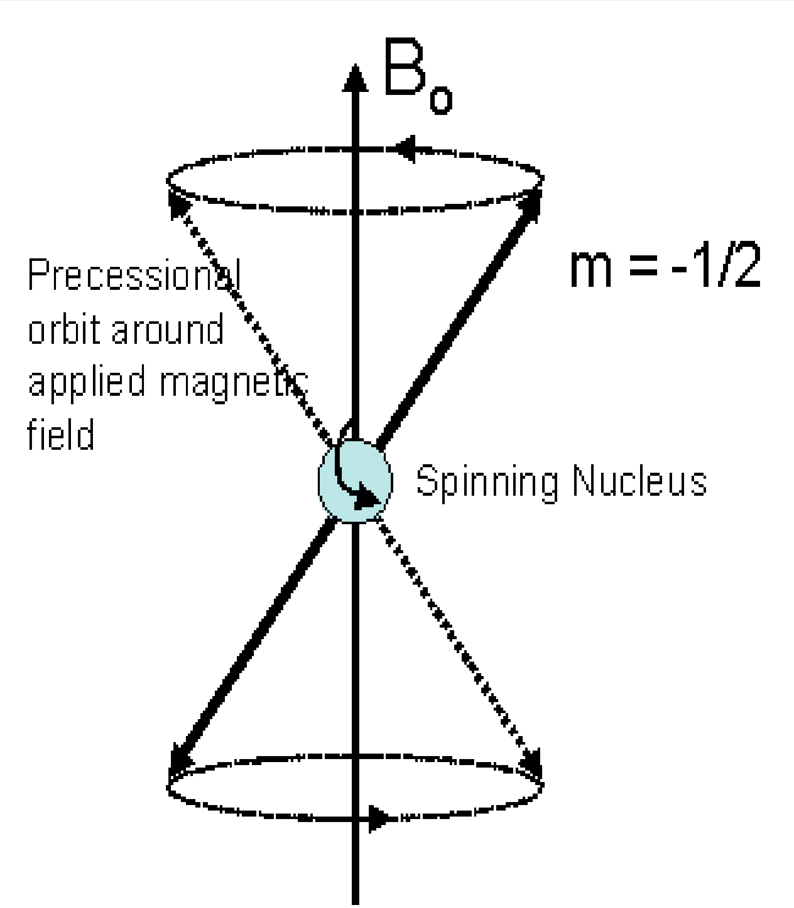
NMR EXPERIMENTS

NMR basics

- Nucleus with spin required
- External magentic field

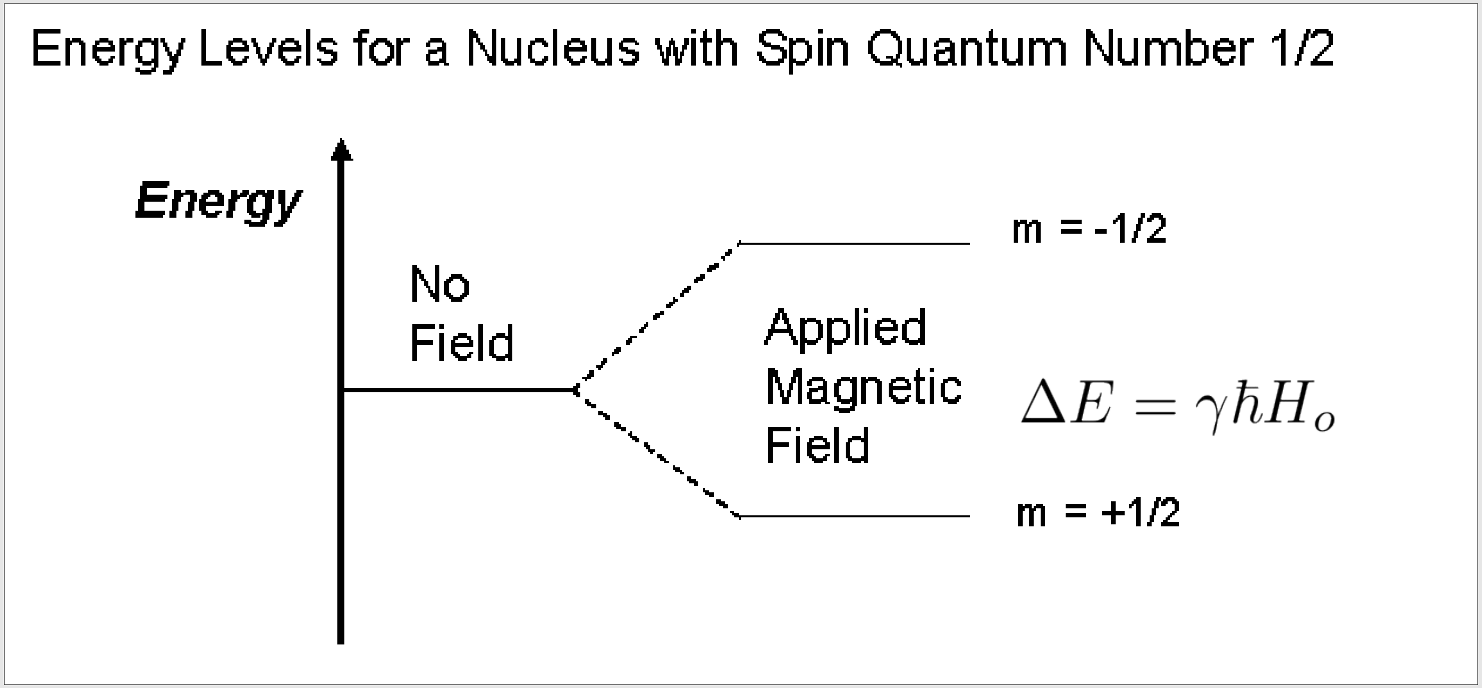
- ➔ precession of magnetc moment
- ➔ splitted energies

