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Schrodinger time Independent wave equation

Consider a system of stationary waves associated with a particle. Let x, y, z be the co-ordinates of particle and ψ be the displacement of the De-broglie wave at any time 't'. ψ is called wave function.

De-broglie's wave length is $\lambda = \frac{h}{mv}$

The classical different equation of the wave motion given by

$$\nabla^2\psi = \frac{1}{v^2}\frac{\partial^2\psi}{\partial t^2}$$

$$\frac{\partial^2\psi}{\partial x^2} + \frac{\partial^2\psi}{\partial y^2} + \frac{\partial^2\psi}{\partial z^2} = \frac{1}{v^2}\frac{\partial^2\psi}{\partial t^2}$$

$$\frac{\partial^2\psi}{\partial t^2} = v^2\nabla^2\psi \longrightarrow (1)$$

Sol of equation (1) can be written as

$$\psi = \psi_0 \sin\omega t \longrightarrow (2)$$

where ψ_0 is amplitude of particle waves at point

Consider it is a function of position (x, y, z) only and independent of time "t"

differ equation (2) w.r.to 't', then we get

$$\frac{\partial\psi}{\partial t} = \psi_0 \cos\omega t \; \omega$$

$$\frac{\partial\psi}{\partial t} = \omega\psi_0 \cos\omega t$$

again diff w.r.to "t"

$$\frac{\partial^2\psi}{\partial t^2} = \omega\psi_0(-\sin\omega t)\,\omega$$

from eq (2) $\psi = \psi_0 \sin\omega t$

$$\frac{\partial^2\psi}{\partial t^2} = -\omega^2\psi$$

we know that $\omega = 2\pi\nu$

$$\frac{\partial^2\psi}{\partial t^2} = -(2\pi\nu)^2\psi$$

$$\frac{\partial^2\psi}{\partial t^2} = -4\pi^2\nu^2\psi \longrightarrow (3)$$

we know that, velocity $v = \nu\lambda$

$$\boxed{\nu = \frac{v}{\lambda}}$$

→ Sub $\nu = v/\lambda$ in eq (3)

$$\rightarrow \frac{\partial^2\psi}{\partial t^2} = -4\pi^2\left(\frac{v}{\lambda}\right)^2\psi$$

$$\rightarrow \frac{\partial^2\psi}{\partial t^2} = -4\pi^2\frac{v^2}{\lambda^2}\psi \longrightarrow (4)$$

Compare eq (1) & (4) we get

$$\rightarrow v^2\nabla^2\psi = \frac{-4\pi^2 v^2\psi}{\lambda^2}$$

$$\rightarrow v^2\nabla^2\psi + \frac{4\pi^2 v^2\psi}{\lambda^2} = 0$$

Dividing with v^2 on both sides

$$\rightarrow \frac{v^2\nabla^2\psi}{v^2} + \frac{4\pi^2 v^2\psi}{\lambda^2 v^2} = 0$$

$$\rightarrow \nabla^2\psi + \frac{4\pi^2}{\lambda^2}\psi = 0$$

we know that debroglies wave length $\lambda = h/mv$

$$\rightarrow \nabla^2\psi + \frac{4\pi^2 m^2 v^2\psi}{h^2} = 0 \longrightarrow (5)$$

Let E be the total energy of particle V be potential energy and K.E is kinetic energy then total energy is

$$E = K.E + V$$

$$E = \frac{1}{2}mv^2 + V$$

$$E - V = \frac{1}{2}mv^2$$

$$2(E - V) = mv^2$$

$$2m(E - V) = m^2v^2 \longrightarrow (6)$$

Sub eq (6) in eq (5)

$$\nabla^2\psi + 4\pi^2 2m(E - V)\psi = 0$$

$$\nabla^2\psi + \frac{8m\pi^2(E - V)\psi}{h^2} = 0 \longrightarrow (7)$$

The eq (7) is known as time independent "Schrodinger's wave equation

In terms of $\hbar$,

$$\nabla^2\psi + \frac{2m(E - V)\psi}{\frac{h^2}{4\pi^2}} = 0$$

$$\nabla^2\psi + \frac{2m(E\psi - V\psi)}{\hbar^2} = 0 \longrightarrow (8)$$

eq (8) represents time independent schrodinger's wave equation in terms of $\hbar$.

