

How do we learn about nuclear spin?

One means is to take a look at the atomic spectra somewhat closely.

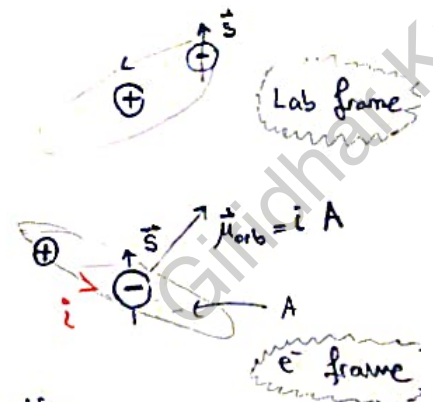
If you examine an atomic spectra quite crudely, you only realize the orbital levels of the electrons. A closer look reveals that there is a so-called **fine structure** which arises from the coupling of the spin and orbital degrees of freedom of the electrons.

How do spin & orbit know about each other?

In the e^- rest frame the nucleus appears

to be moving, which creates an orbital magnetic moment, $\vec{\mu}_{orb}$. The two magnetic moments

have dipole-dipole coupling $\vec{S} \cdot \vec{\mu}_{orb}$, spin-orbit coupling.



This coupling exerts an orbital-dependent shift on the atomic levels

$$\vec{L} + \vec{S} = \vec{J} \quad (\text{because of this coupling, neither } \vec{L}^e \text{ nor } \vec{S}^e \text{ are conserved})$$

At a higher resolution, one finds that even the fine structure components split into subcomponents, so-called **hyperfine structure** which arises from the again magnetic interaction bet. **nuclear** magnetic moment $\vec{\mu}_N$, with the **electronic** magnetic moment $\vec{\mu}_J$

HFS energy splitting

HF Constant

$$\Delta E_{HFS} = \frac{A}{2} [F(F+1) - J(J+1) - I(I+1)]; \quad \vec{F} = \vec{J} + \vec{I}$$

$$A = \frac{g_N \mu_N B_J}{\sqrt{J(J+1)}}$$

nuclear g-factor

nuclear magnetic moment

field produced by the e^- @ nuclear site

total ang. mom. of the atom

total electronic ang. mom.

total nuclear ang. mom.

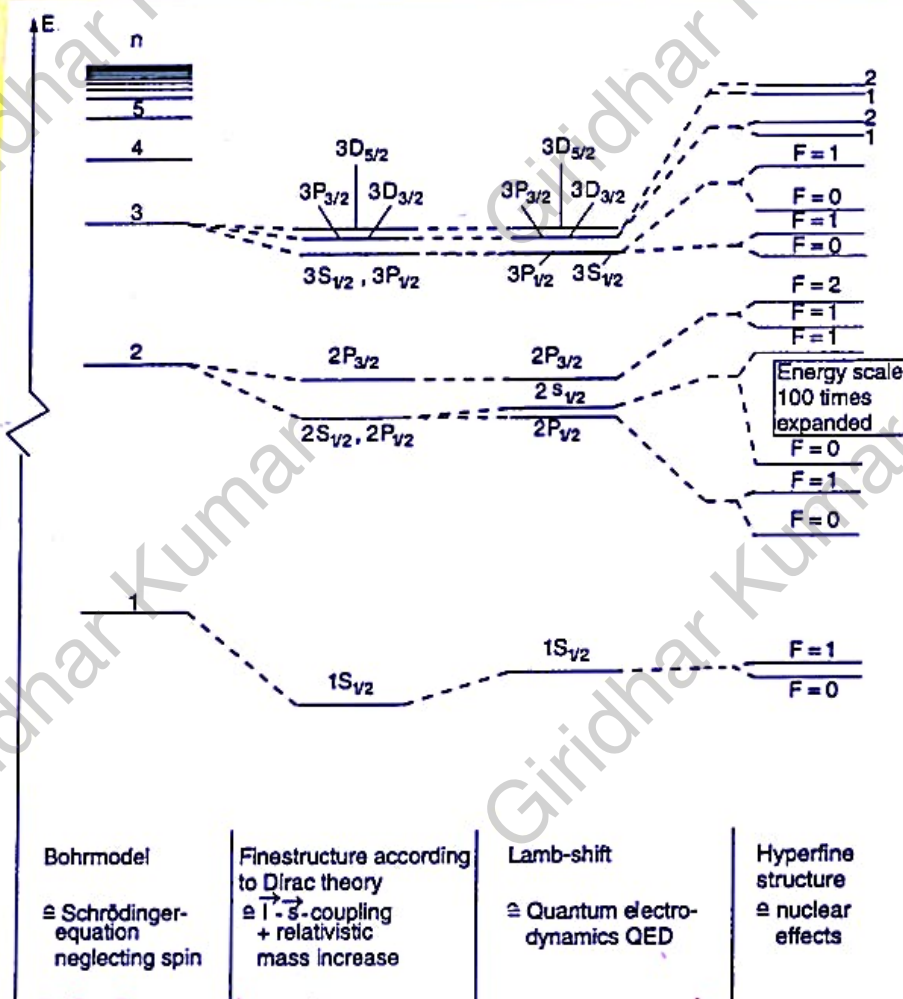
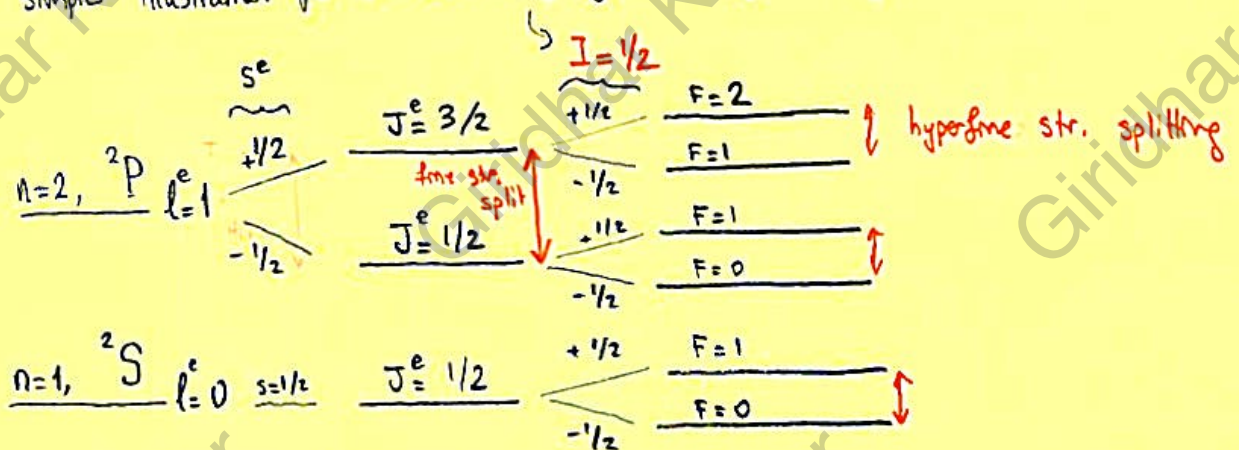


Fig. 5.33. Complete level scheme of the H atom including all interactions known so far. Note: The fine, HFS structure, and the Lamb shift are not drawn to scale. They are exaggerated in order to illustrate the splittings and shifts

Ref: Demtröder, 'Atoms, Molecules and Photons' Springer, 2006.

A simpler illustration for the same Hydrogen splittings is given below (not to scale)



Hence, from the hyperfine splitting multiplet $(2I+1)$ we can infer the value of I as well as the nuclear magnetic moment μ_N