1829

- The Double Slit Experiment was first conducting by Thomas Young
- He established the principle of interference of light
- This experiment demonstrate the wave nature of light

Interference-Super position of 2 waves



# Double Slit Experiment

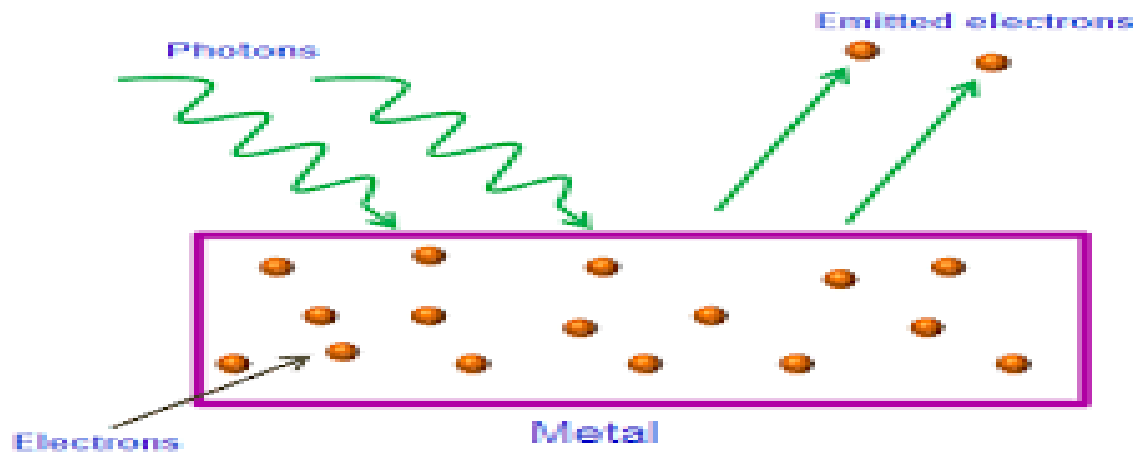


- **Thomas Young** performed an experiment that strongly inferred the **wave-like nature of light**.
- **Young** reasoned that some type of **interaction** would occur when two light waves met.
- This experiment is described in the **Dual wave/particle** theory of light.

<https://youtu.be/J2YB9OZzxPw>

# PHOTOELECTRIC EFFECT

- The **photoelectric effect** is a phenomenon where electrons are emitted from the metal surface when the light of sufficient frequency is incident upon. ...
- This implies that the kinetic energy of electrons increases with light intensity.



Ejection of Electron by light from the surface

# Einstein's Explanation Of Photoelectric Effect

- In 1905 Einstein proposed that electromagnetic or **light made up of photons**
- According to Einstein **Energy of photon  $E=h\nu$**
- $E_k=h\nu-\omega$  where  $E_k$  is the kinetic energy of the photoelectron,  $h$  is the Planck constant,  $\nu$  is the frequency associated with the radiation quantum, and  $\omega$  the work function



# Wave–Particle Duality: De Broglie, Einstein

- Albert *Einstein* first explained the wave–particle duality of light in 1905. Louis *de Broglie* hypothesized that any particle should also exhibit such a duality.

- Einstein relation, says that a particle's momentum  $p$  is inversely proportional to its wavelength  $\lambda$

$$p = h/\lambda$$

- But **de Broglie** proposed that every particle has a wavelength that's inversely proportional to its momentum, with the same universal constant of proportionality,  $h$ .

$$\lambda = h/p$$

- The **de Broglie equation** is an **equation** used to describe the **wave properties of matter**