for a particle V=0, Schrodinger's equation can be written as

$$\nabla^2\psi + \frac{2mE\psi}{\hbar^2} = 0 \longrightarrow (9)$$

multiply with $\hbar^2/2m$ on both sides

$$\frac{\hbar^2}{2m}\nabla^2\psi + \frac{2m(E\psi - V\psi)}{\frac{\hbar^2}{\hbar^2/2m}} = 0$$

$$\frac{\hbar^2}{2m}\nabla^2\psi + E\psi - V\psi = 0$$

$$\frac{\hbar^2}{2m}\nabla^2\psi - V\psi = -E\psi$$

$$-\left(\frac{\hbar^2}{2m} + V\right)\psi = -E\psi$$

$$H\psi = E\psi \longrightarrow (10)$$

∴ here H is the Hamiltonian and E is total Energy of System.

Department Of Physics
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SRIKAKULAM

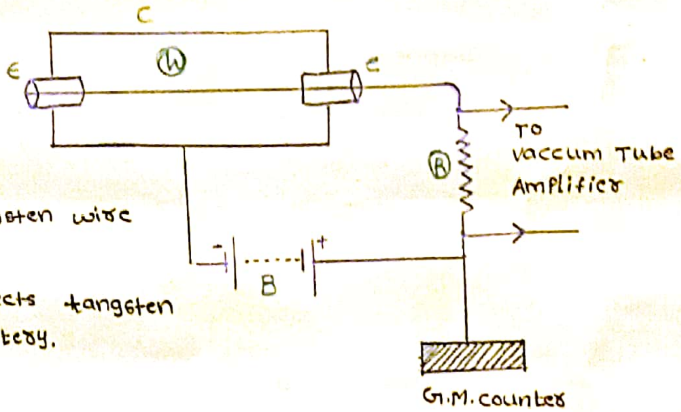
G.M. counter and Cloud Chamber

G.M. counter

Full form of G.M. counter: "Geiger Muller" counter

Principle of G.M. counter: There would be the conduction of the electrical charge on the tube when a particle or photon of incident radiation would turn the gas conductive by the means of ionization.

Construction of G.M. counter:



* C is a metal chamber containing air/gas at a pressure of about 10 cm of Hg (Mercury).
* 'W' is the fine tungsten wire stretched along the axis of tube.
* EE is the end points of the tungsten wire made from ebonite.
* R is the resistance which connects tungsten wire to a +ve terminal of battery.

Working of G.M. counter:

* when an ionizing particle enters the counter, ionization takes place and few ions are produced.
* once applied potential difference is strong an avalanche of electrons moves towards the central wire.
* The critical potential is lowered causing a sudden discharge through 'R'.
* vaccum tube circuit amplifies the potential difference developed across 'R'.
* single particle can be registered.
* The sudden plaise of discharge sweeps aways the ions from the chamber and the counter is ready to register the arrival of next particle.

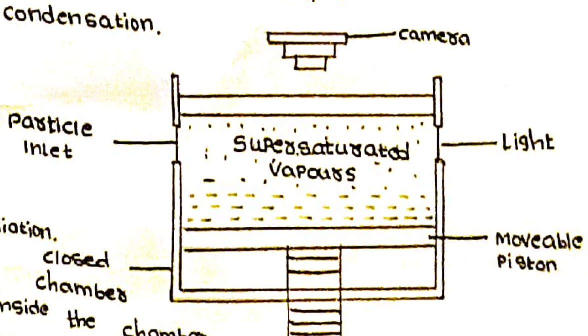
Merits:-
* It is very useful for counting β-particle.
* It can also be used for measuring γ-ray intensities.

Demerits:
* cannot useful for counting α-particle.
* cannot give information about charge, energy momentum of the particle.

