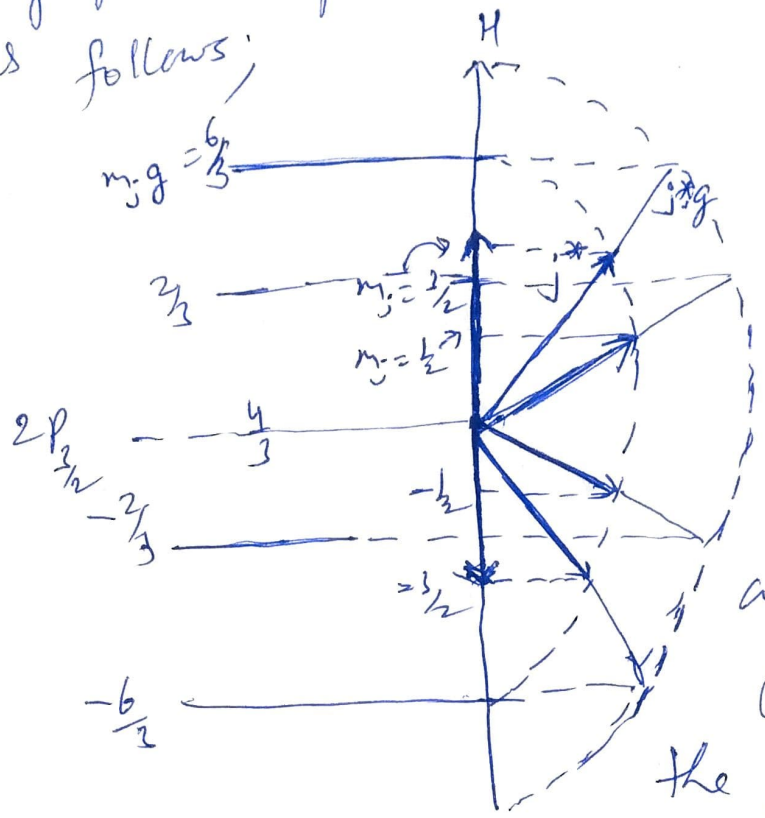
A graphical representation of the splitting is as follows;



Vector j^* shows four allowed positions.

Multiplying j^* by g and projecting the product on the H-axis the displacements shown on the left are obtained.

The complete term value T of any magnetic level may be written

$$T = T_0 - \Gamma - m_j g . L$$

T_0 → term value of hypothetical center of gravity of the field free doublet, Γ is the fine-structure shift, and $m_j g . L$ is the magnetic shift.

Selection Rules: Consider the simple case of a principal-series doublet like the sodium yellow D lines λ 5890 and 5896. The g factors for the initial $^2P_{1/2}$ and $^2P_{3/2}$ states and

for the final $^2S_{1/2}$ state are $^2/_3, ^4/_1$ and 2. respectively

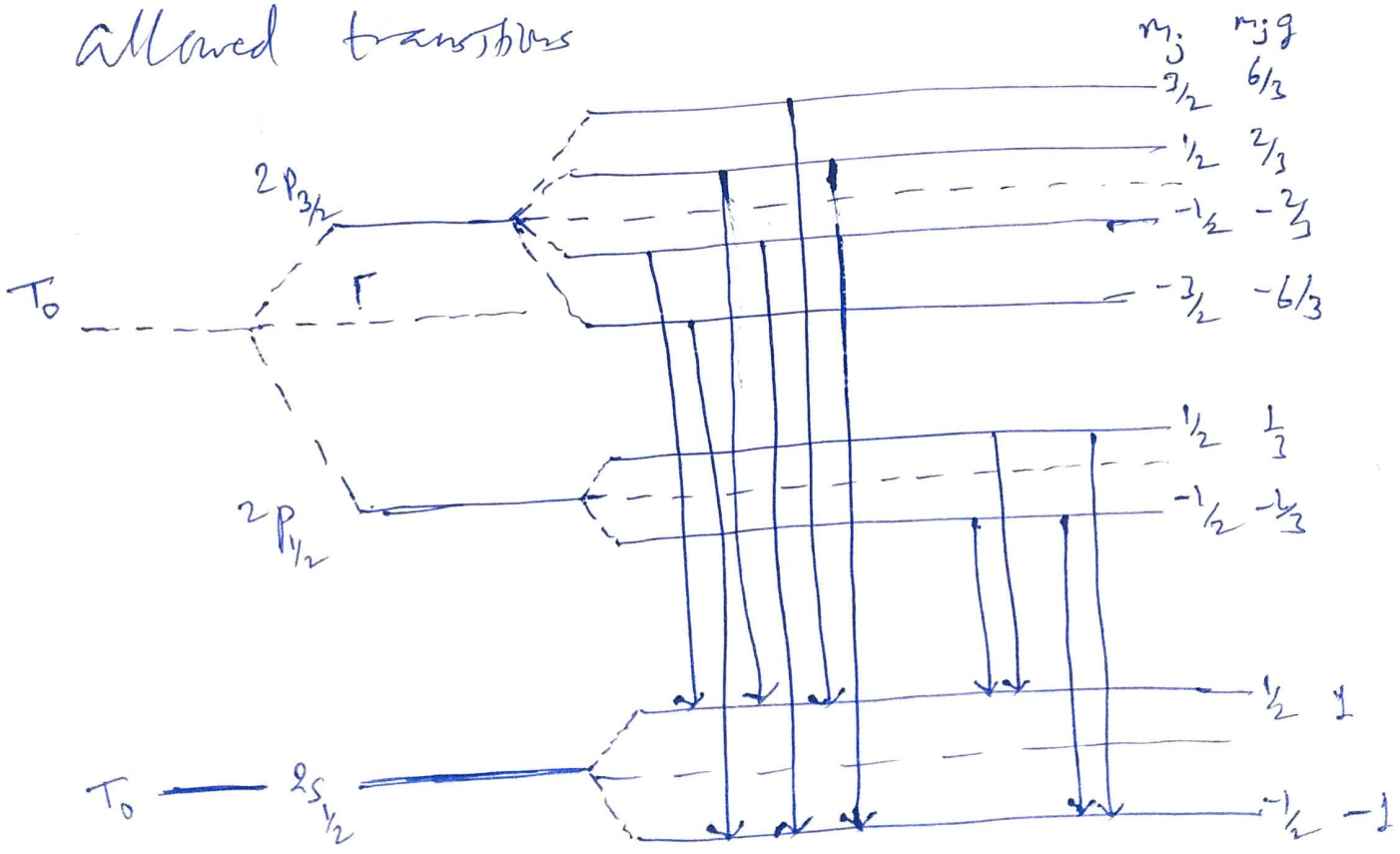
We show the splitting in the following figure.