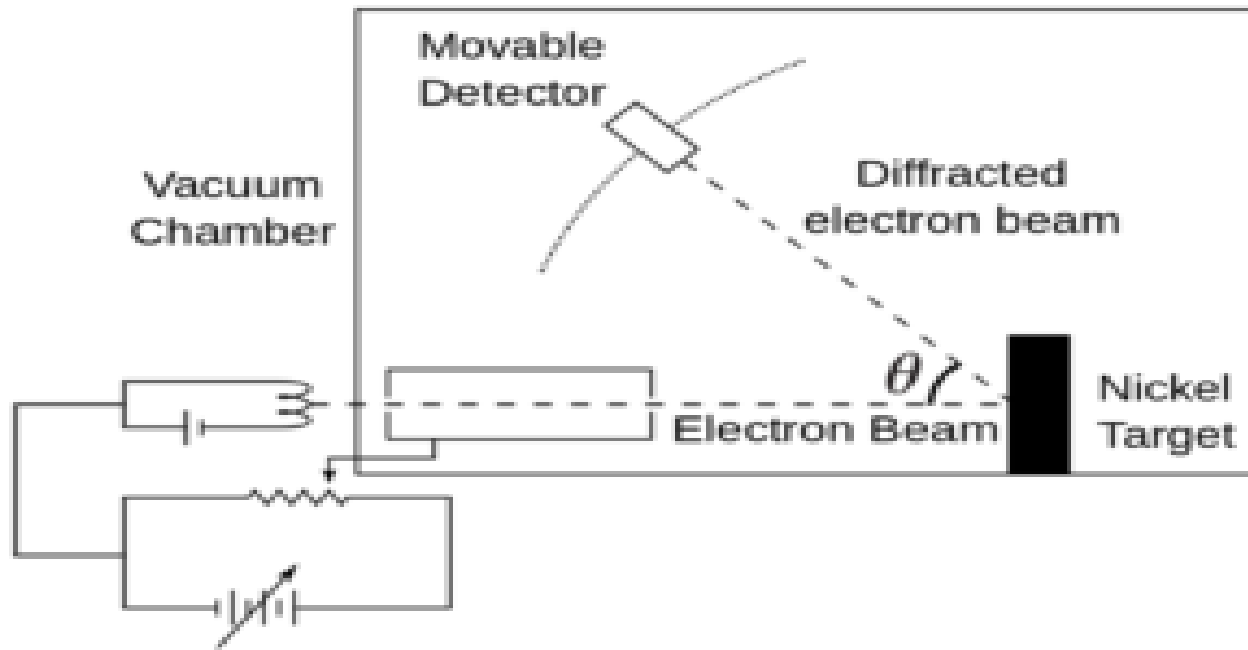


# DAVISSON AND GERMER

- In 1927 **Davisson and Germer** verify the de Broglie hypothesis that a material particle possesses wave nature.
- They experimentally proved the wave nature of electron through diffraction of electron beam by a nickel crystal.

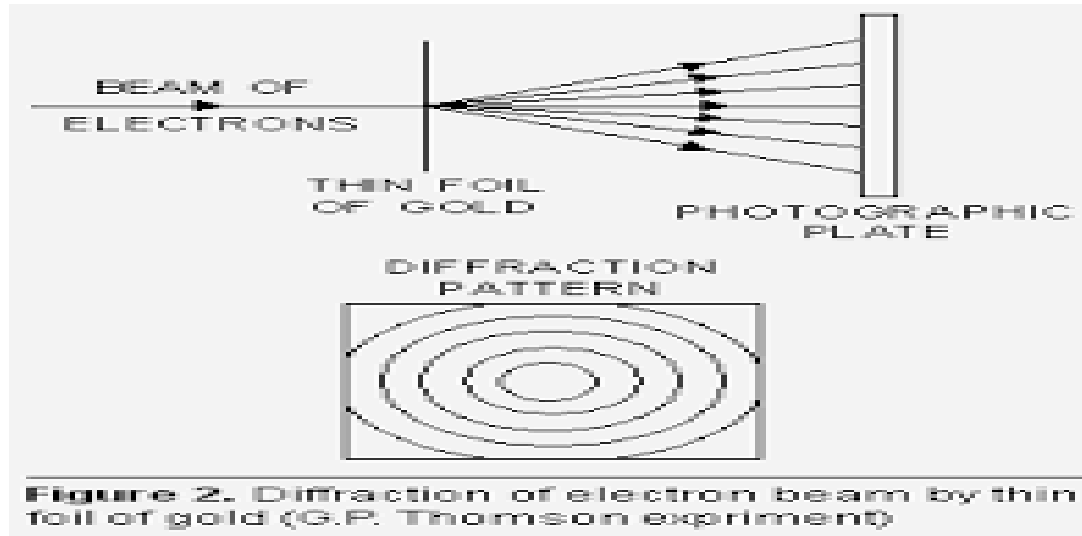
**Davisson and Germer proved De Broglie's Electron wave nature concept**

# DAVISSON AND GERMER EXPERIMENT



- The **Davisson and Germer experiment** showed that electron beams can undergo diffraction when passed through the nickel crystals. This shows that the wave nature of electrons as waves can exhibit interference and diffraction.