picture: www.process-nmr.com/



NMR basics

- Zeeman Hamiltonian: $\mathcal{H}_z = -\gamma\hbar\sum_i I_z^i H_o$
- $E = \pm\gamma\hbar\frac{H_0}{2}$



picture: www.process-nmr.com/

NMR types

Continuous Wave NMR

- Exitation of nucleus with photons
- Frequency changed until resonace found
- Not up to date anymore

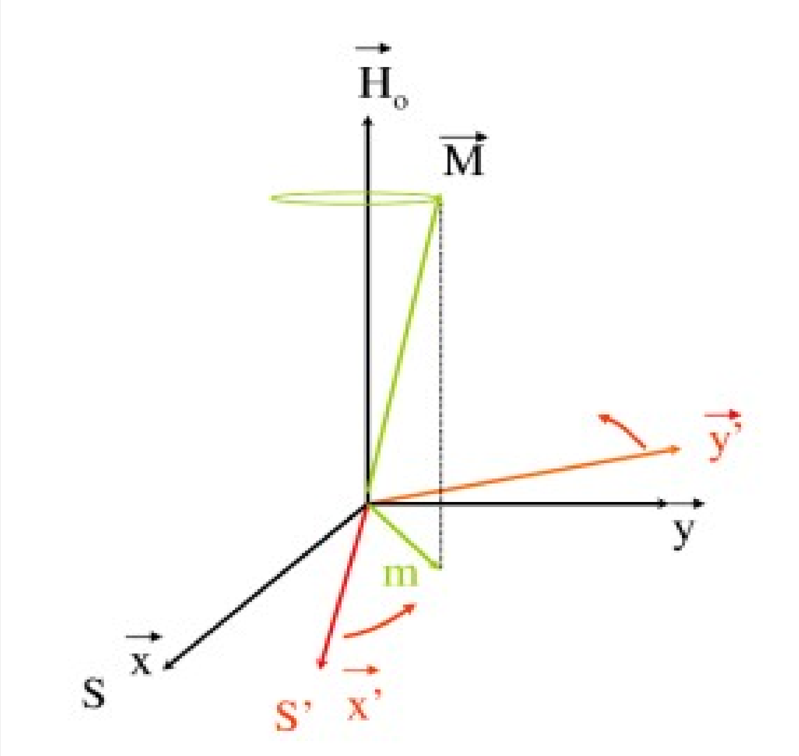
pulsed NMR

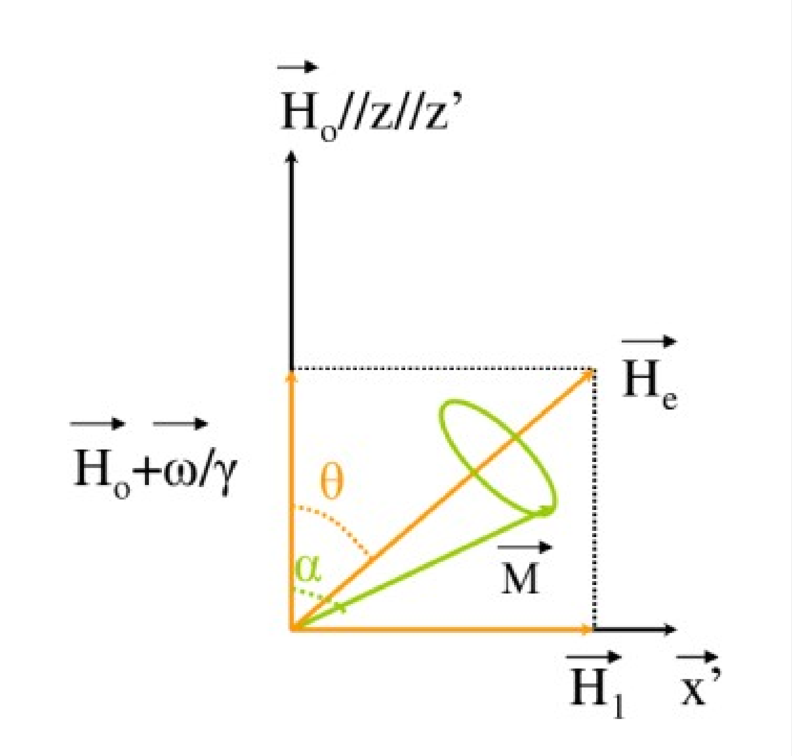
- Second rotating mgnetic field
- Pulsed

NMR pulsed: rotating frame

- Change to rotating frame
- Adding 2nd H-field now

$$H = (H_0 - \frac{\omega}{\gamma})e_z + H_1 e'_x$$