The field-free levels are at the left. The dotted lines → the center of gravity of the associated levels.

The theoretical selection rules for transitions between levels (in agreement with observations) are; In any transitions the magnetic quantum number (m_j) changes by +1, 0, or −1, i.e.,

$$\Delta m_j = 0, \pm 1$$

for the stronger of the two field-free lines there are six allowed transitions and two forbidden transitions. for the other lines there are four allowed transitions



Polarization rules for Zeeman Lines : quantum transitions which obey the selection rules $\Delta m_j = 0, \pm 1$ are permitted.

The selection rule for magnetic quantum number, written in the following fashion, constitutes the polarization rules for Zeeman lines.

Viewed $\perp$ to field
- $\Delta m_j = \pm 1$; plane polarized $\perp$ to H; S(σ) components
- $\Delta m_j = 0$; plane polarized $\parallel$ to H; P(π) components

Viewed $\parallel$ to field
- $\Delta m_j = \pm 1$; Circularly polarized; S(σ) components
- $\Delta m_j = 0$; forbidden, P(π) components

The Paschen-Back Effect :- In dealing the interaction energy between an atom containing one single valence electron and an external magnetic field, it was assumed that the field was weak as compared to the internal fields due to the spin and orbital motion of the electrons.

With the external field become greater than these internal fields the internal motions are perturbed and the atom gives rise to ⟶ Paschen-Back Effect

As the doublet fine-structure separations are a measure of the classical frequency with which l^* and s^* precess around their resultant j^*.

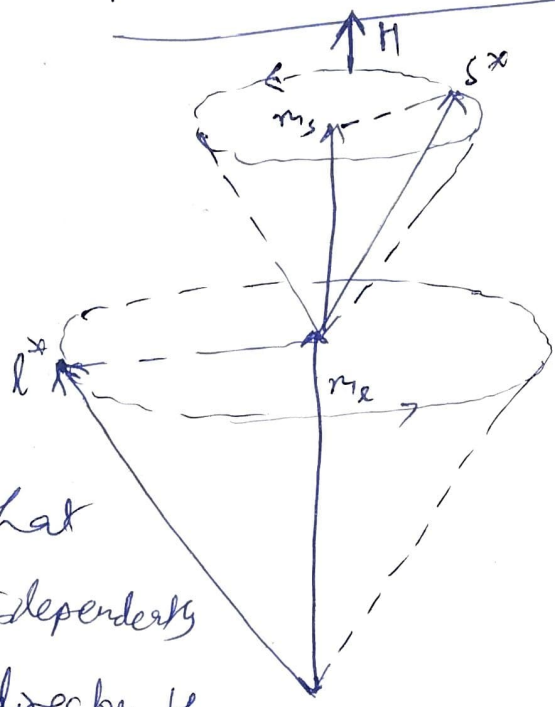
So the Zeeman separations of the same energy states in a weak magnetic field are a measure of the frequency with which j^* precesses around H (or B). In calculating the Zeeman separations → it was assumed that the precession of l^* and s^* around j^* was much faster than that of j^* around H.

This was necessary in order that the components of l^* and s^* normal to j^* average to zero and do not perturb the other precession. If the field (H) is increased until the two precessions are of the same order of magnitude, the Zeeman levels of the doublet will begin to overlap and there will be no averaging to zero

Under these conditions:— the coupling between l^* and s^* will be partially broken down, the classical motion of l^* and s^* will become complicated

and j^* will no longer be fixed in magnitude. As the field is further increased the l^* and s^* will become quantised separately and precess more or less independently around H. ⟶ This is Paschen-Back Effect

. Vector model for the Paschen-Back effect ⟶



field is so strong that l^* and s^* precesses independently around the field direction H.

The total energy of the atom in a field strong enough to give the Paschen-Back effect is made up of three parts:

(1) The energy due to the precession of l^* around B(H)

(2) The energy due to the precession of s^* around B(H)

(3) The interaction energy between l^* and s^*.

By Larmor's theorem, the precessional angular velocities are;