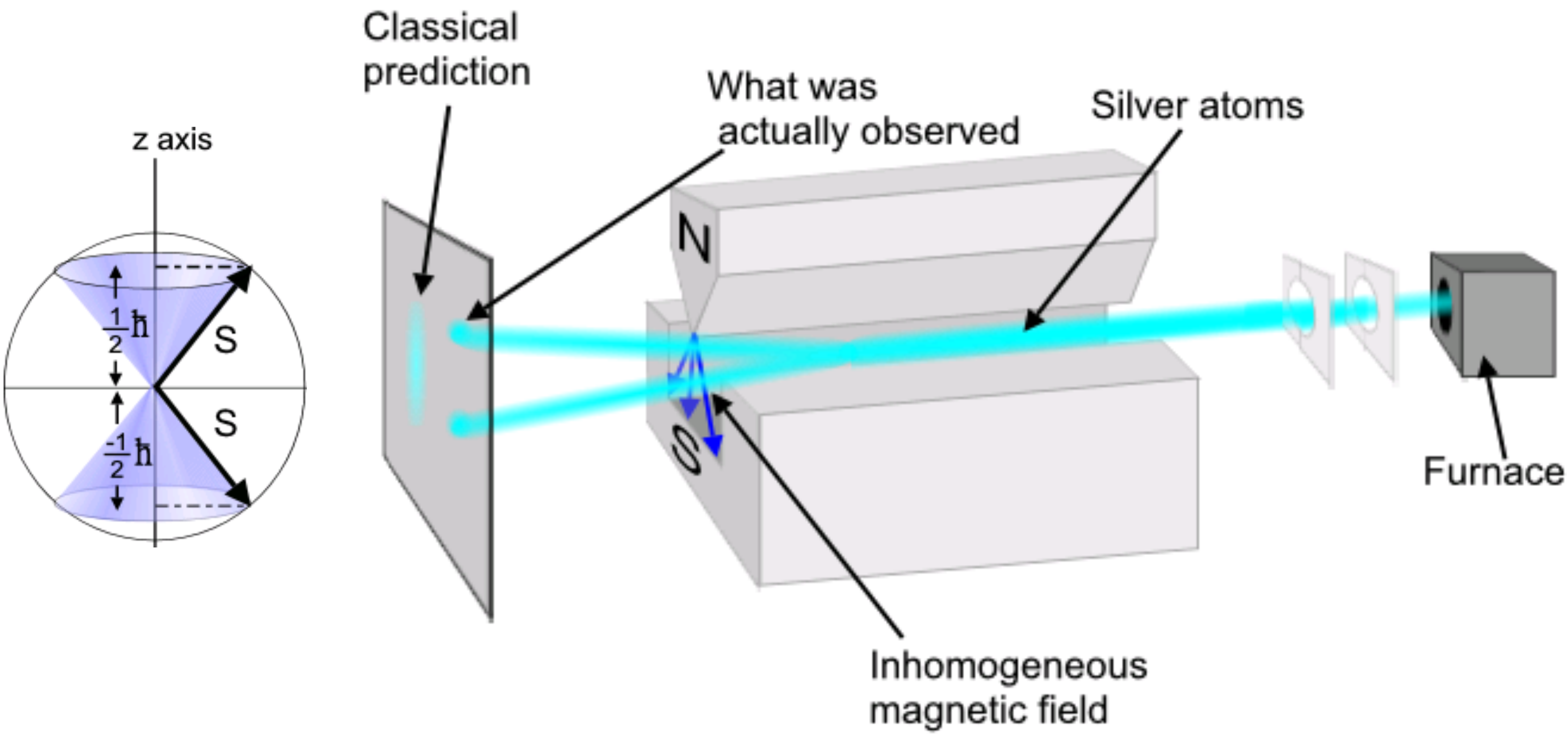
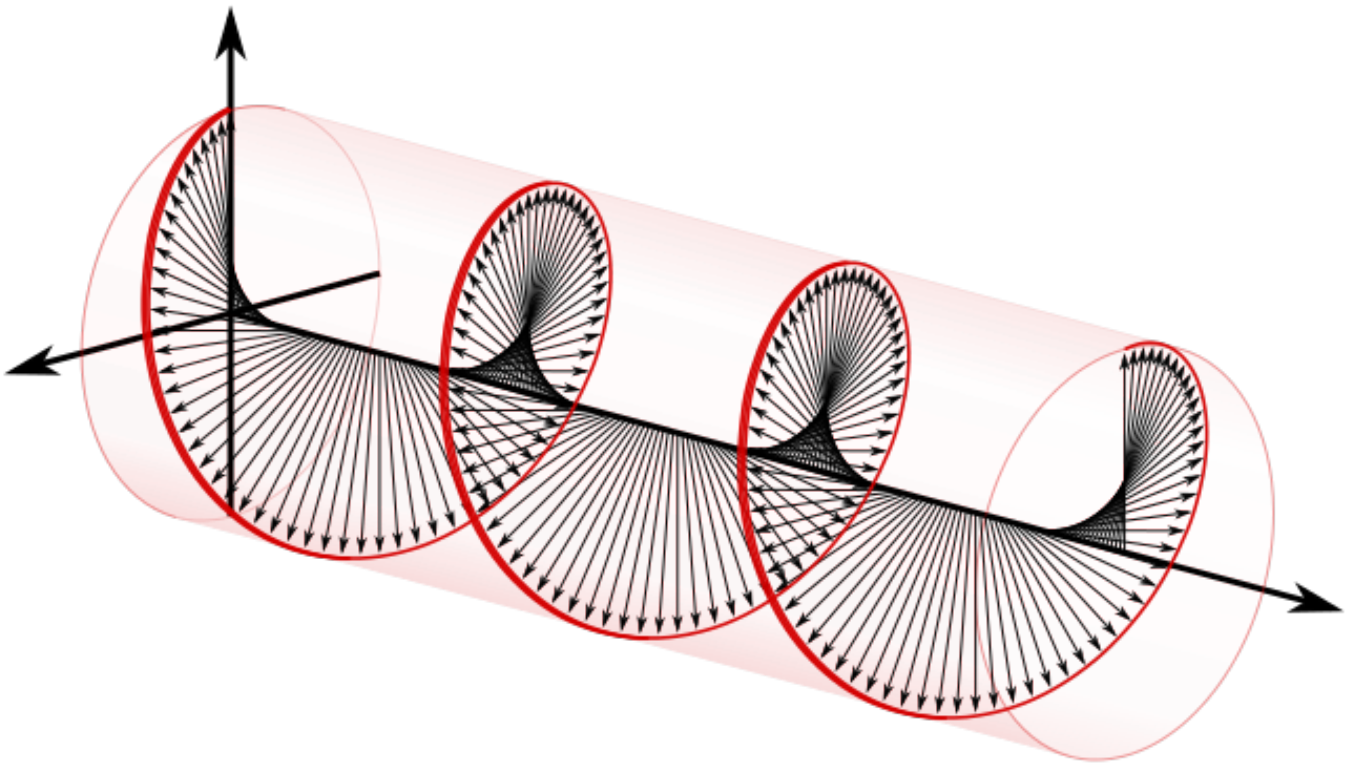
Basic elements of Stern-Gerlach Experiment