Cloud Chamber

Principle of Cloud chamber: Cloud chamber also known as "wilson cloud chamber."
* It creates a track of ions, which under supersaturation conditions act as condensation nuclei around which a mist-like trail of small droplets forms if the gas mixture is at the point of condensation.

Construction:
* Wilson cloud chamber consists of a closed cylindrical chamber with transparent glass top and a moveable piston at the bottom.
* On the sides near the top the cylinder is provided with a glass window for illuminating light and an inlet for the ionization radiation.
* The piston can be moved up or down by or lever attached to it.



Working: The chamber is filled with alcohol and water when the vapour inside the chamber become saturated, the piston is moved as a result of this vapours become supersaturated. Ionization particles passes through the it which causes ionization and their tracks are recorded in the camera through window. through these supersaturated vapours

Uses:
* Used for the discovery of Positrons (1932) and muons (1936).
* The charge, momentum etc of the particles can be found out. $\frac{mv^2}{r} = qvB$

m = magnetic field applied
r = radius of the particle
m, v, q = mass, speed and charge.

Disadvantages:
* continuous operation is not possible
* can detect only a few types of particles.
* better detectors are now available.

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PHASE VELOCITY AND GROUP VELOCITY

GROUP VELOCITY:

*) The square of the amplitude is related to the energy of the waves.

*) The speed of the troughs and crests, known as the phase speed, must be distinguished from the speed and direction of the wave's associated energy (or) information transmission, known as the group velocity, according to mathematical analysis.

*) The wave front moves at only half the speed of the crests, which appear to flow through the packet of waves expanding out over a pond after a rapid disturbance a point.

*) The group velocity is one-half the phase speed for capillary waves.

*) The velocity of a group of waves is referred to as group velocity.

*) As a result, Group velocity is calculated at the same time. The formula of group velocity is given as:

$$v_g = d\omega/dk.$$

Here; $d\omega$ is the rate of change in angular frequency of wave.

dk is the rate of change in angular wavenumber.

PHASE VELOCITY:-

*) The rate at which the phase of a wave propagates through space is known as its phase velocity.

*) The phase of any one frequency component of the wave move at this velocity.

*) The main focus of phase velocity is on a wave's particular features.

*) The crest and through one the two most important aspects of a wave.

*) The formula of phase velocity is given as:

$$v_p = \omega/k.$$

Here ω is the angular frequency and

k is the angular wavenumber

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nano wires , quantum dots

Nano wires and Quantum Dots

Structural and optical properties of nanowire quantum dots (a) Schematic nanowire and magnetic field orientations. (b) PL spectrum of a single exciton recombination. (c) power dependent spectra take at 10 K under nanowire (~1.5/nm) External at B = 0. The two emission peaks are Identified as a charge Exciton (X) and charge Exciton (XX) (d) Integrated of X and XX transition versus of Excitation power. The solid (dashed) line is guide to the Eyes of linear (quadratic) power dependence

↳ Same publication

. . . Crystal, variable, nanowires, one crystal (~ [illegible]) with a [illegible] magnet allowed field orientations (b) PL spectrum of a recombination (c) power, dependent spectra take at 10, under [illegible] (c) belong to a single charged dot For A F.S. which the g-Factor will be as a Charge Exciton (X) and Charge a [illegible] [illegible] [illegible], at Excitation power The solid ([illegible]) line is guide to the Eyes of linear (quadratic) power dependence . . . :

Energy (eV) , ... power (nW) 200 400 600 10 10' 10² ... power (nW) 10 ...

