Anamolous Zeeman effect :- Anamolous ZE is observed is explained by using the concept of spin motion of $\bar{e}$. When $\bar{e}$ revolves around the nucleus then it has 2 type of motion

(1) It rotates around the nucleus in its orbit called as orbital motion of $\bar{e}$.

(2) It also rotates about its own axis which is called as its spin motion. Due

Spin of $\bar{e}$ in ~~orbital~~ ~~its~~ own axis 2 angular momentum vectors l and s are associated with each $\bar{e}$ and their T.A.M quantum no is $\vec{J} = \vec{l} + \vec{S}$

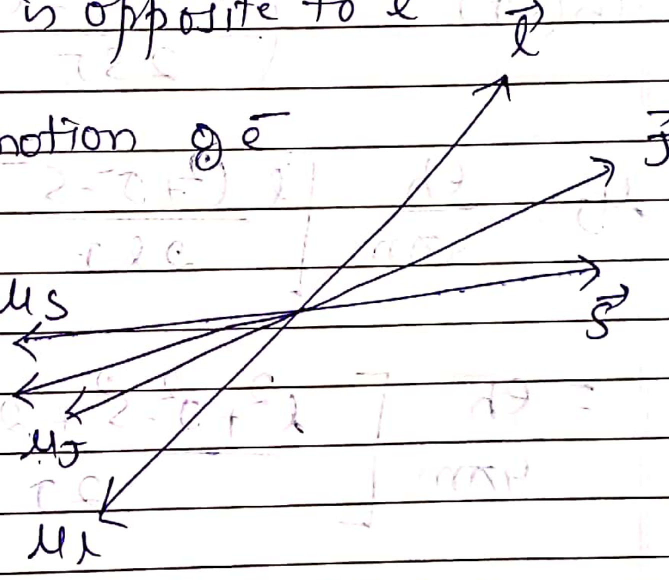
Due to orbital motion of $\bar{e}$

$$\mu_l = l \frac{eh}{4\pi m}$$

Direction of μ_l is opposite to $\vec{l}$

Due to spin motion of $\bar{e}$

$$\mu_S = 2S \frac{eh}{4\pi m}$$



Direction of μ_S is opposite to S because of $\bar{e}$ charge

Now resultant of μ_l and μ_S must be in opp direction to that of J but practically μ is not along J but in other direction shown in figure. Now resolving μ_l & μ_S in 2 ~~direction~~ vertical component one along J and other $\perp^r$ to J. For a period the avg value of these $\perp^r$ component is always zero. Hence net magnetic moment will be along J and let it is μ_J then

μ_J = Component of μ_l along J + Comp of μ_S along J

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$$= \mu_l \cos(\vec{l}\,\vec{J}) + \mu_S \cos(\vec{S}\,\vec{J})$$

$$= \frac{eh}{4\pi m}\, l \cos(lJ) + \frac{2eh}{4\pi m}\, S \cos(SJ)$$

$$\cos(lJ) = \left(\frac{l^{*2} + J^{*2} - S^{*2}}{2lJ}\right)$$

$$\cos(SJ) = \left(\frac{J^{*2} + S^2 - l^2}{2SJ}\right)$$

$$\mu_J = \frac{eh}{4\pi m}\left[l\,\frac{l^2 + J^2 - S^2}{2lJ} + S\,2\,\frac{J^2 + S^2 - l^2}{2SJ} \right]$$

$$= \frac{eh}{4\pi m}\left[\frac{l^2 + J^2 - S^2 + 2S^2 + 2J^2 - 2l^2}{2J} \right]$$

$$= \frac{eh}{4\pi m}\left[\frac{3J^2 + S^2 - l^2}{2J} \right]$$

$$= \frac{eh}{4\pi m}\, J \left(\frac{2J^2 + J^2 + S^2 - l^2}{2J^2} \right)$$

$$= \frac{eh}{4\pi m}\, J \left(1 + \frac{J^2 + S^2 - l^2}{2J^2} \right)$$

According to quantum Mechanics

$$J^2 = J(J+1) \quad l^{*2} = l(l+1)$$

$$S^2 = S(S+1)$$

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$$\mu_J = \frac{eh}{4\pi m} J \left[1 + \frac{J(J+1) + S(S+1) - l(l+1)}{2J(J+1)} \right]$$

$$= \frac{eh}{4\pi m} J g$$

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

= Lande g factor.