http://en.wikipedia.org/wiki/File:Stern-Gerlach_experiment.PNG

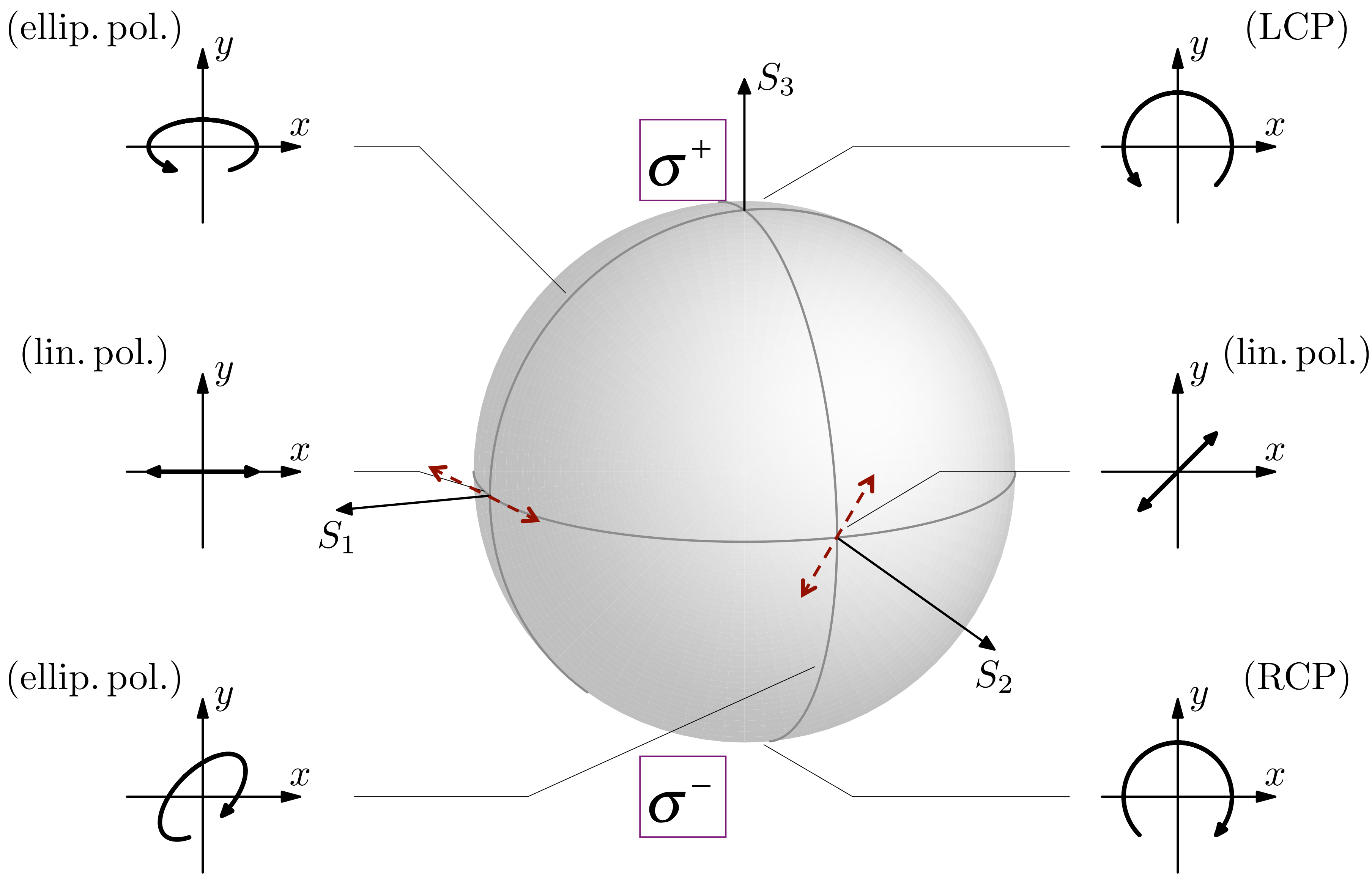
Circularly polarized light



http://en.wikipedia.org/wiki/File:Rising_circular.gif

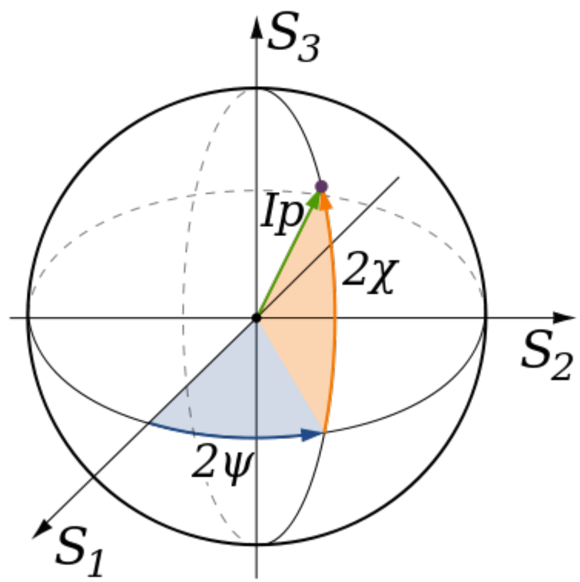
http://en.wikipedia.org/wiki/Circular_polarization