[illegible]

TRANSISTOR AND ITS CONFIGURATIONS

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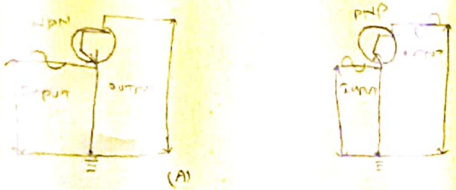
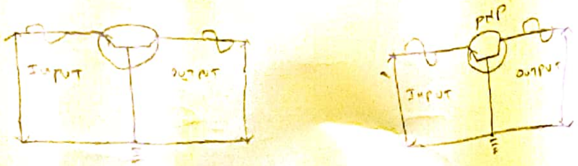
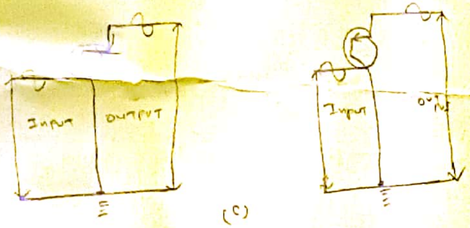


(A)
Common emitter



(B)
Common base



(C)
Common collector

Transistor configurations

A transistor may be connected in any one of three basic configurations (see the figure above): common emitter (CE), common base (CB) and common collector (CC). The term common is used to denote the element that is common to both input and output circuits.

COMMON EMITTER

The COMMON EMITTER CONFIGURATION (CE) shown in figure above (view A) is the arrangement most frequently used in practical amplifier circuits since its provides good voltage, current, and power gain. The common emitter also has a somewhat law input resistance (500 ohms - 1500 ohms) because the input is applied to the forward biased junction, and a moderately high output resistance (30 kΩ - 50 kΩ or more).

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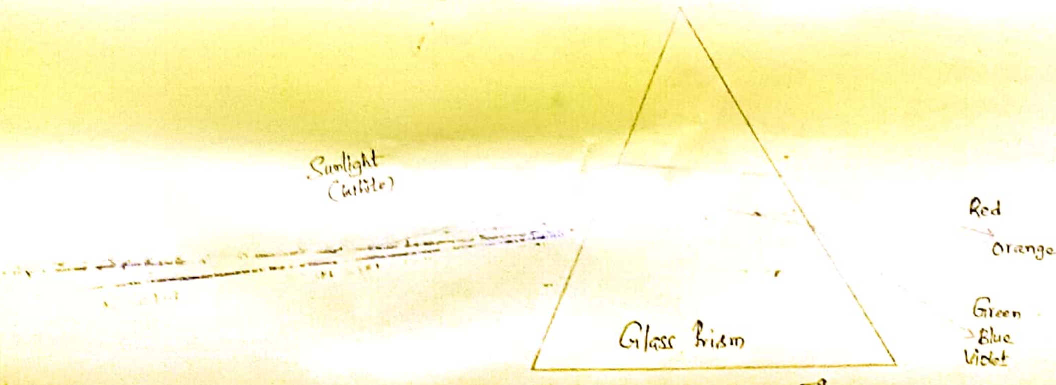
Raman effect

→ Raman effect, change in the wavelength of light that occurs when a light beam is deflected by molecules. when a beam of light traverses a dust-free, transparent sample of a chemical compound, a small fraction of the light emerges in direction other than that of the inciden beam.



1nm (nanometer) = 10^{-9} m

Scattering of light by molecules of gases, liquids, or Solids. The Raman effect Consists of the appearance of extra spectral lines near the wavelength of the incident light. The Raman lines in the incident light. The Raman lines in the scattered light are weaker than the light at the original wavelength. Ls.

→ Light scattering in air was Rayleigh's explanation for why the sky was blue; and Raman found that this was true also for why the sea was blue.

→ The Raman effect is named after Indian scientist C.V. Raman, who discovered it in 1928 with assistance from his student K.S Krishnan. Raman was awarded the 1930 Nobel prize in physics for his discovery of Raman scattering.

→ The Raman Effect is the process of scattering of light particles by molecules of a medium. A difference in the wavelength of light as it reaches the medium causes scattering.

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TOPIC

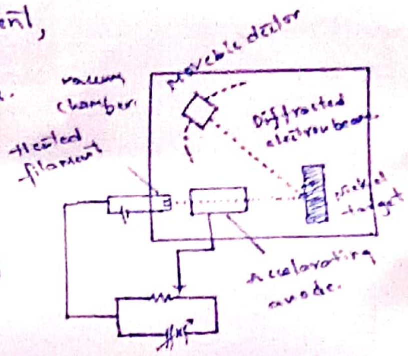
DAVISSON GERMER EXPERIMENT:–

(PHYSICS)

Davisson-Germer Experiment:–

The Davisson Germer experiment proved the wave nature of electrons. Before studying the working of Davisson Germer experiment,....

Construction:–



Working:-

* First the electrons are produced by heating the tungsten filament, coated with barium oxide, using a Low-voltage power source. The process is called "Thermionic Emisson".
* once the electron hits the nickel crystal surface, they got deflection in different directions. The intensity of the deflected electrons in various directions depends mainly on the same angle of the nickel crystal.
* A Moving secondary Electron Detector detects these deflected electrons in different directions

Davisson & Germer Experiment:– observation:–

SED is connected to a Sensitive galvanometer. This Converts the detected electrons into the current, and the intensity of the current is reflected in the gauge. The electron intensities are seen in multiple directions by moving the SED, and the direction (or the angle ...) ... recorded

Outcomes of Davisson Germer Experiment:–

* Intensities of the deflected electrons are obtained by changing the angle (θ) of deflection
* The detector detects the particle nature of the electron. As a result, only the current will be detected by the detector.
* It is found that by changing the angle of scattering (θ), the intensity of deflected electrons can be varied.

Co-relating Davisson Germer Experiment & de-Broglie Relation:–

$\lambda = \frac{h}{p} \Rightarrow \lambda = \frac{h}{\sqrt{2ME}} \Rightarrow \lambda = \frac{h}{\sqrt{2meV}} \Rightarrow$ This eqn gives Bragg's Law.

$n\lambda = 2d\sin\theta(90° - \theta/2)$ $V = 54V$;

$\lambda = \frac{1.227}{\sqrt{54}} = 0.167\ nm$

proof:–

* After deflection, ... constructive ... interference thing a diffraction pattern ... wave nature of the electron was confirmed.

EIGEN FUNCTIONS AND EIGEN VALUES

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The time independent schrodinger wave equation is usually written in the compact form

$$\hat{H}\psi = E\psi$$

It belongs to the class of equation called eigenvalue equations. The word "eigen value" is a partial translation of the German word 'Eigenwert'. A full translation is 'characteristic value'. In the above equation $\hat{H}$ represents the Hamiltonian operator, E the eigenvalue and ψ the eigenfunction.

(operator) (function) = (Constant factor) x (same function).

When an operator operates on a function and the same numerical value, then the function is called an eigenfunction and numerical value is called its eigenvalue. An equation that contains both eigenfunction and eigenvalue is called eigenequation.

The SWE is the eigenvalue equation for Hamiltonian operator. The coordinate wavefunction is the eigenfunction of the Hamiltonian operator, and is often called energy eigenfunction. Solving an equation means finding not only the set of eigenfunction that satisfy the equation, but also the eigenvalue that belongs to each eigenfunction. Two common cases occur. The first case in that the eigenvalue can take an any value within some range of values. The second case is that there is a discrete set of eigenvalues with the values between the members of the set not permitted. The occurance of a discrete spectrum of eighen values corresponds to quantization.

(i) The wave function is single valued.
(ii) The wave function is continuous and
(iii) The wave function is finite.

Examples :-

(1) $\frac{d}{dx}(\sin x)$

Sol:- $\frac{d}{dx}(\sin x) = \cos x$

This is not an eigenequation as function sin x is not generated

(2) $\frac{d}{dx}(\cos x)$

Sol:- $\frac{d}{dx}(\cos x) = -\sin x$

This is not an eigenequation as function cos x is not generated.

(3) $\frac{d}{dx}(e^{ax})$

Sol:- $\frac{d}{dx}(e^{ax}) = a\, e^{ax}$

This is an eigen equation with an eigenvalue of a.

(4) $\frac{d}{dx}(e^{x})$

Sol:- $\frac{d}{dx}(e^{x}) = 1\, e^{x}$

This is an eigen equation with an eigenvalue of a.