Now when this atomic magnet is placed an external field then it acquires some energy which is given by

$$\Delta E = M \cdot B \cos\theta$$

$$= \mu_J B \cos(J B)$$

$$= \frac{eh}{4\pi m} J g B \cos(JB)$$

But $J \cos(JB)$ = Projection of J along the direction of B

$$= M_J$$

$$\Delta E = \frac{eh}{4\pi m} g B M_J$$

$\frac{eh}{4\pi m} B = L$ = Lorentz unit

$$\Delta E = g L M_J$$

This equation gives the extra energy acquired by atomic magnet due to which splitting of spectral line into more than 3 components and it is called anamolous Zeeman effect

Zeeman effect for 2D levels of sodium

There are two case

(1) Weak MF (2) Strong MF

Weak MF :- The presence of weak field, interaction energy is

$$-\Delta T = -\frac{\Delta E}{hc}$$

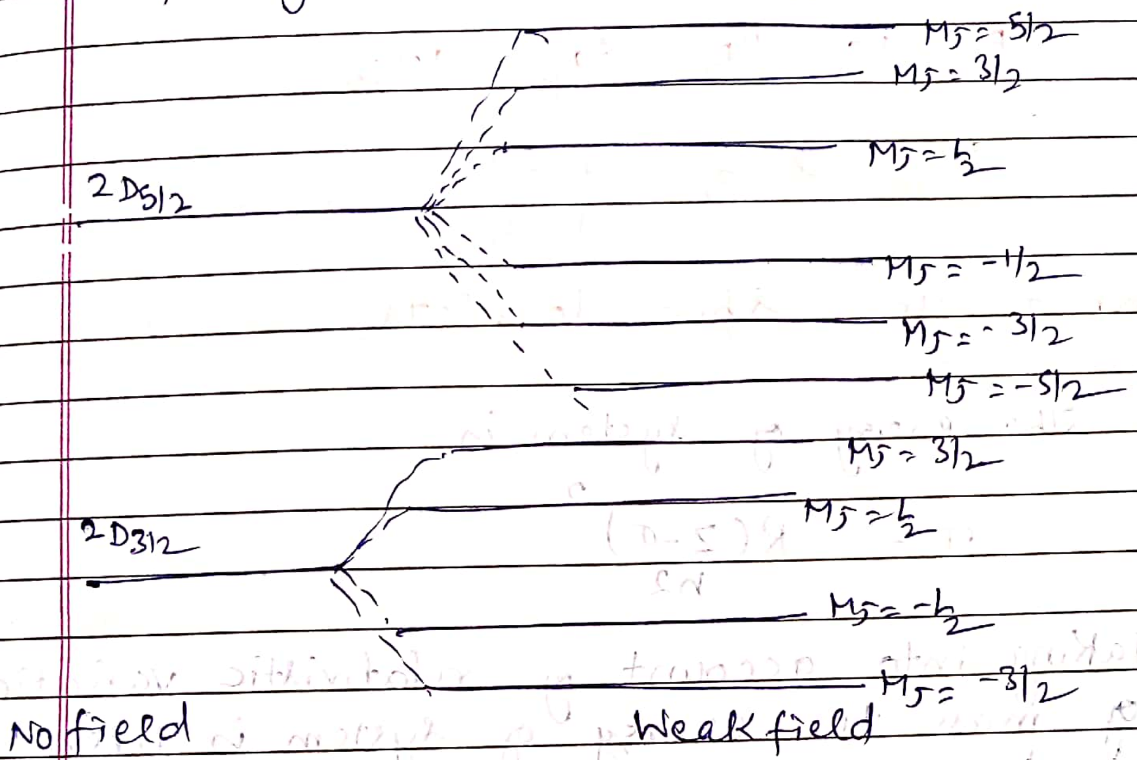
$$= -\frac{eB}{4\pi mc} g M_J = -g M_J L'$$

$$g = 1 + \frac{J(J+1) + S(S+1) - L(L+1)}{2(J+1)J}$$

Given term ^2D has two fine structure $^2D_{3/2}$ & $^2D_{5/2}$.

Fine structure level	No. of weak field levels $(2J+1)$	g	M_J $(-J$ to $J)$	$g M_J$
$^2D_{3/2}$ $L = 2, S = \frac{1}{2}, J = \frac{3}{2}$	4	$\frac{4}{5}$	$-\frac{3}{2}$ to $\frac{3}{2}$	$\pm 2/5$ $\pm 6/5$
$^2D_{5/2}$ $L = 2, S = \frac{1}{2}, J = \frac{5}{2}$	6	$6/5$	$-\frac{5}{2}$ to $\frac{5}{2}$	$\pm 3/5$ $\pm 9/5$ $\pm 15/5$

Splitting are shown in figure



In strong M.F :- In this case M.I.E is

$$-\Delta T = (M_L + 2M_S) L'$$

Term	No. of Strong field Level $(2L+1)(2S+1)$	M_L	M_S	$(M_L + 2M_S)$
		2	$\frac{1}{2}, -\frac{1}{2}$	3, 1
^2D		1	$\frac{1}{2}, -\frac{1}{2}$	2, 0
	$5 \times 2 = 10$	0	" "	1, -1
$L = 2, S = \frac{1}{2}$		-1		0, -2
		-2	" "	-1, -3

Split: