In *jj* coupling, the interaction between l_1^* and s_1^*, and that between l_2^* and s_2^* are stronger than the interaction between l_1^* and l_2^* and that between s_1^* and s_2^*. Hence in this case $\triangle T_3$ and $\triangle T_4$ predominate over $\triangle T_1$ and $\triangle T_2$ in eq. (ii).

Since the angles between l_1^* and s_1^*, and between l_2^* and s_2^* are fixed, $\triangle T_3$ and $\triangle T_4$ are readily calculated from the cosine law :

$$\triangle T_3 = \tfrac{1}{2} a_3 (j_1^{*2} - l_1^{*2} - s_1^{*2}) \qquad \text{...(xi)}$$

and

$$\triangle T_4 = \tfrac{1}{2} a_4 (j_2^{*2} - l_2^{*2} - s_2^{*2}). \qquad \text{...(xii)}$$

But the angles between s_1^* and s_2^*, and between l_1^* and l_2^* are continually changing, and so the cosines in $\triangle T_1$ and $\triangle T_2$ must be averaged. The average values are given by

$$\overline{\cos (s_1^* \, s_2^*)} = \cos (s_1^* \, j_1^*) \cos (j_1^* \, j_2^*) \cos (j_2^* \, s_2^*)$$

and

$$\overline{\cos (l_1^* \, l_2^*)} = \cos (l_1^* \, j_1^*) \cos (j_1^* \, j_2^*) \cos (j_2^* \, l_2^*).$$

Using these average values in eq. (ii), we get

$$\Delta T_1 + \Delta T_2 = [a_1 \, s_1^* \, s_2^* \cos(s_1^* \, j_1^*) \cos(j_2^* \, s_2^*) + a_2 \, l_1^* \, l_2^* \cos(l_1^* \, j_1^*) \cos(j_2^* \, l_2^*)] \cos(j_1^* \, j_2^*)$$
$$= \tfrac{1}{2}(a_1 \beta_1 + a_2 \beta_2)(J^{*2} - j_1^{*2} - j_2^{*2}), \quad \ldots \text{(xiii)}$$

where
$$\beta_1 = \frac{s_1^{*2} + j_1^{*2} - l_1^{*2}}{2 j_1^{*2}} \; \frac{s_2^{*2} + j_2^{*2} - l_2^{*2}}{2 j_2^{*2}} \quad \ldots \text{(xiv)}$$

and
$$\beta_2 = \frac{l_1^{*2} + j_1^{*2} - s_1^{*2}}{2 j_1^{*2}} \; \frac{l_2^{*2} + j_2^{*2} - s_2^{*2}}{2 j_2^{*2}} . \quad \text{(xv)}$$

Writing
$$a_1 \beta_1 + a_2 \beta_2 = B, \quad \text{(xvi)}$$
eq. (xiii) becomes
$$\Delta T_1 + \Delta T_2 = \tfrac{1}{2} B (J^{*2} - j_1^{*2} - j_2^{*2}). \quad \ldots \text{(xvii)}$$

We may again write any fine-structure term by the formula
$$T = T_0 - \Delta T_1 - \Delta T_2 - \Delta T_3 - \Delta T_4$$
where T_0 represents the hypothetical centre.

A good example of a *ps* configuration having *jj* coupling is found in tin. For *ps* configuration, we have
$$l_1 = 1, \; s_1 = \tfrac{1}{2}; \quad \therefore \quad j_1 = \tfrac{1}{2}, \tfrac{3}{2}$$
$$l_2 = 0, \; s_2 = \tfrac{1}{2}; \quad \therefore \quad j_2 = \tfrac{1}{2}.$$

This gives rise to two (j_1, j_2) combinations, namely $(\frac{1}{2}, \frac{1}{2})$ and $(\frac{3}{2}, \frac{1}{2})$. We know that
$$J = |j_1 - j_2|, \; |j_1 - j_2| + 1, \ldots\ldots (j_1 + j_2).$$

Thus the J-values corresponding to the above combinations are 0, 1 and 1, 2 respectively. Thus we have the terms
$$\left(\frac{1}{2}, \frac{1}{2}\right)_{0,\,1} \quad \text{and} \quad \left(\frac{3}{2}, \frac{1}{2}\right)_{1,\,2} .$$