(5) $\frac{d^2}{dx^2}(\cos\frac{x}{4})$

Sol:- $\frac{d^2}{dx^2}(\cos\frac{x}{4}) = -\frac{1}{16}\cos\frac{x}{4}$

This is an eigenvalue equation with an eigenvalue of -1/16.

(6) $\frac{d}{dx}(e^{-4x})$

Sol:- $\frac{d}{dx}(e^{-4x}) = -4(e^{-4x})$

This is an eigenvalue equation with an eigenvalue of -4.

(7) $\frac{d}{dx}(e^{-4x^2})$

Sol:- $\frac{d}{dx}(e^{-4x^2}) = -8x(e^{-4x^2})$

This is not an eigenvalue equation because although the original function is reproduced, it is multiplied by another function -8x.

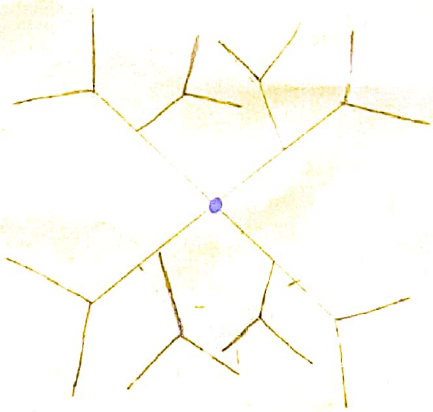
Classification of nano materials

A. Satyanarayana

metal nanorods
ceramic crystals

Gold nanowires,
polymeric nano fibers
Self assembled structure

Carbon coated
nanoplates



Dendrimer

The term nanoscale refers to the dimensions of 10^{-9} meters. It is the one billionth of a meter. So, the particles whose any of the external dimensions or surface structure dimensions lies in the range of 1nm to 100nm are considered as Nanomaterials.

These materials are invisible to the naked eye. The material science-based approach of nanotechnology is considered for nanomaterials. At this scale, the materials have unique optical, electronic, mechanical and quantum properties compared to their molecular-scale behaviour. a nanomaterial can be a nano object or a nanostructured material.

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General properties of Nuclei

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* The important static properties of the nuclei include their electric charge, mass, binding energy, size, shape, angular momentum, magnetic dipole moment, electric quadrupole moment, statistics, parity, and iso-spin.

Properties of Nuclei

=) All Nuclei are composed of protons and neutrons (exception: ordinary hydrogen)

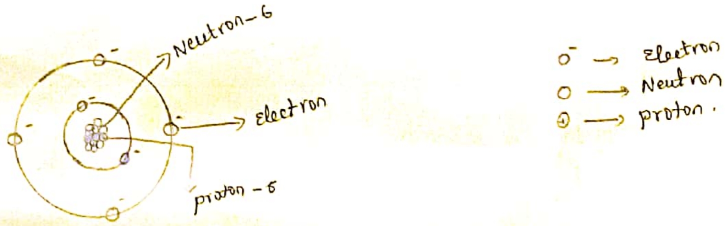
=) The "neutron number" N, is the no. of neutrons in the Nucleus.

=) The "atomic number" Z, equals the no. of protons in the Nucleus.

=) The "mass number" (not the same as the mass). A is the no of nucleons in the nucleus:

$A = Z + N$

=) Nucleon is a generic term used to refer to either a proton or a neutron



Nature of nuclei

The nucleus is the double membrane limited structure within an eukaryotic cell that contains the chromosomes and where the DNA is replicated or transcribed into RNA.

Nuclei:- A nucleus as related to genomics is the membrane-enclosed organelle within a cell that contains the chromosomes.

* Nuclei with the same Z, but different A are called isotopes.
* Nuclei with the same A, but different Z are called isobars.
* Nuclei with the same number of n are known as isotones.

=) According to the special theory of relativity propounded by Albert Einstein. mass and energy are equivalence.

