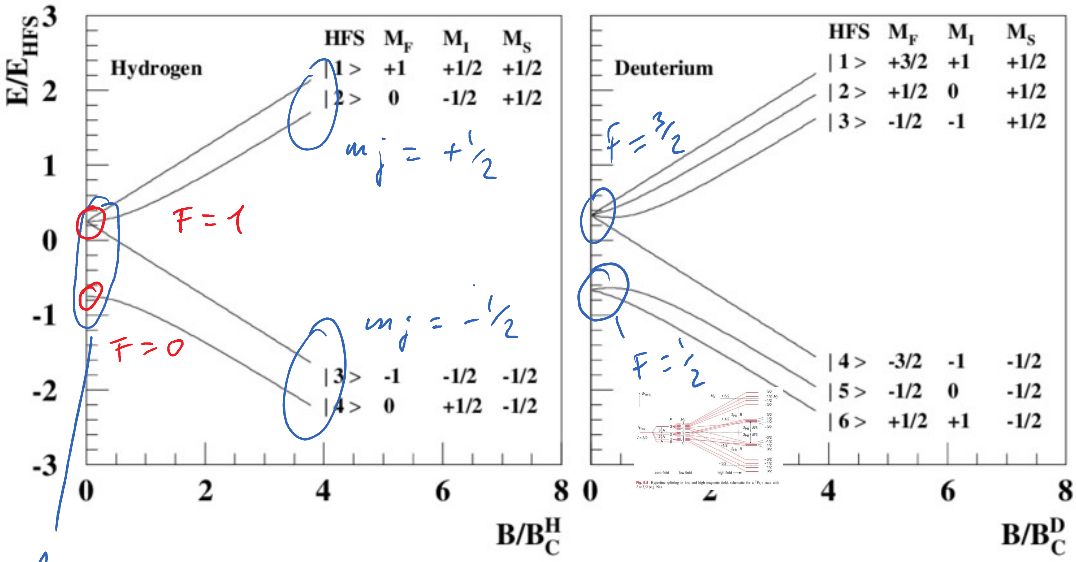
Hyperfine

Donnerstag, 8. Dezember 2022 12:32



low field   Breit-Rabi-Diagrams

H

H 1s

$$\left.\begin{array}{l} l = 0 \\ s = 1/2 \end{array}\right\} j = 1/2 \rightarrow m_j = \pm \tfrac{1}{2}$$

$I = 1/2$

$F = j - I = \frac{1}{2} - \frac{1}{2} = 0$

$j + I = \frac{1}{2} + \frac{1}{2} = 1$

$s = \frac{1}{2}$

$j = \frac{1}{2}$

$I = 1$

$F = I - j = \frac{1}{2}$

$I + j = \frac{3}{2}$

$$\boxed{\begin{array}{ll} F = 0 \rightarrow & m_F = 0 \\ F = 1 \rightarrow & m_F = -1, 0, +1 \end{array}}$$

$F = \frac{1}{2} \rightarrow m_F = -\frac{1}{2}, +\frac{1}{2}$

$F = \frac{3}{2} \rightarrow m_F = -\frac{3}{2}, -\frac{1}{2}, +\frac{1}{2}, +\frac{3}{2}$

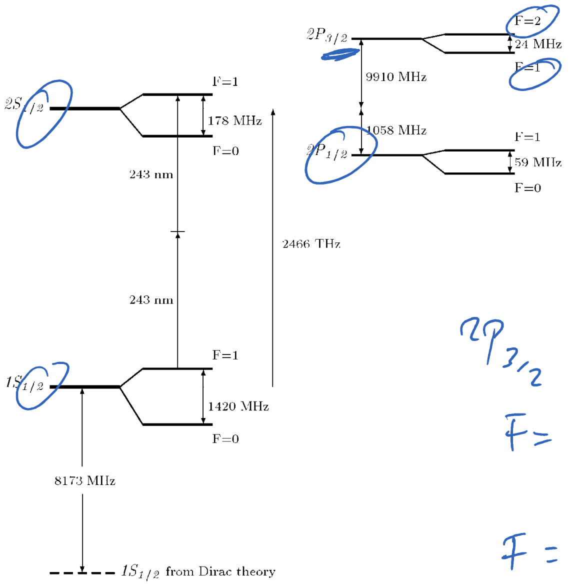
Zeeman effect:

low field $E = g \mu_B B \cdot m_F$

$m_F = 1$

low field $E = g\mu_B B \cdot m_F$

H

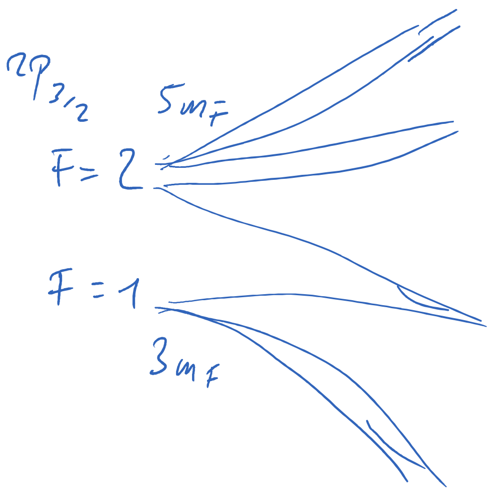


$2P_{3/2}$ $j = \frac{3}{2}$ $\pm$ $I = \frac{1}{2}$

$F = 1 \rightarrow m_F = -1, 0, 1$

$F = 2 \rightarrow m_F =$

$-2, -1, 0, +1, +2$



4 m_j

$-\frac{3}{2}$ $-\frac{1}{2}$ $\frac{1}{2}$ $\frac{3}{2}$

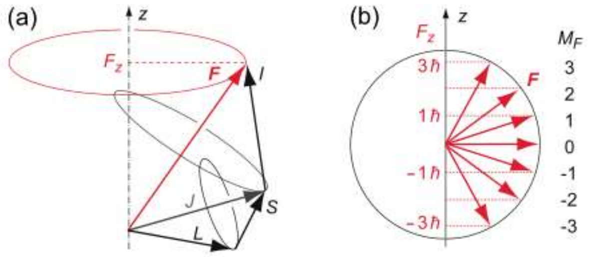


Fig. 9.1 (**a**) Vector model for coupling $\boldsymbol{L}$ and $\boldsymbol{S}$ to $\boldsymbol{J}$, and of $\boldsymbol{J}$ and $\boldsymbol{I}$ to $\boldsymbol{F}$, (**b**) $\boldsymbol{F}$ ha possibilities of orientation in space

Table 9.2 Properties of some hadrons and atomic nuclei (STONE 2005). The notation ${}^{A}_{Z}X$ refers to an atomic nucleus X with Z protons (atomic number) and a total of $\mathcal{A}$ nucleons (atomic mass number). The unit of area, 1 b (see Appendix A.2) corresponds to the area of an average size atomic nucleus