Stokes vectors and Poincare (Bloch) sphere



Spin & Polarization

Stokes parameters, Coherency matrix, Pauli matrices



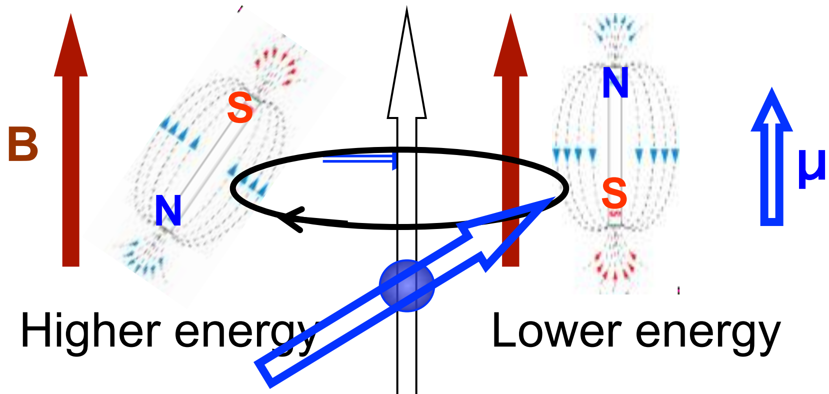
$$S_0 = I$$
$$S_1 = Ip\cos 2\psi \cos 2\chi$$
$$S_2 = Ip\sin 2\psi \cos 2\chi$$
$$S_3 = Ip\sin 2\chi$$

$$\mathbf{\Psi} = \frac{1}{2}\sum_{j=0}^{3} S_j \sigma_j, \text{ where}$$

$$\sigma_0 = \begin{bmatrix} 1 & 0 \\ 0 & 1 \end{bmatrix} \quad \sigma_1 = \begin{bmatrix} 1 & 0 \\ 0 & -1 \end{bmatrix}$$

$$\sigma_2 = \begin{bmatrix} 0 & 1 \\ 1 & 0 \end{bmatrix} \quad \sigma_3 = \begin{bmatrix} 0 & -i \\ i & 0 \end{bmatrix}$$