Quantum Numbers

Quantum Numbers:-

The set of numerical values which gives us acceptable solution to schroding wave equaction for hydrogen atom are called quantum number (s)

The number or labels which completely describe an electron in an atom

* there are four quantum numbers that completely describe an electron completely:

① principal quantum number (n)

② Azimuthal quantum number (l)

③ magnetic quantum number (m)

④ Spin quantum number (s)

1. principal quantum number (n):

* It tells us about the orbit number of electron
* Represented by (n), its value is a non-zero positive integer
* n = 1, 2, 3, 4 ....
* max no. of electron in a energy shell = $2n^2$

2. Azimuthal quantum number (l):

* It tells about the sub shell of electron
* It is represented by (l)
* Its value ranges from 0 to n-1 , l = 0, 1, 2, 3, 4
* Max no of electron in energy shell = 2(2l+1)

3. magnetic quantum number (m):

* It tells us about the no of ways in which different subshell are arranged x, y & z axis
* Represented by (m)
* Its value ranges from -l to 0 to +l
* m = 0, ±1, ±2, ±3 .... ±l   m = (2l+1)

4. Spin quantum number (s):

* It tells us about the direction of spin of electron
* It is represented by (ms)
* Clock wise Rotation = +1/2
* Anti clock wise Rotation = -1/2.

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[illegible]

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BCS THEORY

BCS Theory :- BCS stands for bardeen, Copper and Schriffer. the BCS Theory explains The Super Conductivity of only Type I Super Conductivity and Does not explain Type II Super conductor. The aim of BCS theory is to provide a Satisfactory Explanation to the Super Conductivity of Type I Super conductors.

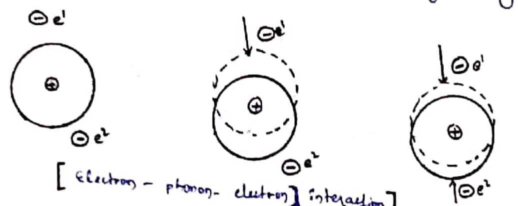
⇒ This Theory assumes the existence of electron pairs in Super Conductors. The two electrons in Such a pair are bound to each other and move together. They have opposite wave vectors and opposite spins, and denoted by $+k\uparrow$ and $-k\downarrow$.

⇒ In a Superconductor state the one particle orbits are occupied or vacant in pairs. If an orbital with $+k\uparrow$ is occupied Then The orbital with $-k\downarrow$ is also occupied, otherwise both are vacant. Such electron pair is called as "Copper pair".

⇒ In normal material electrons repels with each other. But it is assumed, in a Superconductors electron pairs is exist due to electron-lattice-electron [electron-phonon-electron] interaction.

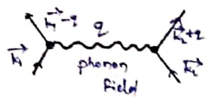
⇒ Suppose an electron approaches a positive ion core due to Coulombic attraction lattice (phonon) is distorted. If mass of the positive ion is small then greater will be distortion, The energy of the $2e^-$ is lowered by lattice, during this interaction process, the modified ion come back to its original position and second electron gets attracted towards then ion.

⇒ They we interrupt that two electrons interact via a phonon. This type of interaction is called electron-phonon-electron interaction. this interaction is very strong when two electrons have equal and opposite Momenta and spin.



[Electron – phonon – electron] interaction

Let an electron of wave vector k_1 emits a virtual phonon q' which is absorbed by an electron whose wave function is k_2 They k_1 is scattered as $k_1 - q$. k_2 is scattered as $k_2 + q$.

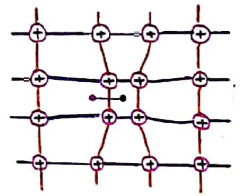


[Electron – phonon-Interaction]

Pair copper :- Two electrons which interact attractively in a phonon field is called as Copper pair.

⇒ "When a pair of electron flow in the form of copper pair, The resistance factor vanishes, Conductivity becomes infinity name as Super Conductivity."

Bcs Theory Diagram :-



Advantage :- provide an Explanation of the Super-Conductivity of type I superconductivity.

⇒ Explains Superconductivity within the realms of classical mechanism.

⇒ Explains the relative difference in superconductivity between metals, better conductors at normal temperature are terrible superconductors.

Disadvantage :-

⇒ Does not Explain the Superconductivity of Type II Super-conductors.

⇒ Does not predict The effect of superconductivity.

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