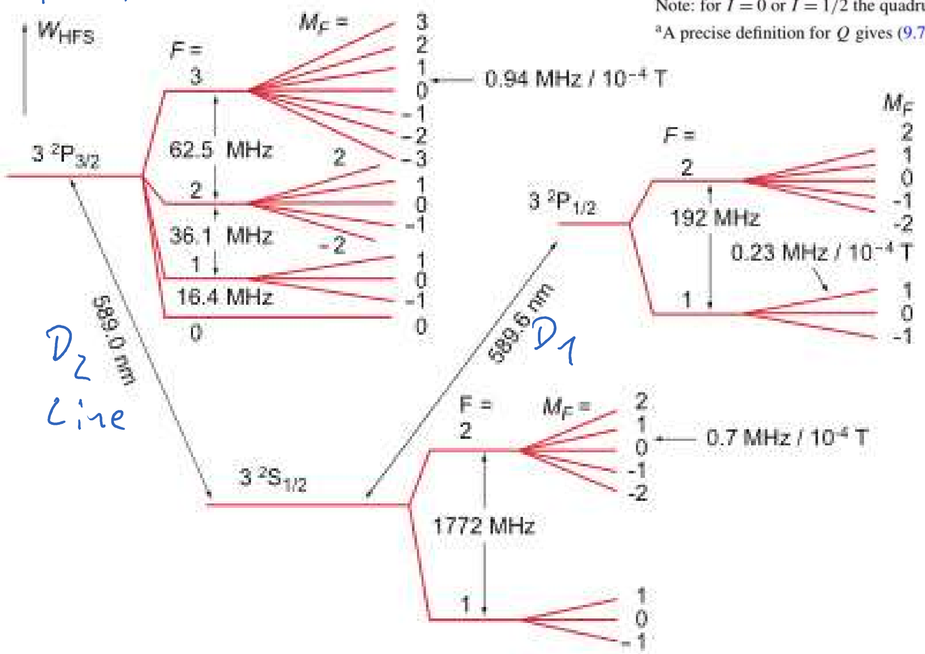
Nucleon or atomic nucleus	Spin I	Landé factor $g_I = \mathcal{M}_I/(I\mu_N)$	Magnetic moment $\mathcal{M}_I/\mu_N$	Quadrupole moment[a] Q / eb	NMR[b]
Proton p	1/2	5.58569471(5)	2.79284736(2)	0	+
Neutron n	1/2	−3.8260854(10)	−1.9130427(5)	0	
Deuteron ${}^{2}_{1}$D	1	0.8574382284	0.8574382284	0.0286(2)	
${}^{3}_{2}$He	1/2	−4.25499544(6)	−2.12749772(3)	0	
${}^{4}_{2}$He	0	–	0	0	
${}^{6}_{3}$Li	1	0.8220473(6)	0.8220473(6)	−0.00083(8)	
${}^{7}_{3}$Li	3/2	2.1709513(13)	3.256427(2)	−0.0406	
${}^{12}_{6}$C	0	–	0	0	
${}^{13}_{6}$C	1/2	+1.4048236(28)	+0.7024118(14)	0	+
${}^{14}_{7}$N	1	0.40376100(6)	+0.40376100(6)	+0.02001(10)	
${}^{15}_{7}$N	1/2	−0.56637768(10)	−0.28318884(5)	0	+
${}^{16}_{8}$O	0	–	0	0	
${}^{19}_{9}$F	1/2	+5.257736(16)	+2.628868(8)	0	+
${}^{23}_{11}$Na	3/2	1.478348(2)	+2.217522(2)	+0.109(3)	
${}^{29}_{14}$Si	1/2	−1.11058(6)	−0.55529(3)	0	+
${}^{31}_{15}$P	1/2	+2.2632(6)	+1.13160(3)	0	+
${}^{39}_{19}$K	3/2	0.26098(2)	+0.39147(3)	+0.049(4)	
${}^{67}_{30}$Zn	5/2	0.3501916(4)	+0.875479(9)	+0.150(15)	
${}^{85}_{37}$Rb	5/2	0.541192(4)	+1.35298(10)	+0.23(4)	
${}^{129}_{54}$Xe	1/2	−1.555952(16)	−0.777976(8)	0	
${}^{133}_{55}$Cs	7/2	0.7377214(9)	+2.582025(3)	−0.00371(14)	
${}^{199}_{80}$Hg	1/2	1.0117710(18)	+0.5058855(9)	0	
${}^{201}_{80}$Hg	3/2	−0.3734838(9)	−0.5602257(14)	+0.38(4)	
${}^{235}_{92}$U	7/2	−0.108(10)	−0.38(3)	4.936(6)	
Comparison		$g_e = \lvert\mathcal{M}_S/(S\mu_B)\rvert$	$\mathcal{M}_S/\mu_N$		
Electron e⁻	1/2	2.002319...	−1838.2819709(8)	–	
Muon μ⁻	1/2	2.002331...	−8.8905971(2)	–	

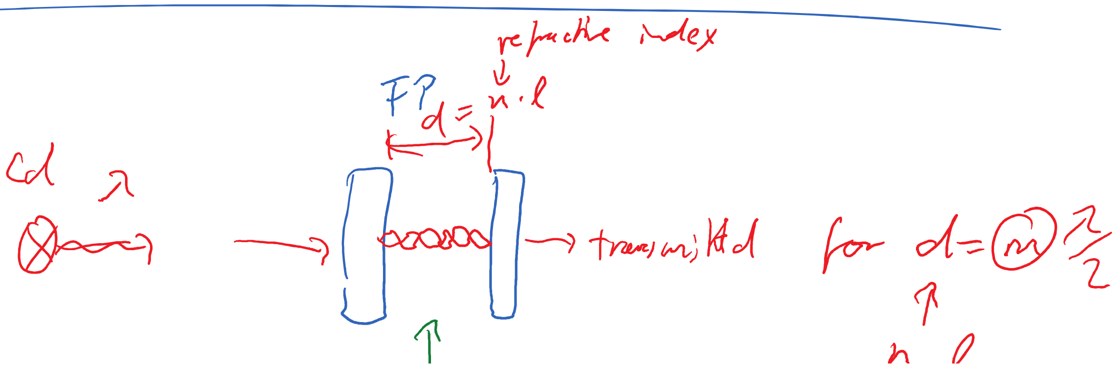
Note: for $I = 0$ or $I = 1/2$ the quadrupole moment is always $Q \equiv 0$

