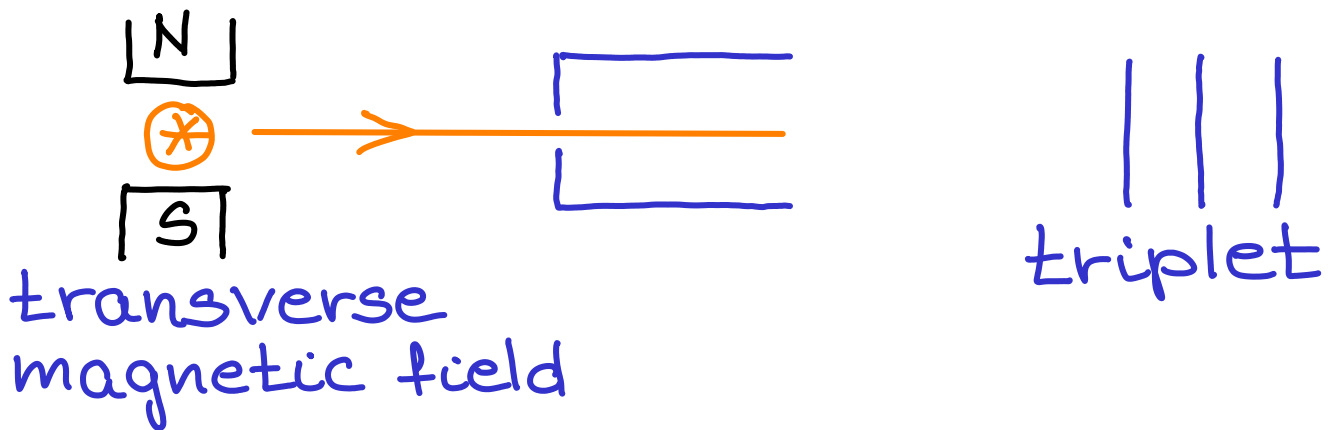
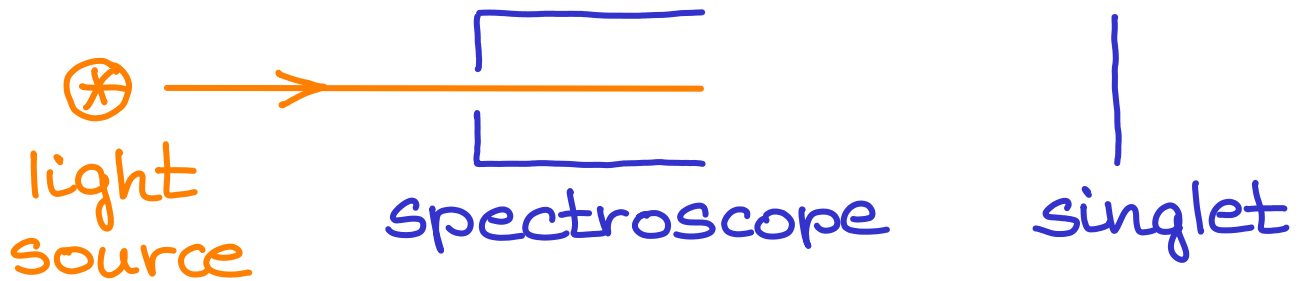


Zeeman - effect

Zeeman (Nobel, 1902)



(the magnetic field can be in the longitudinal direction)

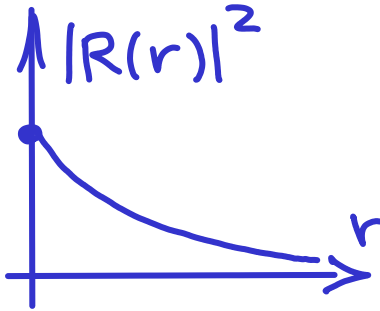
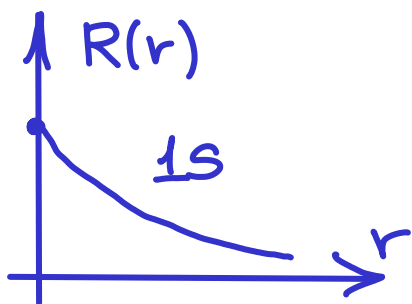
normal Zeeman

- simpler
- lines split to 3, 5, 7
- mainly due to orbital angular momentum

anomalous Zeeman

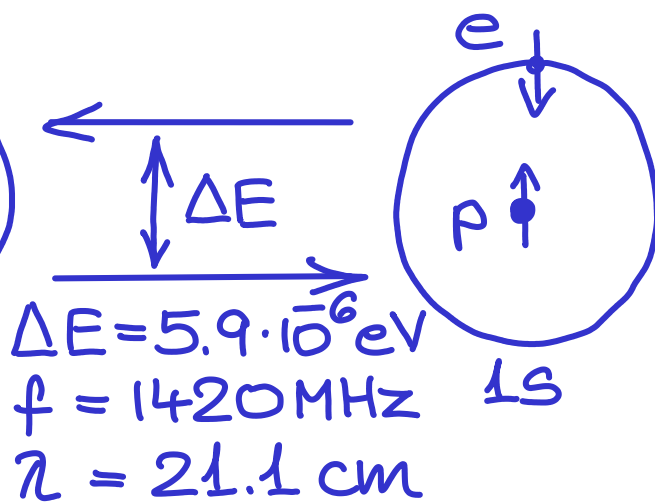
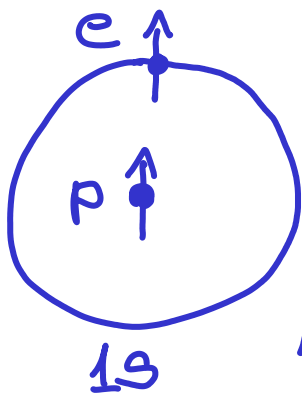
- more complex
- lines split to 2, 4
- electron spin must also be included

Hyperfine transition of Hydrogen



R^2 : local probability density

R^2 is nonzero at the proton's position for the 1s, 2s, 3s... states.



$\Delta E = 5.9 \cdot 10^{-6} \text{ eV}$
 $f = 1420 \text{ MHz}$
 $\lambda = 21.1 \text{ cm}$

} spin-spin interaction of the proton and the electron.

This is due to magnetic dipole transition. It is forbidden via electric dipole transition.

very long lifetime : 20 million years.
But since Hydrogen (atomic and molecular) is everywhere in inter-stellar space, this is the most common transition in radio frequency.