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NAAC ACCREDITED ‘A’ GRADE

Topic: SHELL MODEL
Course Title: Elements of Modern Physics
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Name of the Department: Physics

SHELL MODEL

Nuclear spin

Parity

Shell Model

From Liquid drop model we get an idea about nuclear matter but give nothing about single nucleons. From atomic model one can have an idea about the motion of the electrons in the field provided by the nucleus.

Now the questions comes:

(i) Is the nucleons exist in well defined quantum controlled nuclear shells?

(ii) Is there any grouping of nucleons in the shells?

(iii) Is the quantum numbers similar to n,l,s,j be applicable to the nucleus?

From experiments it is evident that for certain numbers of neutrons or protons, called magic number, nuclei exhibit some special characteristics.

For S= $\frac{1}{2}$

$$J = \frac{1}{2} \text{ for } l = 0$$

$$J = \left(l + \frac{1}{2}\right), \left(l - \frac{1}{2}\right) \text{for } l \neq 0$$

$$j = l - \frac{1}{2};\ \xi_{ls} = \hbar^2 \frac{(l+1)}{2} \langle \emptyset(r) \rangle$$

$$j = l + \frac{1}{2};\ \xi_{ls} = -\hbar^2 \frac{l}{2} \langle \emptyset(r) \rangle$$