[a] A precise definition for Q gives (9.71); see also Appendix A.2

interval rule (6.14)

$E_F - E_{F-1} = A \cdot F$



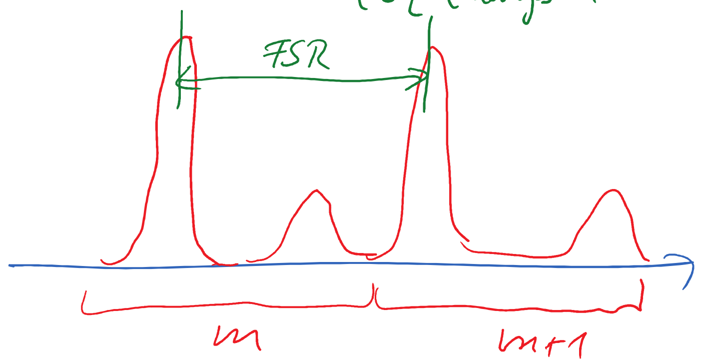


for $d = m\frac{\lambda}{2}$

n 0

$n \cdot l$

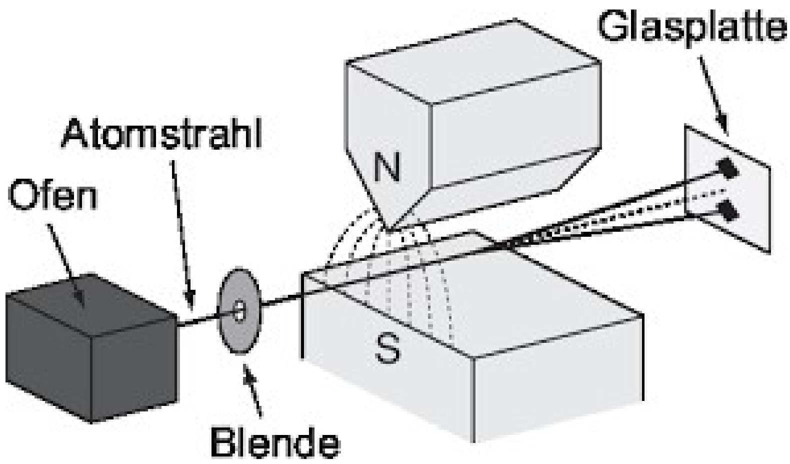
CO_2 changes n



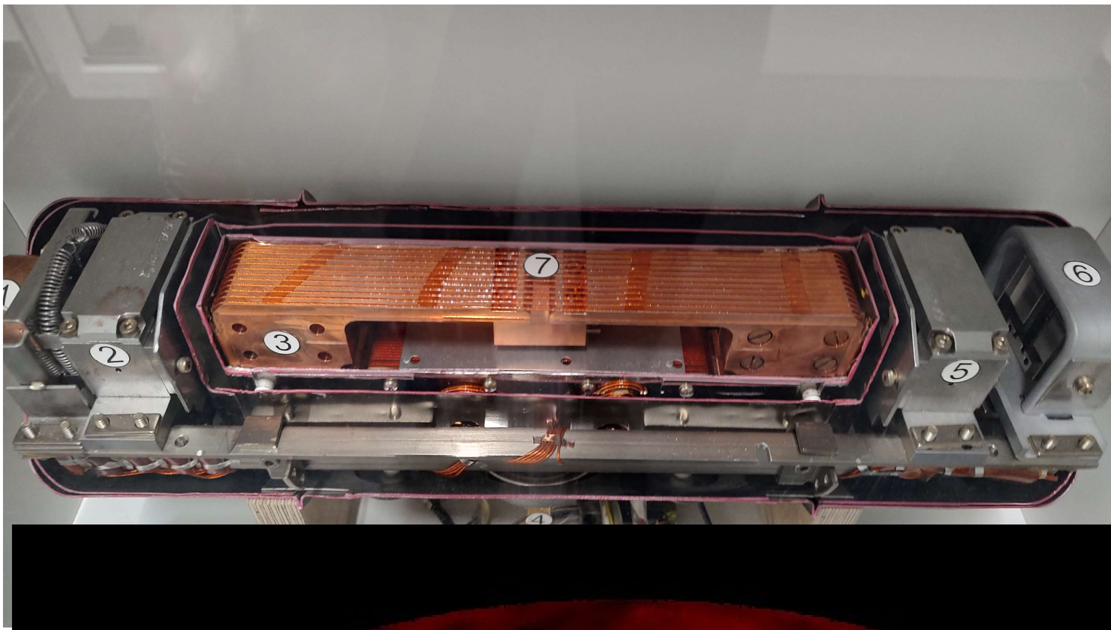
free spectral range
$\Rightarrow$ frequency axis
$d\lambda$, $d\nu$