Nuclear Magnetic Resonance



$E_{mag} = -\mu\cdot B$

$t = \mu \times B$

$w = -g B$

$$g = \frac{\text{Magnetic dipole moment}}{\text{Spin angular momentum}}$$

electron

$g_e < 0$

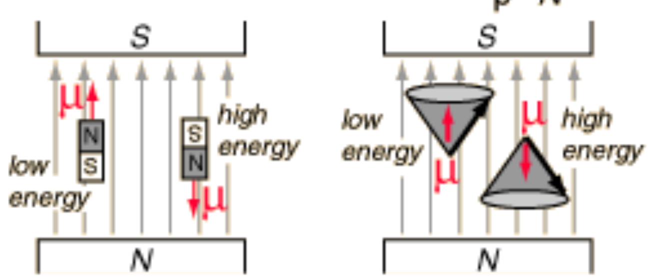
$m_e = g_e S$ ~58 meV/T

proton

$g_p > 0$

$m_p = g_p I$ ~32 neV/T

$\mu = g_p \mu_N$



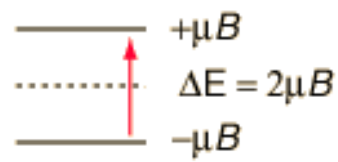
Bar magnet magnetic moment

Proton spin magnetic moment

$g = 2.79$

$\mu_N = 3.15x10^{-8} eV/T$

B=1Tesla



$\Delta E = 2\mu B = 2 g_p \mu_N B$

$\Delta E = 2\cdot 2.79 \cdot 3.15x10^{-8} eV/T \cdot 1T$

$\Delta E = 1.76x10^{-7} eV$

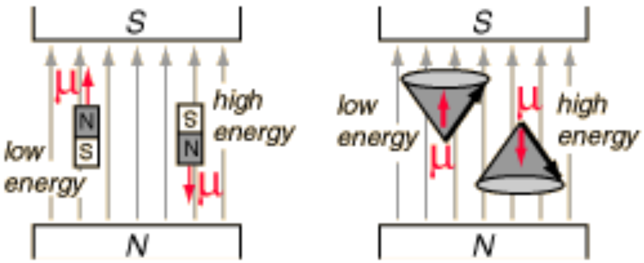
kT~25meV@300K

$$e^{\frac{-\Delta E}{kT}} \cong 1 - \frac{\Delta E}{kT} = 1 - \frac{1.76x10^{-7}}{0.04} = 1 - 4.4x10^{-6}$$

High filed
Low temperature
Paramagnetic ions

Nuclear spin and Hyperfine interaction

$\mu = g_p \mu_N$



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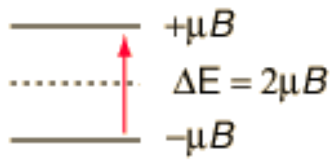

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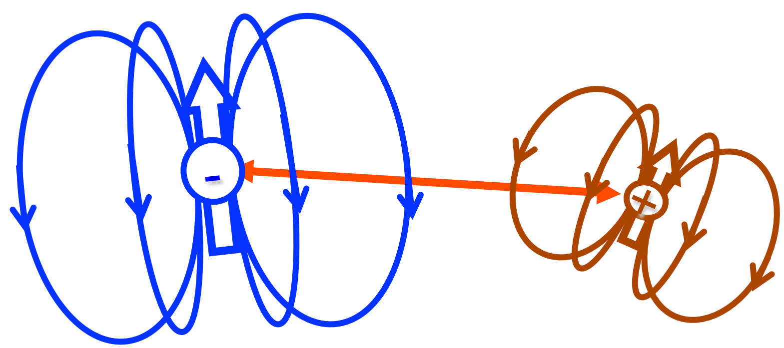
High filed
Low temperature
Paramagnetic ions

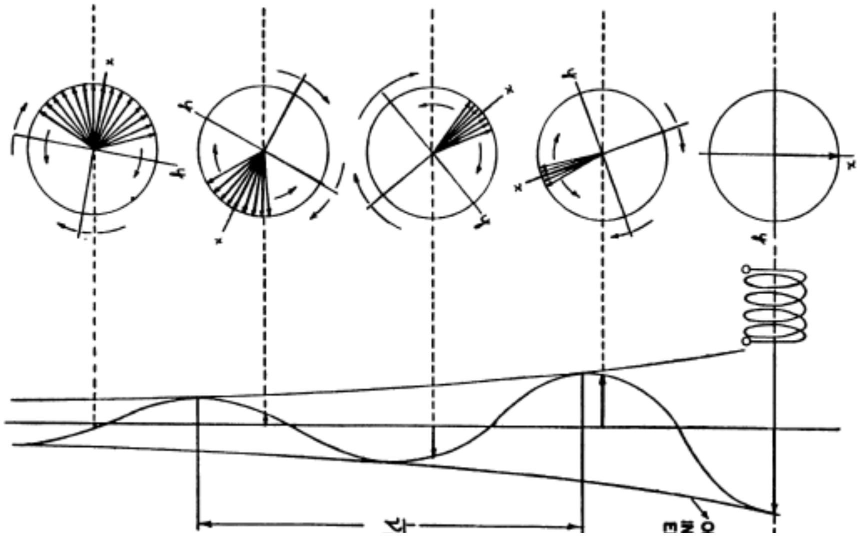
Isotope/Atom	^{85}Rb	^{87}Rb	^{23}Na
Natural abundance	72.2%	27.8	100
Nuclear spin	I=$^5/_2$	$^3/_2$	$^3/_2$
Magnetic moment	m_n =+1.35m_p	+2.75	+2.22

