Summary of Bohr's theory:

The theory was proposed to explain the experimental findings (particularly atomic spectra) which the classical theory failed to account for. The main assumptions are as follows:

1- The hydrogen atom consists of a nucleus of charge +e and an electron of charge –e orbiting around the nucleus. Such an orbit is classically unstable but Bohr simply ignored it.

2- Planck-Einstein relation which relates the quantity hv to an energy difference between two discrete states of the atom holds for the absorption or emission of radiation , thus if the energies of the two discrete states of the electron in an atom are E_1 and E_2 then the frequency of the spectral line due to the transition of an electron from state I to State II given by $E_2 - E_1 = \Delta E = hv$

3- The angular momentum of the electron in discrete states is quantized units of $h/2\pi$, i.e. it can only have the values

Angular momentum $= n\left(\frac{h}{2\pi}\right) = n\hbar$ where n is an integer

No justification is offered for this assumption using these assumption, Bohr derived the following equations for allowed orbital energies and allowed transition energies:

Transition energies

1- $En = \frac{-mZ^2e^4}{2n^2h^2}$ where m= mass of electron

Z= number of protons

e= charge of electron

n= an integer

h= Planck's constant

2- For hydrogen Z=1

$$E_2 - E_1 = hv = \frac{me^4}{2\hbar}\left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right) \qquad \frac{2\pi^2 me^4}{h^3 c}$$

C/λ=v where c is the velocity of light

$$\frac{1}{\lambda} = w = \frac{2\pi^2 me^4}{h^3 c}\left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right)$$

Where w=1/$\lambda$is called wave number (cm^{-1}). If the value of the constant $\frac{2\pi^2 me^4}{h^3 c}$ are obtained the value 109737 cm-1 which is in excellent agreement with the experimental value of Rydberg constant.

Bohr's theory succeeded in predicting the wavelengths of the spectral lines of hydrogen atom in various series for:

Lyman series $n1= 1$; $n2= 2, 3,4, 5, 6, 7, 8$

Balmer series $n1= 2$; $n2= 2, 3,4, 5, 6, 7, 8$

Paschen series $n1= 3$; $n2= 2, 3,4, 5, 6, 7, 8$

Brackett series $n1= 4$; $n2= 2, 3,4, 5, 6, 7, 8$

Pfund series $n1= 5$; $n2= 2, 3,4, 5, 6, 7, 8$

Unfortunately Bohr's theory faild completely when applied to any other atom with more one electron, thus it was applicable for only one electron atom H, He^{+} and Li^{2+} .

OUR QUANTUM WORLD
Wave Particle duality of Nature OUTLINE

Atom and its size

Waves and Particles

Waves as particles and Particles as Waves – Quantum View

Milestones of Quantum physics

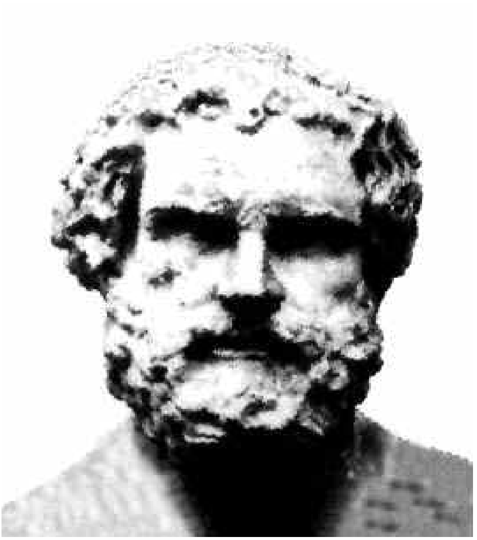
Wave nature of Matter : de Broglie

Interference of waves

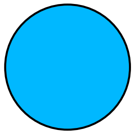
Heisenberg’s uncertainty principle

Quantum versus Classical world view

How big are atoms ?

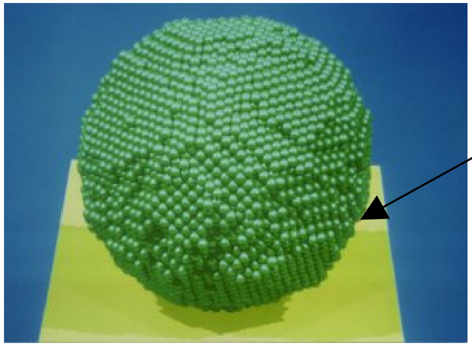


Democritus : Atoms as
building blocks.



Size?
Shape ?
Substance?