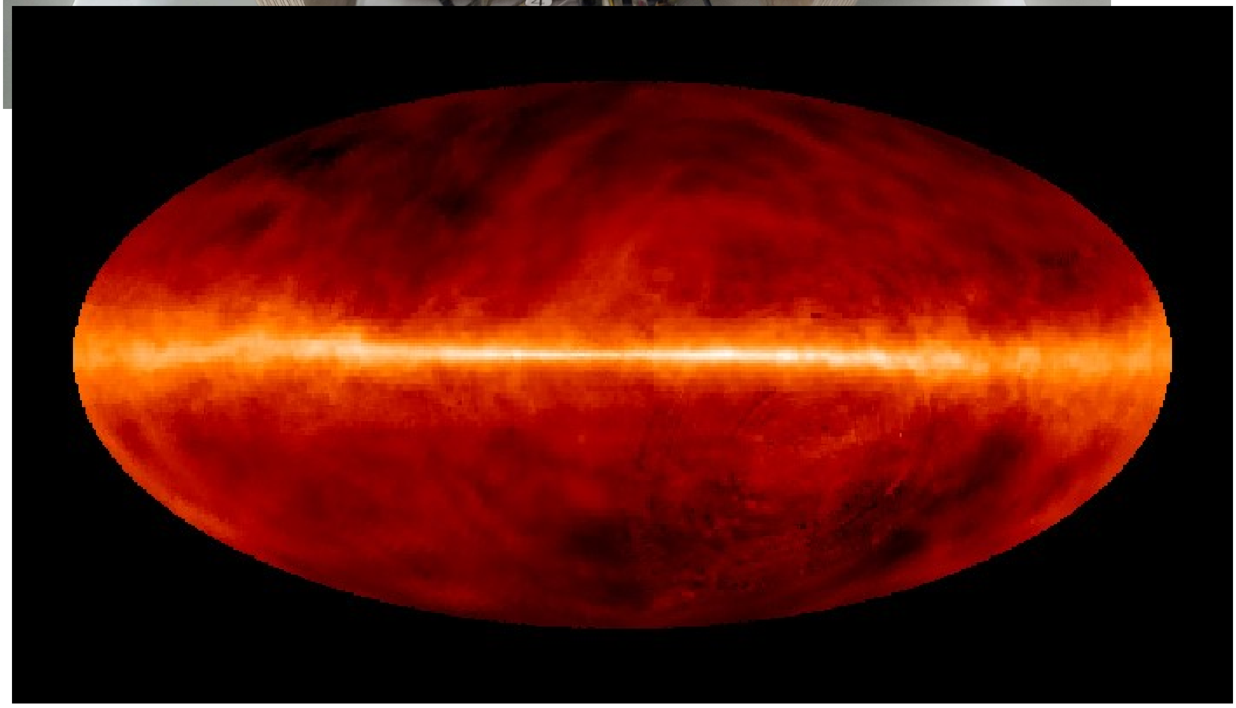
$\propto p_{CO_2}$
$\propto n$
$\propto \Delta\lambda$

Stern-Gerlach experiment



Atomic clock





1,4 GHz $\hat{=}$ 21cm   H 1s-HFS

$F = 0 \leftrightarrow 1$