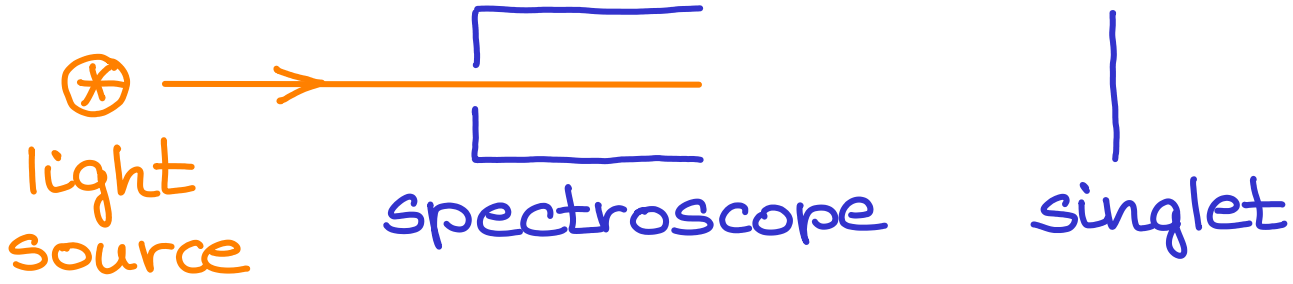
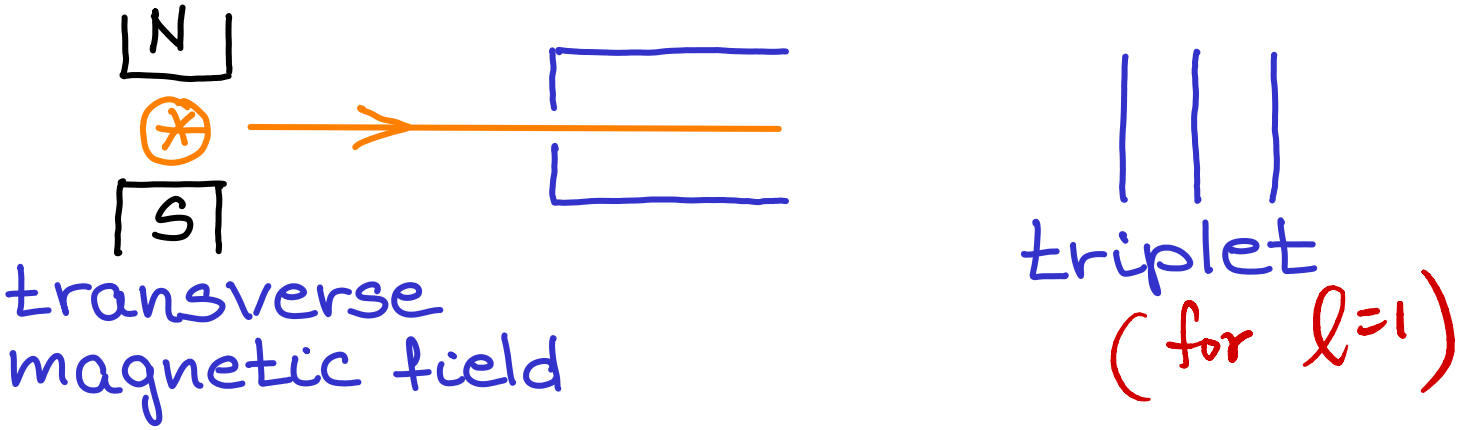
Zeeman - effect

Zeeman (Nobel , 1902)

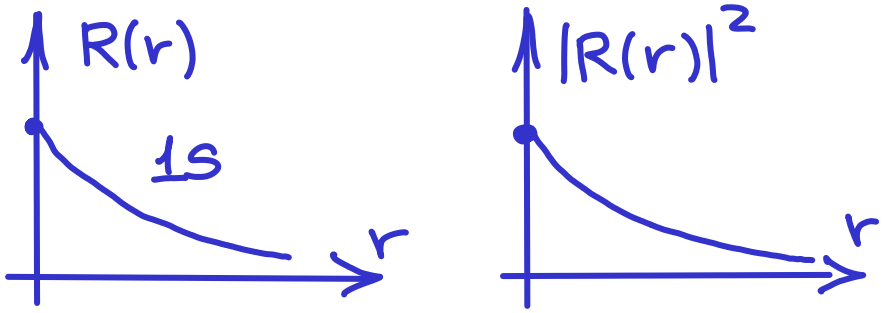




(the magnetic field can be in the longitudinal direction)

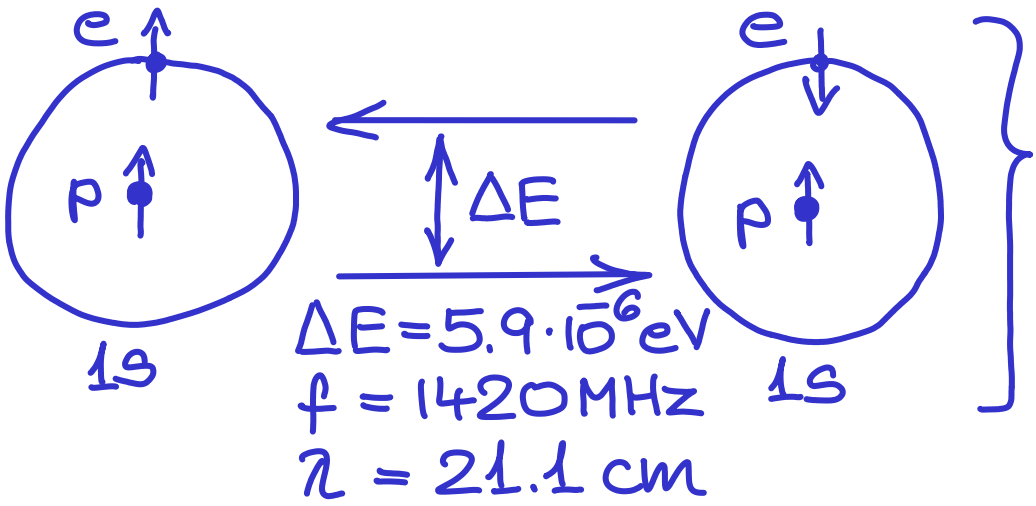
normal Zeeman	anomalous Zeeman
- simpler	- more complex
- lines split to 3,5,7	- lines split to 2,4
- mainly due to orbital angular momentum	- electron spin must be included

Hyperfine transition of Hydrogen



R^2: local probability density

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



spin-spin interaction of the proton and the electron.

This is a forbidden transition (for 1s → 1s : $\Delta l = 0$), it has a 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.