17000 Copper
atoms



Diameter 10^{-7} cm

1 nm = 10^{-9} meters

Atomic size determined not till the 19^{th} century

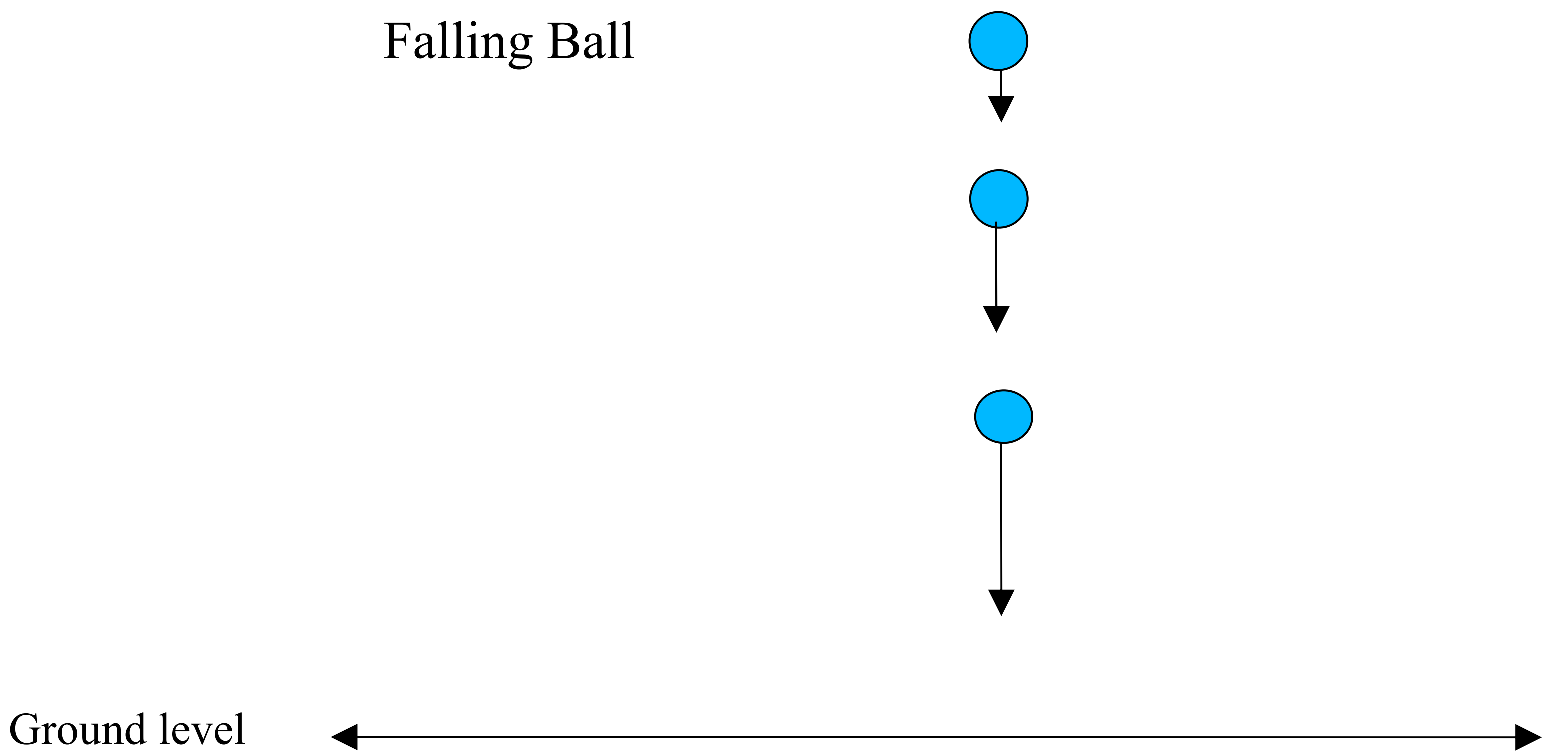
Atoms are very small ; about 0.5 nanometers.

Nanotechnology deals with atomic manipulations.

Waves and Particles : What do we mean by them?

Material Objects:

Ball, Car, person, or point like objects called particles.
They can be located at a space point at a given time.
They can be at rest, moving or accelerating.

