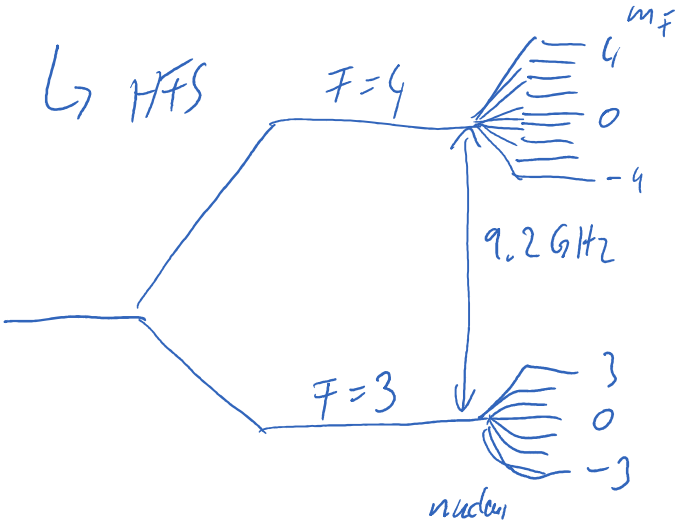
Ramsey spectroscopy & atomic clocks

Donnerstag, 16. Dezember 2021 12:57

1 sec $\hat{=}$ 9,192,631,770 periods of radiation from g.s. HFS in ^{133}Cs

- ^{133}Cs only occurring isotope
- Alkali: 1 valence electron $6\,^2S_{1/2}$
- Spin nucleus $7/2$

↳ HFS



$F=3 \quad m_F=0 \quad \uparrow\downarrow$

$F=4 \quad m_F=0 \quad \uparrow\uparrow$

↳ insensitive to magnetic (stray) fields

- extremely long lifetime of upper state

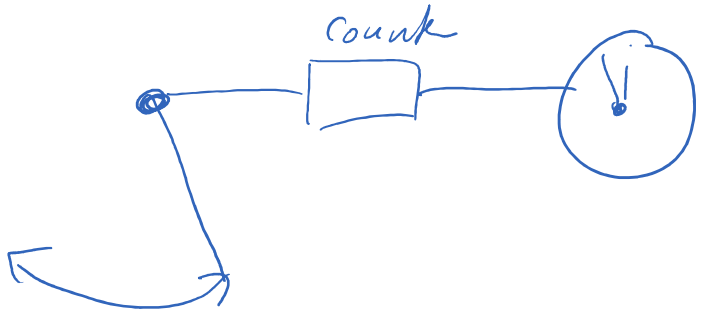
40'000 years

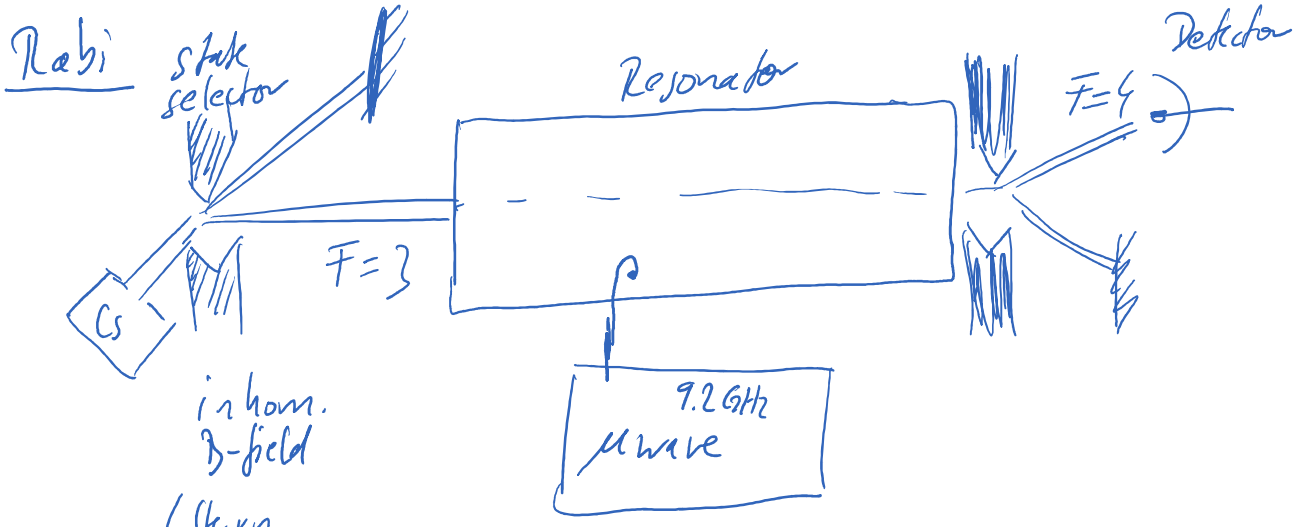
↳ very narrow resonance

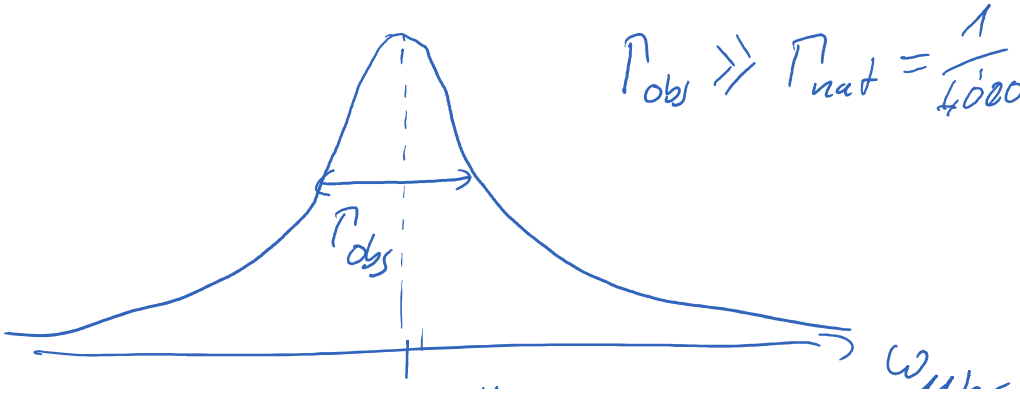
↳ good for precision

- convenient μwave frequ.
  can be counted

Clock = pendulum + counter







$\Gamma_{obs} \gg \Gamma_{nat} = \frac{1}{40200\,s}$

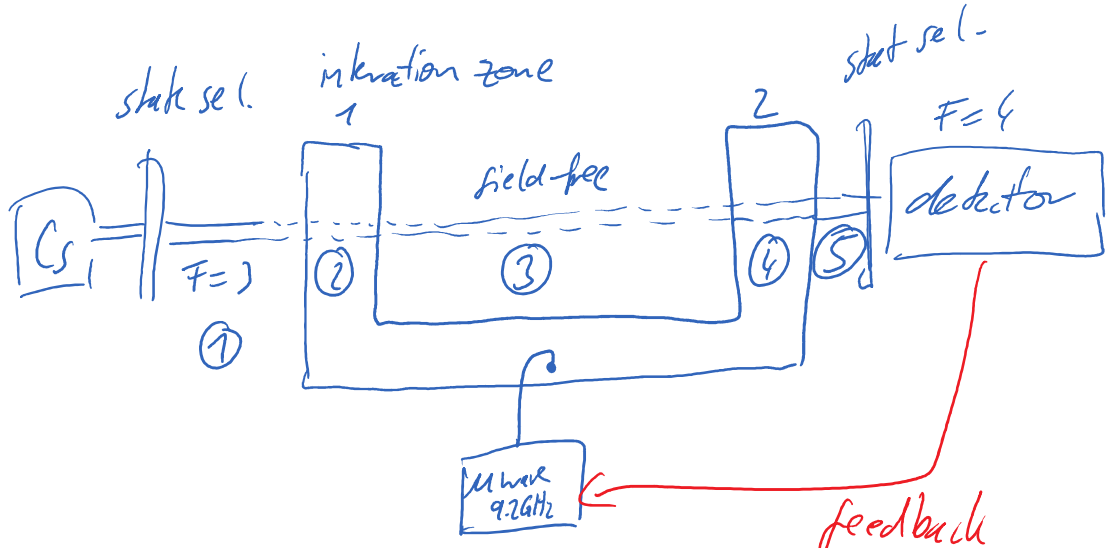
time-of-flight broadening
increases the observed line width

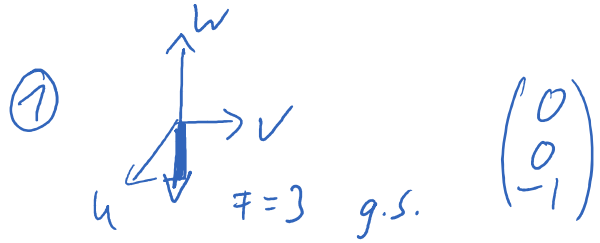
Cs atoms ~ 300 m/s

typical TOF ~ 3 ms → ~ 4 Hz line width

bad

Ramsey's trick



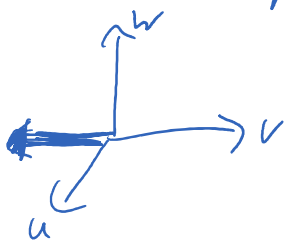


② 1st. interaction zone : $\frac{\pi}{2}$ pulse

$\Omega_0 \cdot \tau = \pi/2$

τ 1st. interaction time

→ coherent superposition



$\begin{pmatrix} 0 \\ -1 \\ 0 \end{pmatrix}$

③ field-free region

excited atomic Dipole oscillates at ω_{12}
$\hat{=}$ unperturbed atomic freqn.

- on resonance: $\delta = 0$

  Bloch vector stays at $\begin{pmatrix} 0 \\ -1 \\ 0 \end{pmatrix}$

  (RWA: $\omega_L = \omega_{12}$)
  $\hat{=}$ μwave freqn.

