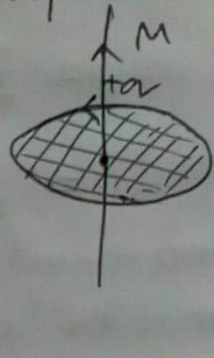
Space quantization:~

From the theory of electromagnetism we know that a current carrying loop behaves as a thin magnetic shell with poles in the opposite ~~direction~~ faces of the shell. Actually the direction of the magnetic dipole moment of the shell is determined by the direction of flow of current through the loop.

The magnitude of ~~dip the dip~~ magnetic dipole moment

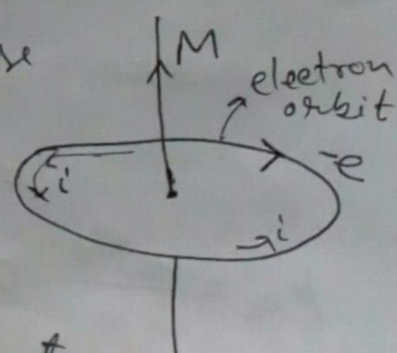


= current through the loop × area of the loop

= $i \times A$

i.e., $M = iA$

In hydrogen atom, the electron revolves in a closed orbit of radius r around the nucleus. ~~Suppose~~ Since the electron is a charged particle, its revolution along a closed path will give rise to a current. Suppose the electron revolves in the clockwise direction then the corresponding current (i) will be in the anticlockwise direction. The area of the loop $= \pi r^2$. So the magnetic moment of the electron $= M = i\pi r^2$. Now



$i = \frac{e}{T}$, where e = electronic charge and

T is period of revolution. If ω be the angular velocity of the revolving electron, then

$$i = \frac{e}{2\pi/\omega}, \quad \because \omega = \frac{2\pi}{T}.$$

or $$i = \frac{e\omega}{2\pi}$$

$$\therefore M = \frac{e\omega}{2\pi} \cdot \pi r^2$$
$$= \frac{e\omega}{2} r^2$$
$$= \frac{e}{2m} \cdot m\omega r^2$$
$$= \frac{e}{2m} L,$$ where $L = m\omega r^2$ = angular momentum of the electron (due to orbital motion of the electron) and

m = mass of the electron.

According to Bohr's theory, L is quantised in the following way:

$$L = n\hbar, \text{ where } n = 1, 2, 3, --$$

$$\therefore M = \frac{e}{2m} n\hbar$$
$$= n\frac{e\hbar}{2m}$$
$$= n\mu_B,$$ where

$\mu_B = \frac{e\hbar}{2m}$ is called Bohr magneton ~~magnetion~~. All the quantities in the expression of μ_B are constants

So, $$\boxed{M = n\mu_B}$$

This is the orbital magnetic moment

of the hydrogen atom. We see that that the orbital magnetic moment is also quantised. In quantum mechanics it is denoted by μ_L ⇒ $\boxed{\mu_L = n\mu_B}$

For $n = 1$, $\mu = \mu_B$ → this is the smallest value of the atomic magnetic moment. So, μ_B, the Bohr magneton constitute the unit of magnetic moment in atomic physics. The value of $\mu_B = 9.2 \times 10^{-24}\ Am^2 = 1$ Bohr magneton.

Thus, an atom has an orbital magnetic moment. If such an atom possessing a magnetic moment is placed in an external magnetic field, then in which direction its ~~mom~~ magnetic moment is going to orient itself?

Experiment shows that the magnetic of the atom (and hence the angular ~~momen~~ momentum) can not take up all possible orientations with respect to the external magnetic field.

The orientations of the atomic magnetic moment in presence of an external magnetic field are quantised and this phenomena is known as space quantisation.

This quantisation rule says that if p_l be the orbital angular momentum of the electron, then p_l will have such orientations with respect to the ~~ex~~ direction of the external magnetic ~~moment~~ field B, that the projections of p_l along B will be an integral multiple of $\hbar$. Thus,

$p_l \cos\theta = m_l \hbar$, where m_l is an integer, known as magnetic quantum number.

The possible values of m_l are $m_l = -l, (-l+1), (-l+2) \ldots \ldots, 0, \ldots (l-2), (l-1), l$.

So, total no of values m_l can have is $(2l+1)$.

For example, if $l = 2$, the values of m_l are $2, 1, 0, -1, -2$.

Total $= (2 \times 2 + 1) = 5$.

Next question is what happens to the energies of the electron in presence of the magnetic field?