# G.P. THOMSON EXPERIMENT



- In 1927, **G.P. Thomson** experimentally confirmed the existence of matter waves by demonstrating that **electron** beams are **diffracted** when they are scattered by the regular atomic rays of crystals.
- He proved De Broglie's **Electron wave nature** concept .

**Electron Diffraction refers to the wave nature of Electrons.**



# NIELS BOHR



- **Bohr** was the first to **discover** that electrons travel in separate orbits.
- Electrons should move around the nucleus but only in prescribed orbits.
- When jumping from one orbit to another with lower energy, a **light quantum is emitted**.
- The Bohr model was also the **first atomic model** to incorporate **quantum theory in 1913**.

He discovered Energy Levels-1913

# Postulates of Bohr model

- The electron is able to revolve in certain stable orbits(Standing Wave) around the nucleus **without radiating any energy**.
- Electrons can only gain and lose energy by jumping from one allowed orbit to another.

$$\Delta E = E_2 - E_1 = h \nu$$

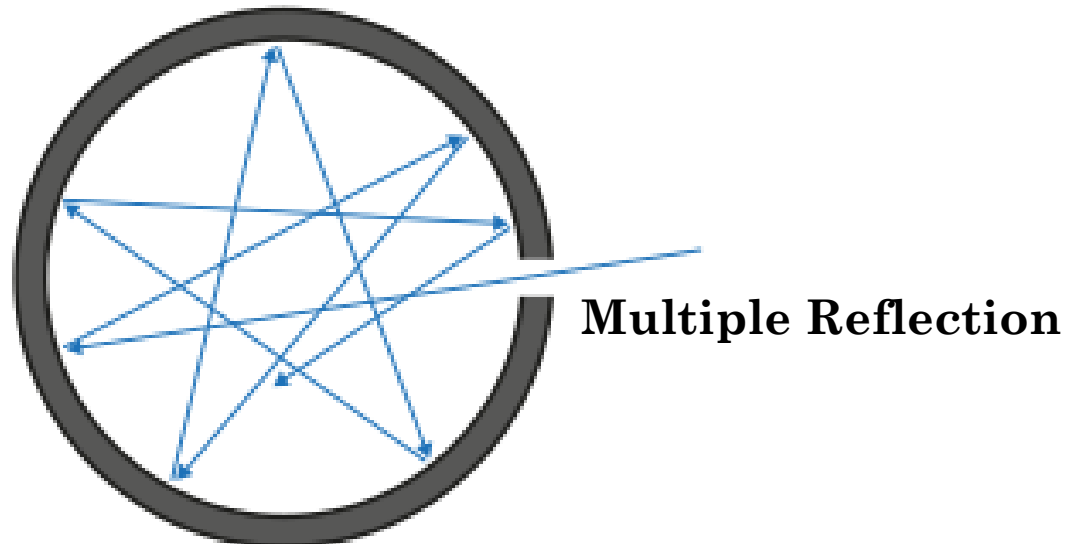
- During a quantum jump a *discrete* amount of energy is radiated.
- The angular momentum of the revolving electron is an integral multiple of planck's constant .

$$L = n \hbar$$



# BLACK BODY RADIATION

- A **black body** is one that **absorbs** all the EM radiation (light...) that strikes it.
- To stay in thermal equilibrium, it must **emit radiation** at the same rate as it absorbs.
- Blackbody is a **perfect absorber** for all incident radiation.
- Blackbody as an **ideal** radiation absorber