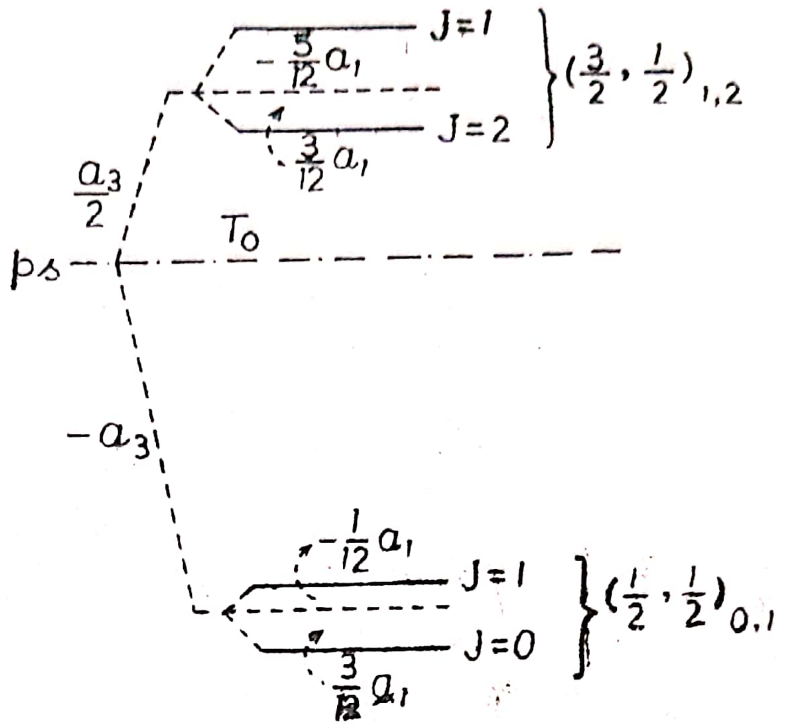
The shift of each term from the centre of gravity is $\Delta T_3 + \Delta T_4$. Now,
$$\Delta T_3 + \Delta T_4 = \tfrac{1}{2} a_3 (j_1^{*2} - l_1^{*2} - s_1^{*2}) + \tfrac{1}{2} a_4 (j_2^{*2} - l_2^{*2} - s_2^{*2}).$$

Putting $j_1 = \frac{1}{2}$, $j_2 = \frac{1}{2}$ and the values of l_1, s_1, l_2, s_2, we get
$$\Delta T_3 + \Delta T_4 = - a_3.$$

Thus the term $\left(\frac{1}{2}, \frac{1}{2}\right)_{0,\,1}$ is shifted down the hypothetical centre by a_3.

Again, putting $j_1 = \frac{3}{2}$, $j_2 = \frac{1}{2}$ and the same other values, we get
$$\Delta T_3 + \Delta T_4 = \frac{a_3}{2} .$$

Thus the term $\left(\frac{3}{2}, \frac{1}{2}\right)_{1,2}$ is shifted up by $a_3/2$. This has been shown in Fig. 8.



(Fig. 8)

For the separation of fine-structure levels, we calculate $\Delta T_1 + \Delta T_2$, which is

$$\Delta T_1 + \Delta T_2 = \frac{1}{2} B\,(J^{*2} - j_1^{*2} - j_2^{*2}).$$

For the term $\left(\frac{3}{2}, \frac{1}{2}\right)_{1,2}$, we have

$$B = \frac{1}{3}\,a_1$$

and $\Delta T_1 + \Delta T_2 = -\frac{5}{4}\,B,\ \frac{3}{4}\,B$

$$= -\frac{5}{12}\,a_1,\ \frac{3}{12}\,a_1 .$$

For the term $\left(\frac{1}{2}, \frac{1}{2}\right)_{0,1}$ we have

$$B = -\frac{1}{3}\,a_1$$

and $\Delta T_1 + \Delta T_2 = -\frac{3}{4}\,B,\ \frac{1}{4}\,B$

$$= \frac{3}{12}\,a_1,\ -\frac{1}{12}\,a_1 .$$

These separations are also shown in Fig. 8. It can be seen in Fig. 8 that the total ^3P separation, *i.e.* the interval between $J=0$ level and $J=2$ level is $3a_2/2$, which is the same as in L–S coupling.