pictures: 'NMR-MRI, uSR and Mössbauer Spectroscopies in Molecular Magnets' by Carretta, Lascialfari

NMR pulsed: signal

- Same coil for sending pulse end recieving signal
- Signal is proportional to:

  resonance frequency

  and to the x-y part of M
- This signal transformed into the rotationg frame

  is called FID free induced decay

NMR

- Bloch equations:

$$\frac{dM_z}{dt} = \gamma(\boldsymbol{M} \times \boldsymbol{H}_0)_z + \frac{M_0 - M_z}{T_1}$$

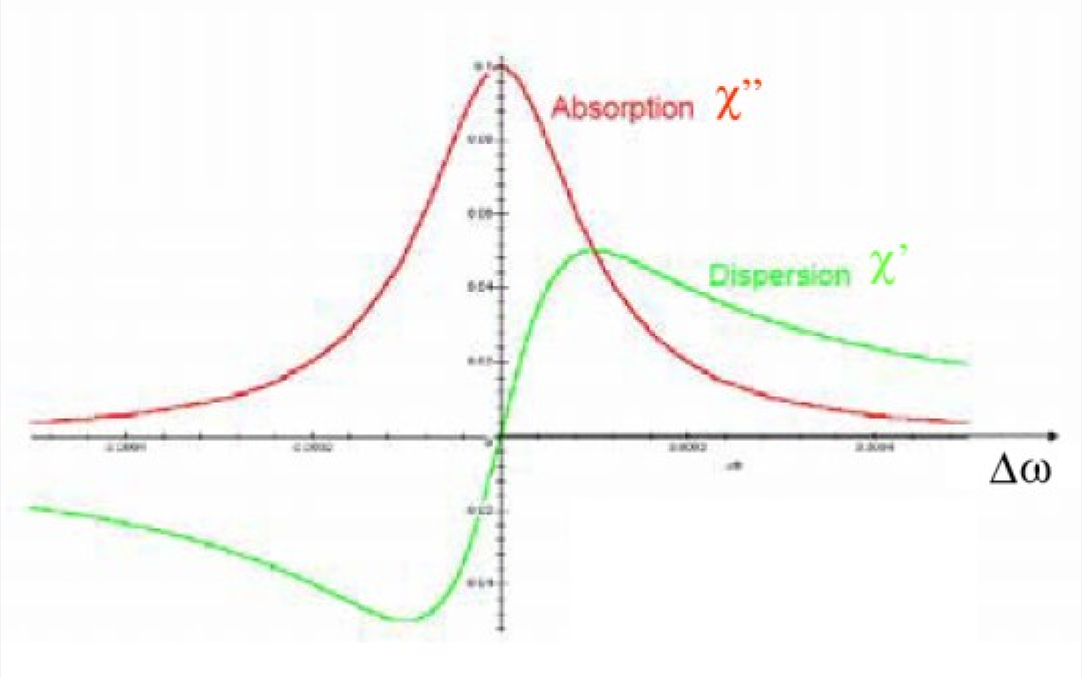
$$\frac{dM_{x,y}}{dt} = \gamma(\boldsymbol{M} \times \boldsymbol{H}_0)_{x,y} - \frac{M_{x,y}}{T_2}$$