**BLACK BODY**

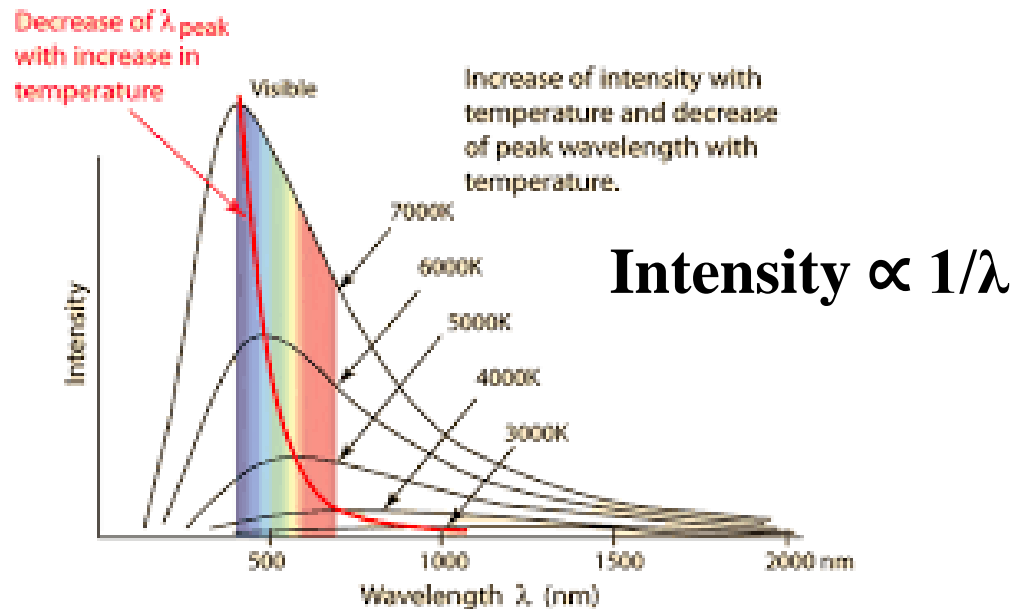


# LAWS GOVERNING BLACKBODY RADIATION

- **Wien's displacement law**
- **Rayleigh–Jeans law**
- **Planck's blackbody radiation law**



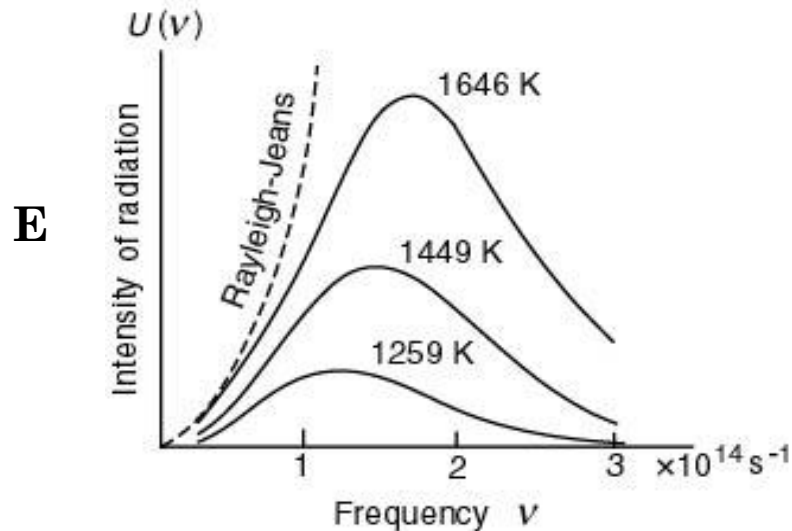
# Wien's displacement law



- Wien's displacement law explains relationship between the **temperature and the wavelength** of a blackbody.
- It states that the **black-body radiation** curve for different temperatures will peak at different wavelengths that are **inversely proportional** to the absolute temperature of the body.