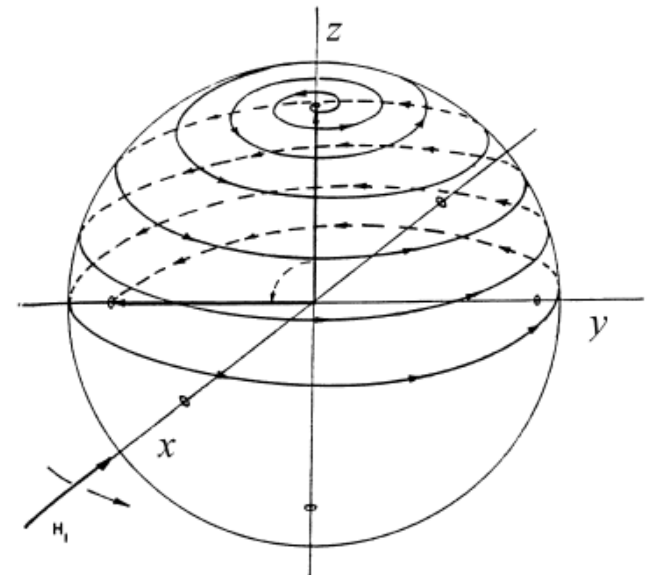
$m_e/m_p \tilde{} g_p/g_e \sim m_e/m_p \sim 10^3$