- Lead to magnetization and suszeptibility depending on the frequency

$$\chi = Rel(\chi) + Im(\chi) = \chi' + \chi''$$

NMR

- For a small H_1 :



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NMR spectra

- $f(\omega)d\omega$ Gives the fraction of nuclei with resonance in this frequency area
  - Is proportional to the absorbed power
  - Is proportional to the real part of the suszeptibility

$$P(w) = \frac{\chi_o}{2}\omega\omega_0 H_1^2 f(\omega) 2\pi$$

$$P(w) = \frac{1}{2}\omega H_1^2 \chi"(\omega) V$$

CW NMR signal:

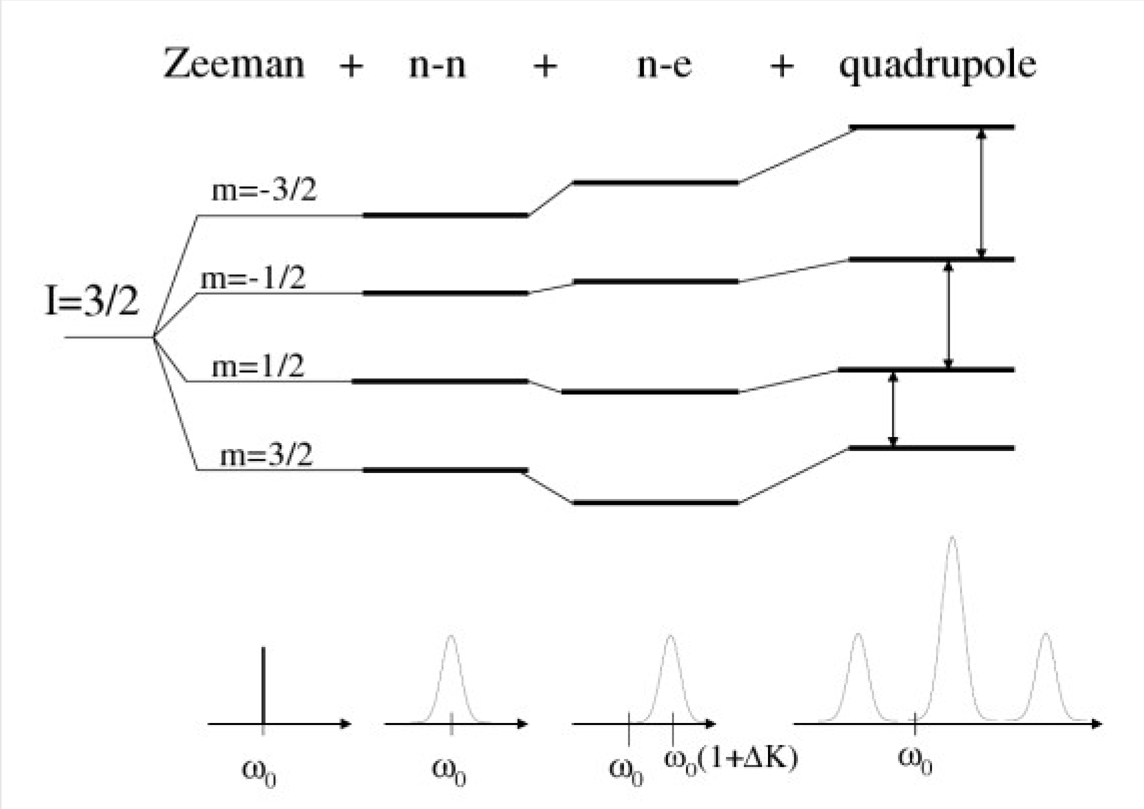
- proportional to absorbed Power

NMR spectra

- pulsed NMR signal: proportional to
  - Resonance frequency
  - Transverse M
- Furier transform of pulsed NMR signal is the spectrum

NMR hyperfine hamiltonian

$$\mathcal{H} = \mathcal{H}_z + \mathcal{H}_{n-n} + \mathcal{H}_{n-e} + \mathcal{H}_{EFG}$$



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references

- 'NMR-MRI, uSR and Mössbauer Spectroscopies in Molecular Magnets' by Carretta, Lascialfari
- Wikipedia
- www.process-nmr.com/
- www.cis.rit.edu/htbooks/nmr/inside.htm