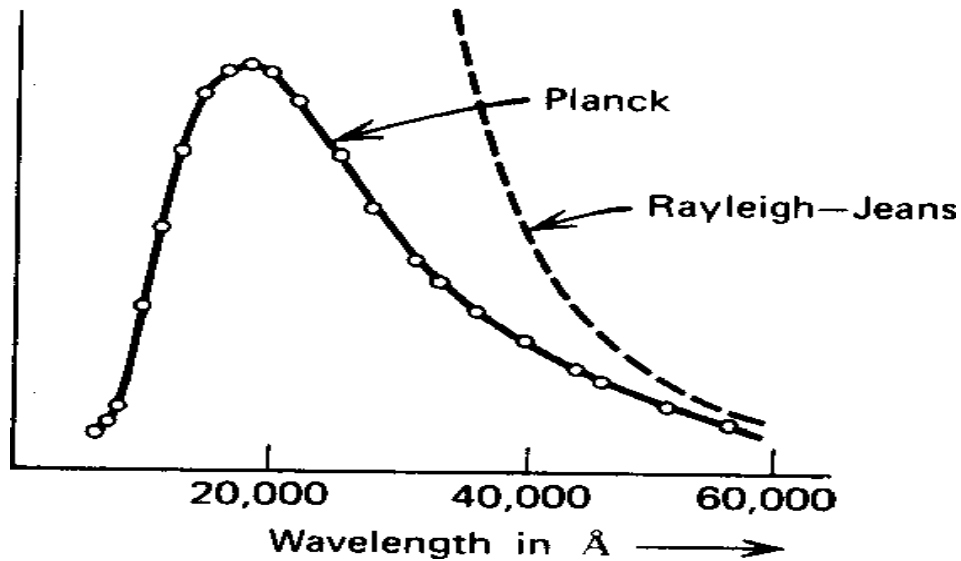


# THE RAYLEIGH–JEANS LAW



- Blackbody at thermal equilibrium will emit radiation in all frequency ranges, emitting more energy (Continuous manner) as the frequency increases.
- The **Rayleigh–Jeans law** agrees with experimental results at large wavelengths but **strongly disagrees at short wavelengths**.
- This inconsistency between observations and the predictions of classical physics is commonly known as the **ultraviolet catastrophe**.

# PLANCK'S BLACKBODY RADIATION LAW



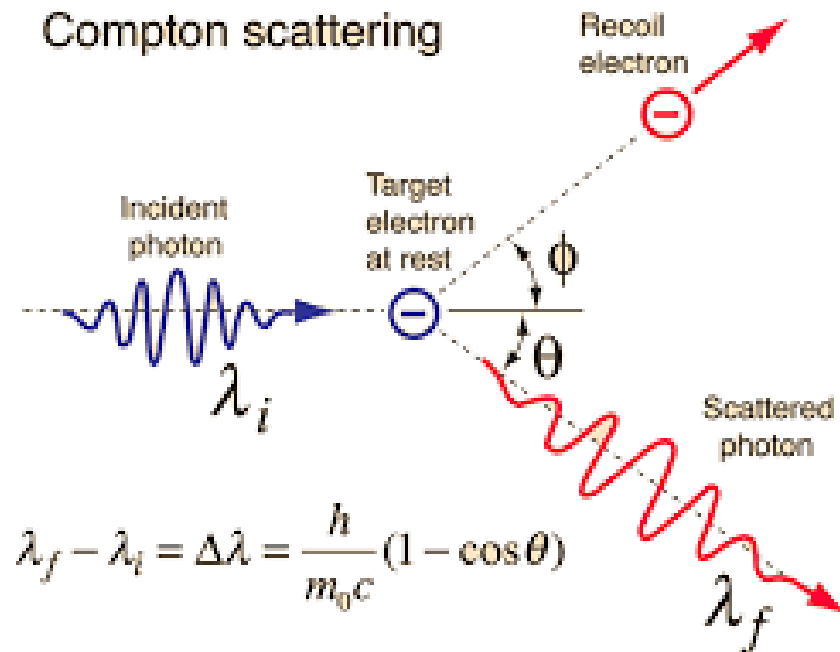
- In 1900 Max planck explains the **spectral-energy distribution of radiation** emitted by a **blackbody**.
- Energy of the radiation emitted by the oscillating atoms may have **discrete** values

$$E=h\nu$$



# COMPTON SCATTERING

- In 1922 Arthur Compton discovered the **scattering** of a photon by an electron. It results in a decrease in energy of the photon called the **Compton effect**.
- Compton proved that photons behave like a particle as well as a wave



Increase in wavelength of photon that have been elastically scattered by electrons”