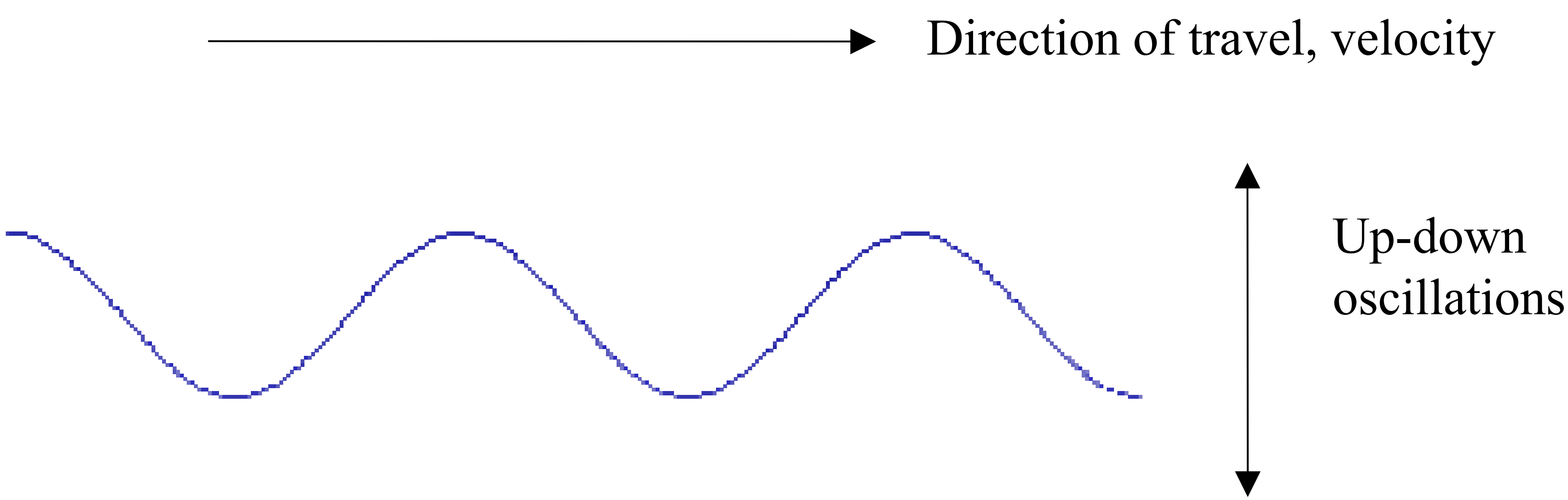


Common types of waves:

Ripples, surf, ocean waves, sound waves, radio waves.

Need to see crests and troughs to define them.

Waves are oscillations in space and time.

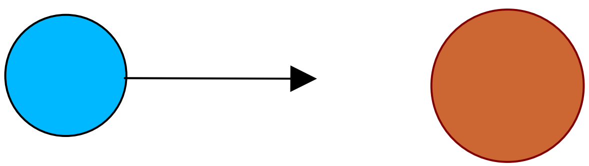


Wavelength ,frequency, velocity and oscillation size defines waves

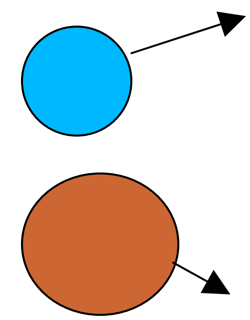
Particles and Waves: Basic difference in behaviour

When particles collide they cannot pass through each other !
They can bounce or they can shatter

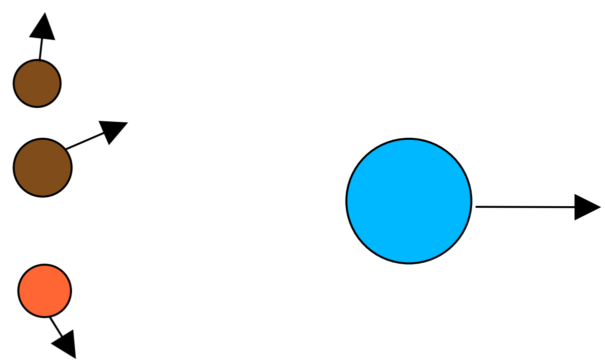
Before collision



After collision



Another after collision state shatter

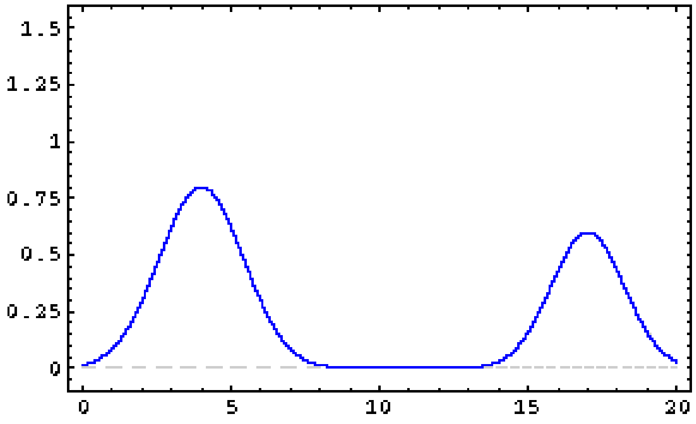


Waves and Particles Basic difference:

-Waves can pass through each other !

-As they pass through each other they can enhance or cancel each other

-Later they regain their original form !



Waves and Particles:

Wavelength

Frequency

Waves

Spread in space and time

Can be superposed – show interference effects

Pass through each other

Particles

Localized in space and time

Cannot pass through each other - they bounce or shatter.

OUR QUANTUM WORLD

In the 20^{th} century, study of atomic systems required a fundamental revision of these classical ideas about physical objects.

1. Light waves exhibited particle like properties – phenomena called photo-electric effect in which light impinging on certain metals cause instanteous almost emission of electrons in a billiard ball like impact.
   – the basis of automatic door openers in grocery stores

2. Electrons (particles) exhibit wave like properties – they can pass through each other ! Phenomenon of electron interference – basis of electron microscopes

This quantum picture of the world is at odds with our common sense view of physical objects.We cannot uniquely define what is a particle and what is a wave !!

- Neils Bohr and Werner Heisenberg were the architects of this quantum world view, along with Planck, Einstein, de Broglie,Schrodinger, Pauli and Dirac.