$$\Delta\xi_{ls} = \hbar^2 (l + \frac{1}{2}) \langle \emptyset(r) \rangle$$

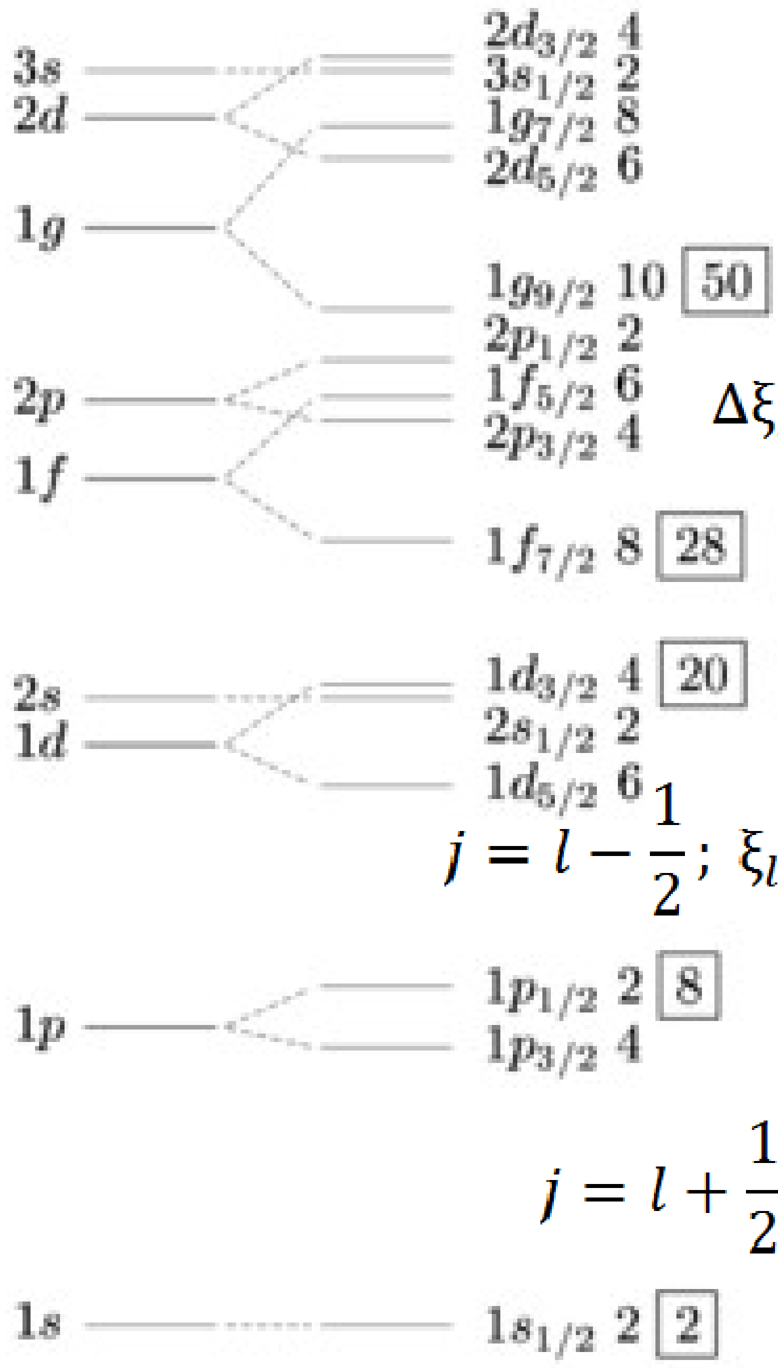
3s,2d,1g $\frac{11}{2}\hbar\omega$

2p,1f $\frac{9}{2}\hbar\omega$

2s,1d $\frac{7}{2}\hbar\omega$

1p $\frac{5}{2}\hbar\omega$

1s $\frac{3}{2}\hbar\omega$



0	1	2	3	4	5	6
S	P	d	f	g	h	I
2	6	10	14	18	22	26
$2(2l+1)$						

$$\Delta\xi_{ls} = \hbar^2 (l + \frac{1}{2}) \langle \O(r) \rangle$$

$$j = l - \frac{1}{2};\ \xi_{ls} = \hbar^2 \frac{(l+1)}{2} \langle \O(r)$$

$$j = l + \frac{1}{2};\ \xi_{ls} = -\hbar^2 \frac{l}{2} \langle \O(r) \rangle$$

Nuclear spin:

Being Fermions nucleons have intrinsic spin angular momentum s=1/2 (in unit of ħ

The nucleons also posses quantized orbital angular momentum ℓ about the centre of mass of the nucleus.

So the resultant angular momentum of nucleons **I= ℓ+s**

The resultant spin angular momentum of the nucleous **S** =$\sum s_i$

The resultant orbital angular momentum is given by $L = \sum \ell_i$

The intrinsic angular momentum of nucleus is a vector **I** = $\sum \ell_i + \sum s_i$ = **L+S**

Since $s_i = \frac{1}{2}$ S can be either integral or half integral depending upon the value of A.

Since ℓ_i Is integral or zero, so **L** Is integral or zeroThus the total angular momentum

Thus the total angular momentum **I** can be either integral (for A even) or half odd integral (for A odd).

This total nuclear angular momentum I is usually referred to as the nuclear spin.

Measurements of ground state spin of nuclei show that for even-even nuclei it is zero (I=0). Which indicates that there is a pairing between the nucleons of equal and oppositely aligned angular momenta.

The highest measured value of the ground state spins of the nuclei is 9/2. Which confirm that there is pair formation within the nuclei.

In case of major nucleus the even number of nucleons form a core making group in pair that produces zero total angular momentum or nuclear spin.

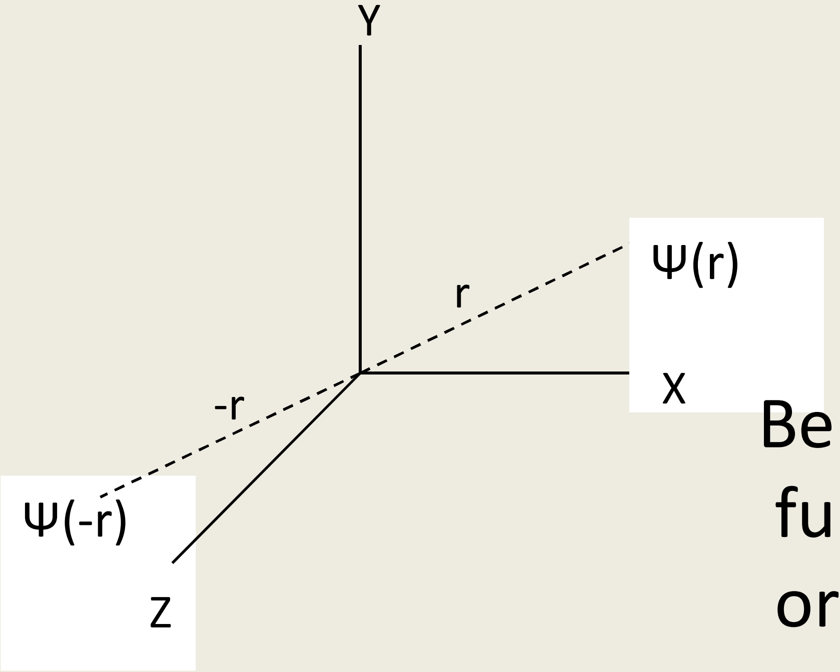
The few remaining nucleons outside the core determine the nuclear spin which is a small number, integral or half odd integral.

Parity:

Parity corresponds to space part of wave function.

If the wave function is symmetric about reflection at origin then the parity is even.

Again if the wave function is anti-symmetric about reflection at origin then the parity is odd.



$\Psi(r) = \Psi(-r)$ parity is even $\pi = +$

$\Psi(r) = -\Psi(-r)$ parity is odd $\pi = -$

Being related to space part of wave function it is also related to orbital quantum number

For ℓ- even i.e. 0,2,4, -------- $\pi = +$

For ℓ- odd i.e. 0,2,4, -------- $\pi = -$