# MAX BORN



- He played a vital role in the development of quantum mechanics
- Born's rule gives the probability that a measurement of a **quantum** system
- In 1927 Max born was introduced the physical interpretation of wave function  $\psi^2$  or  $\psi \psi^*$
- **Born** shared the 1954 Nobel Prize for Physics with Walther Bothe for his statistical interpretation of quantum theory.

$$\text{Intensity} \propto \text{Amplitude}^2$$

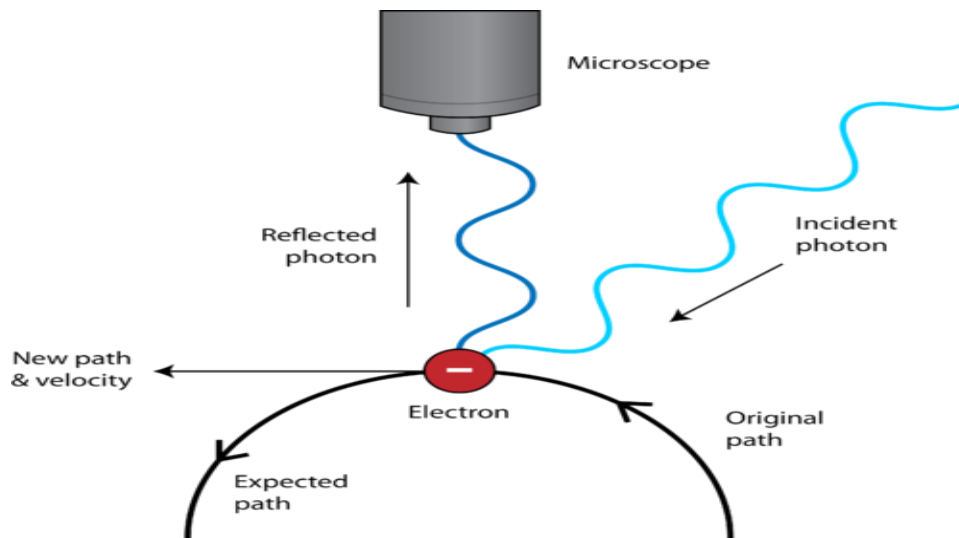
# Important characteristics of wave function

- $\Psi$  should be **continuous** and **single-valued**.
- it is a **complex quantity**
- it should **approach to zero** as **r is tending to infinity**.
- The wave function itself has **no physical meaning**.
- The probability of finding a particle in whole space is unity. i.e. Integration of  $\Psi \times \Psi^* dV = 1$ . This is called normalizing condition.
- It explains the motion of quantum mechanics particle when operated with Schrodinger's Wave Equation.



# HEISENBERG UNCERTAINTY PRINCIPLE

- In 1927 Heisenberg was stated the **Uncertainty principle**
- He states that the position and momentum of a particle **cannot be measured simultaneously** also can't measure **complementary variable** of matter/particle at the same time to certainty



$$\Delta x \Delta p \gtrsim h$$

$$\Delta x \cong \frac{h}{m \Delta v_x}$$

$$\lambda_B = \frac{h}{m_0 v}$$





**HEISENBERG GETS PULLED OVER**

# SCHRODINGER EQUATION

- In 1926 he discovered the mathematical equations to **finding an electron** in a certain position.
- It describe the **wave nature of the electron** motion around the nucleus .
- It trued for any charged particle and it is also used to find the **allowed energy levels** of quantum mechanical systems.



# Timeline of PHYSICS

Classical Physics



Modern Physics

Democritus  
(470B.C)

Aristotle  
(384B.C)

Young's Double Slit  
Experiment(1801)

Dalton  
(1803)

J. J. Thomson  
(1897)

Planck's blackbody radiation  
(1900)

Einstein  
photoelectric  
effect  
(1905)

Born's rule  
(1927)

Heisenberg  
Uncertainty  
Principle  
1927

Davisson and Germer  
experiment  
(1927)  
G.P. Thomson  
Experiment

Schrödinger  
wave  
equation  
(1926)

de Broglie  
(1924)

Compton  
scattering  
(1922)

Niels Bohr  
(1913)

Rutherford  
(1911)