In the above m_l can have $(2l+1)$ values right from $+l$ to $-l$, so effect of magnetic field is to split up each energy level into $(2l+1)$ levels, and the magnitude of the separation depends on the strength of the magnetic field. (2)

For (1) case $\Delta m_l = 0$ for (2) case $m_l = +1$ and for case (3) $m_l = -1$

Thus single line gives up three lines in each cases.

Vector atom model and Anomalous Zeeman effect:— (Calculation of Lande's factor g):—

We can give the explanation of the anomalous Zeeman effect when we introduce the spin of the electron in vector atom model. With the introduction of the electron spin we may say that l^* and s^* vectors (i.e. orbital and spin angular momentum vectors) precesses around their resultant vector J^* (Total angular momentum vector), then we have;

$$J^* = l^* + s^* \quad \text{—— (1)}$$

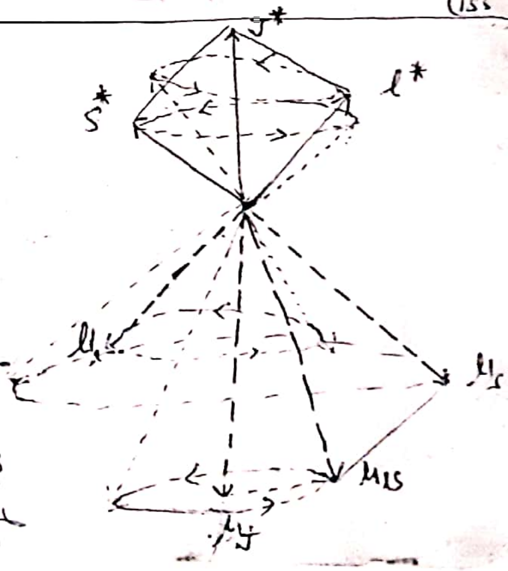
The magnetic moment due to orbital motion

$$\mu_l = l^* \frac{eh}{4\pi m_e} \quad \text{—— (2)}$$

Similarly magnetic moment due to the spin is given by

$$\mu_s = 2s^* \frac{eh}{4\pi m_e c} \quad \text{—— (3)}$$

μ_l is directed oppositively to l^* and μ_s to s^* because of the negative charge of the electron. Now since l^* and s^* precesses around J^*, μ_l and μ_s will also precesses around μ_J (μ_J is not in the line of the resultant of μ_l and μ_s). To find out the resultant magnetic moment of the electron, we resolve μ_l & μ_s in two directions; one along J^* and other ⊥r to J^*. The ⊥r component averages out to zero due to the continuous change of direction and the ‖ components are added up or we can say that ‖ components of μ_l and μ_s contribute for μ_J while ⊥r component dont. Hence



Vector model showing the magnetic and mechanical moments of a single valence electron

μ_J = Component of the μ_l along the direction of J^* + Component of μ_s along the direction of J^* ②A

$$= \frac{eh}{4\pi m e} l^* \cos(l^* J^*) + \frac{eh}{4\pi m e} 2s^* \cos(s^* J^*)$$

Second Term is double, due to spin.

$$= \frac{eh}{4\pi m e}\left[l^* \cos(l^* J^*) + 2s^* \cos(s^* J^*)\right]$$

$$\mu_J = \left[l^* \cos(l^* J^*) + 2s^* \cos(s^* J^*)\right] \frac{h}{2\pi} \cdot \frac{e}{2me}$$

Since the last two factors in this eqn are equivalent to one Bohr magneton the quantity determined by the bracket gives the total magnetic moment of the atom in Bohr's magnetons. This bracket term is readily evaluated by setting it equal to J^* times a constant g.

$$J^* g = l^* \cos(l^* J^*) + 2s^* \cos(s^* J^*) \quad — ④$$

Making use of vector model and the cosine law that

$$s^{*2} = l^{*2} + J^{*2} - 2 l^* J^* \cos(l^* J^*)$$

we get $l^* \cos(l^* J^*) = \frac{s^{*2} - l^{*2} - J^{*2}}{2J^*}$

and $l^* \cos(l^* J^*) = \frac{J^{*2} + l^{*2} - s^{*2}}{2J^*}$ — ⑤

and $s^* \cos(s^* J^*) = \frac{J^{*2} - l^{*2} + s^{*2}}{2J^*}$ — ⑥

$l^{*2} = s^{*2} + J^{*2} - 2s^* J^* \cos(s^* J^*)$

⑤ and ⑥ in ④

$$J^* g = \frac{1}{2J^*}\left[J^{*2} + l^{*2} - s^{*2} + 2(J^{*2} - l^{*2} + s^{*2})\right]$$

$$g = 1 + \frac{J^{*2} - l^{*2} + s^{*2}}{2J^{*2}} \quad — ⑦A$$

$$g = 1 + \frac{J(J+1) + S(S+1) - l(l+1)}{2J(J+1)} \quad — ⑦B$$