PHYSICS

B.Sc Part-III (H) Paper-V Gr-C

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SYMETRIC AND ANTISYMMETRIC WAVE FUNCTIONS

PAULI EXCLUSION PRINCIPLE

Symmetric and Antisymmetric wave function

~~Let~~ us consid an atom having two electrons. one is in quantum state 'a' and the second in the quantum state b. When first particle in the quantum state a and second particle in the quantum state 'b' then:

$$\psi(1,2) = \psi_a(1)\,\psi_b(2) \quad \text{--- (1)}$$

If the second particle in the quantum state (a) and 1st particle in the quantum state (b) then.

$$\psi(2,1) = \psi_a(2)\,\psi_b(1) \quad \text{--- (2)}$$

The wave function may be interchanged by the phase factor $e^{i\alpha}$

$$\psi(2,1) = e^{i\alpha}\,\psi(1,2) \quad \text{--- (3)}$$

Where α is real constant

The wave function may be again interchanged to the original wave function when it is multiplied by the phase factor $e^{2i\alpha}$, Hence this implies that

$$e^{2i\alpha} = 1$$

$$\& \; e^{i\alpha} = 1^{\frac{1}{2}} = \pm 1$$

From equ^n (3) $\psi(1,2) = \pm\,\psi(2,1)$.

If a wave function changes sign on interchanging the particle, it is said to be an antisymmetric function. For such function

$$\psi(1,2) = -\psi(2,1)$$

The particle that are described by the antisymmetric wave function are terms "Fermion" They obey "Fermi-dirac Statistics"

If a wave function remains unchange on interchanging the particle it is said to be symmetric wave function

$$\psi(1,2) = \psi(2,1)$$

The particle that are described by symmetric functions are called "Bosons" They obey "Bose-Einstein Statistics"

Pauli Exclusion Principle

Statement:- The wave function of a many electron system is antisymmetric to exchange of co-ordinate of any two electron.

There are four quantum number of the electron

① Principal quantum number (n) :- This gives total energy

② Orbital quantum number (l):- This gives orbital angular momentum and magnetic moment of electron.

③ Magnetic quantum number (m_l):- This gives the spatial quantisation of the angular momentum and magnetic moment of electron in applied mag. field.

④ Spin magnetic quantum number (m_s):- This gives the spin angular momentum and magnetic moment due to the spin of electron.

$$m_l = \pm l, \pm(l-1), \pm(l-2), \text{---} 0$$

$$m_s = \pm 1$$

In an electron having more than one electron, the electrons may arrange themselves in different quantum state. The wave function of the electron should be antisymmetric. They obey Fermi-dirac statistics.

The antisymmetric combination of N function corresponding to the N! Permutation of the particle can be expressed in the Slater determinant

$$\psi(1,2,3 \text{---} N) = \frac{1}{\sqrt{N}} \begin{vmatrix} \psi_1(1) & \psi_1(2) & \psi_1(3) & \text{----} & \psi_1(N) \\ \psi_2(1) & \psi_2(2) & \psi_2(3) & \text{----} & \psi_2(N) \\ \vdots & \vdots & \vdots & & \vdots \\ \psi_N(1) & \psi_N(2) & \psi_N(3) & \text{---} & \psi_N(N) \end{vmatrix}$$

When ever two or more rows of the determinant are identical, the determinant vanishes. So that two or more fermions of a system can't occupy the same state. This Principle is K/A Pauli's exclusion Principle.

The end.

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