- off-resonance: $\delta \neq 0$

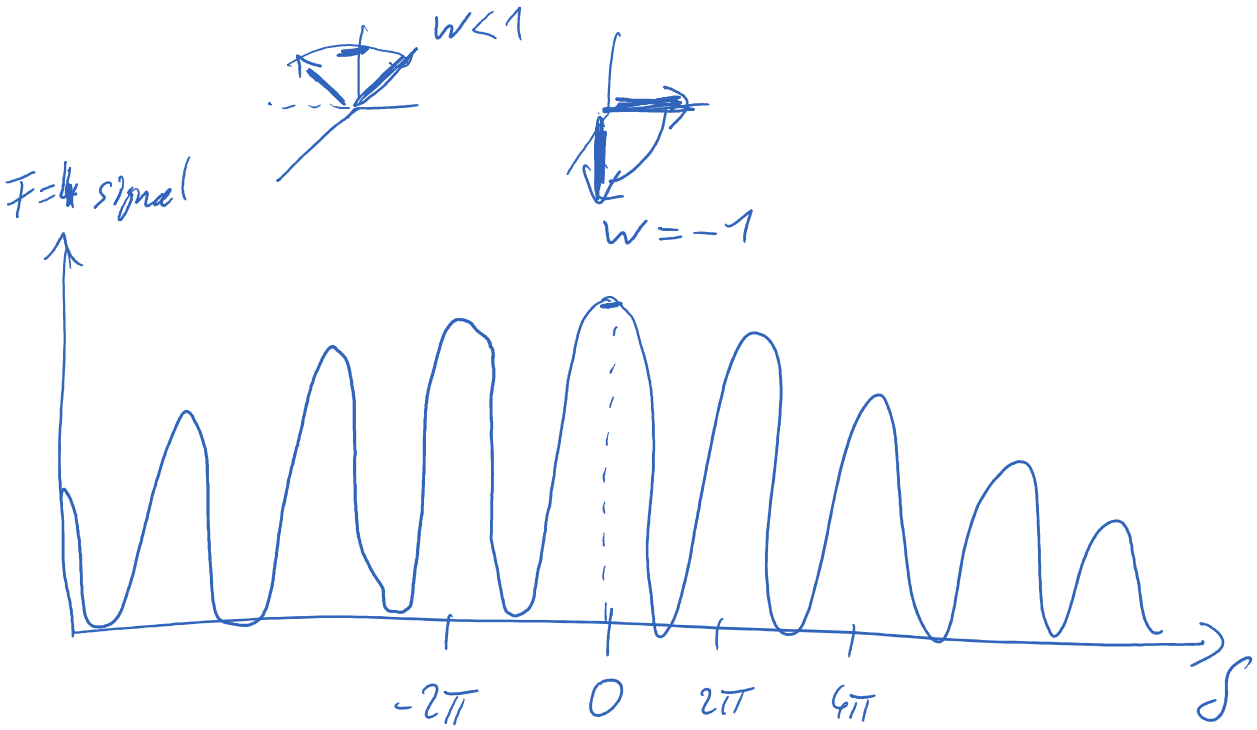
  Bloch vector rotates around w axis

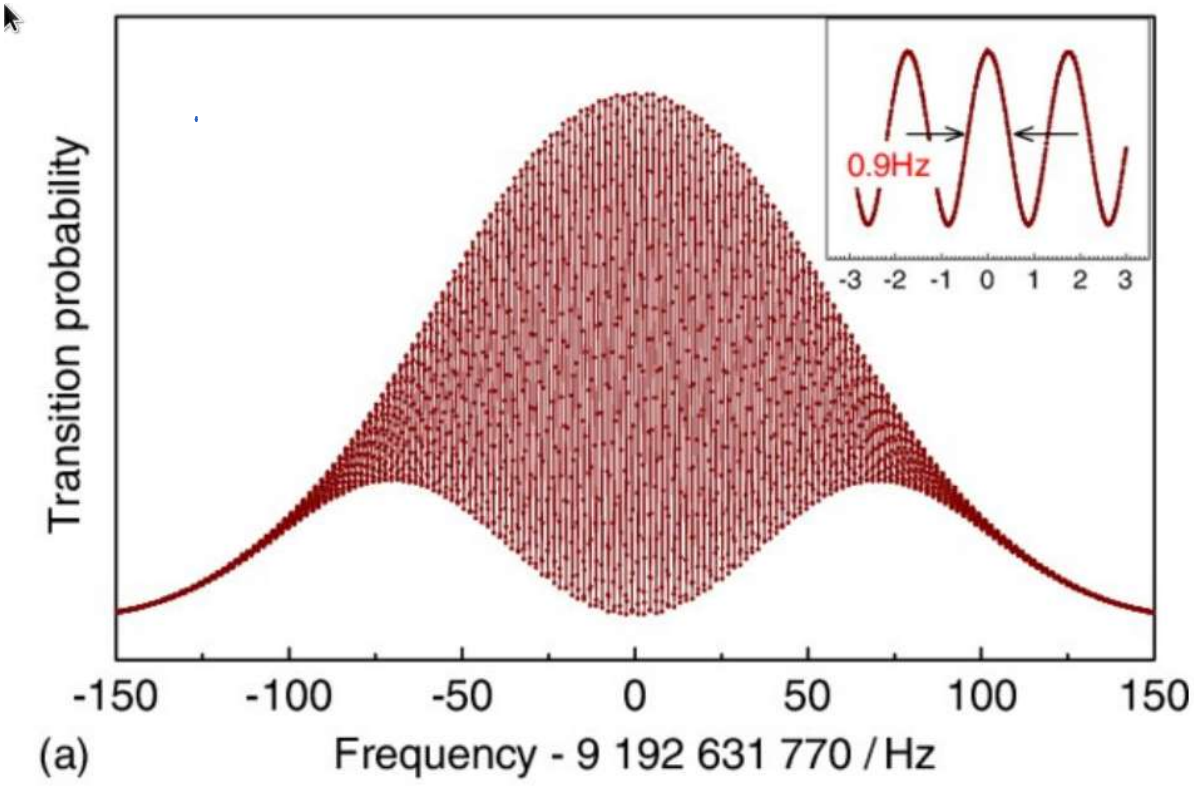
  $\begin{pmatrix} -\Omega_0 \\ 0 \\ -\delta \end{pmatrix}$ $t = 0$ in region ③ this is not

④ 2nd interaction zone:
another $\frac{\pi}{2}$ pulse

$\delta = 0$ ← max signal

$\delta \neq 0$ off-resonance various possibilities





modern Cs clock

Fountain clock