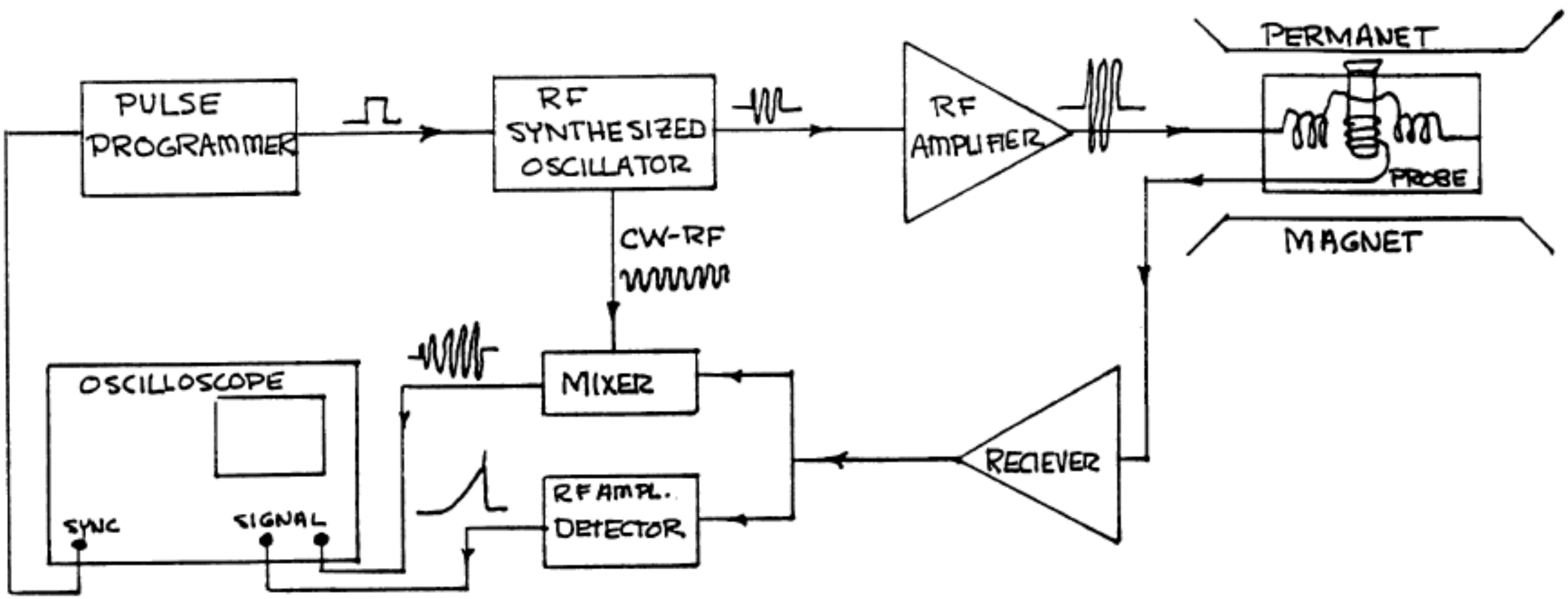


Hyperfine interaction

Pulse NMR Experiments







What is optical pumping?

$$\frac{n_1}{n_2} = exp^{\left(\frac{E_2 - E_1}{kT}\right)}$$

$$k = 8.62 \times 10^{-5} \text{ eV K}^{-1}$$

kT~0.03eV@300K
First excited state ~ 2e

The Boltzmann factor is therefore
which implies that only about one a
is in an excited state at any given m

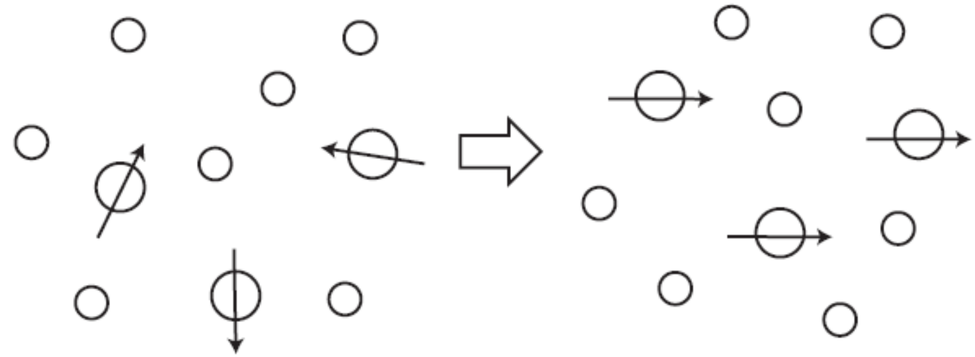


Figure 1: Optical pumping can be used to polarize a gas of atoms that have magnetic dipole moments. In practice, these atoms are often mixed with a nonpolar *buffer gas*, which helps keep the polarized atoms from touching with the walls of the container and losing their polarization.

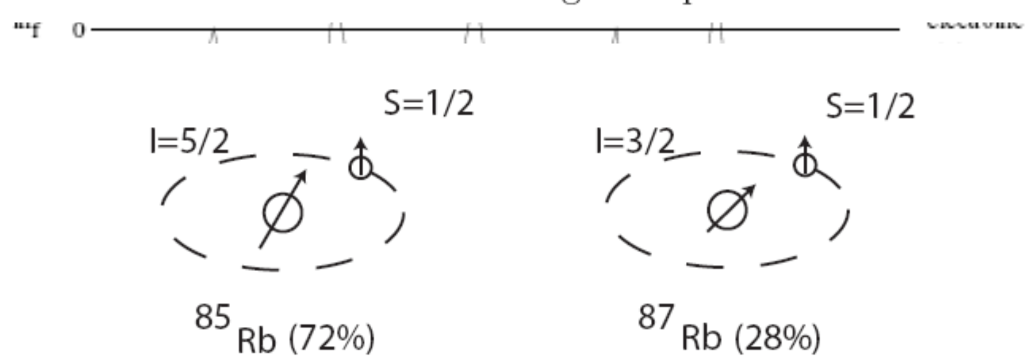


Figure 2: There are two commonly-occurring isotopes of Rubidium found in nature, ^{85}Rb and ^{87}Rb. Both have only one valence electron and can be approximated as one-electron atoms. The major difference between the isotopes is in the nuclear spin I.