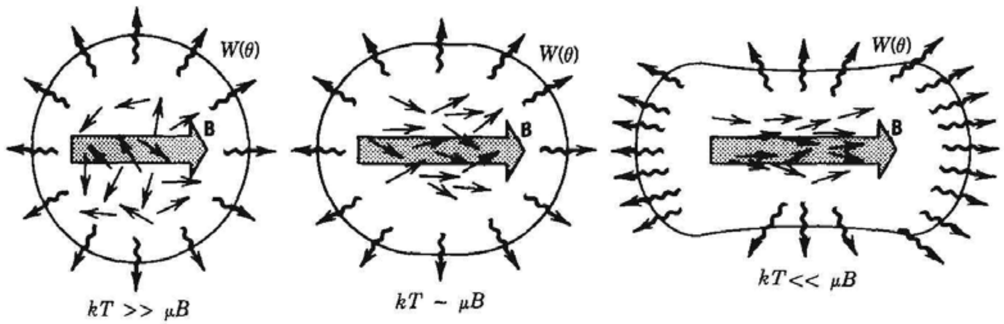
Nuclei with oriented spins show angular distribution of γ emission:



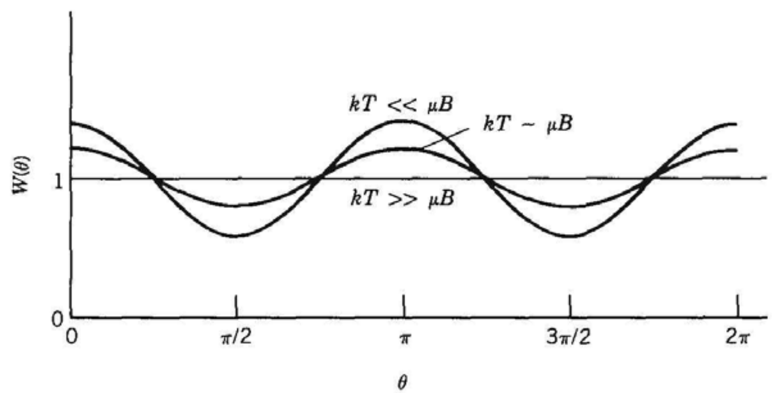


Figure 10.3 Angular distributions of nuclei with spins oriented at low temperatures. At top left is shown the distribution of radiation expected at high temperature; the magnetic field has essentially no effect in orienting the nuclear spins because of the thermal motion. At intermediate temperature (top center), the spins begin to align with the field, and the radiation distribution becomes nonuniform. At very low temperature, the spins are essentially completely aligned with the field. Measuring the angular distribution for dipole radiation would give the results shown at the bottom.

Transition probabilities for γ rays with various multipolarities

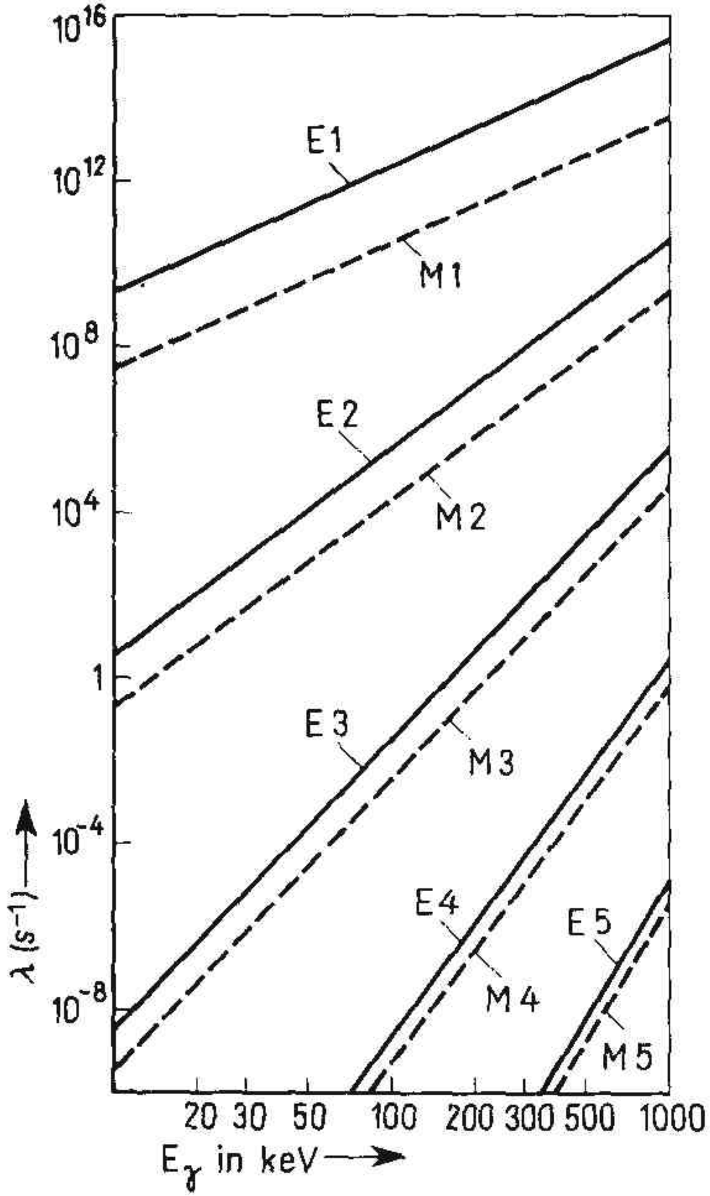
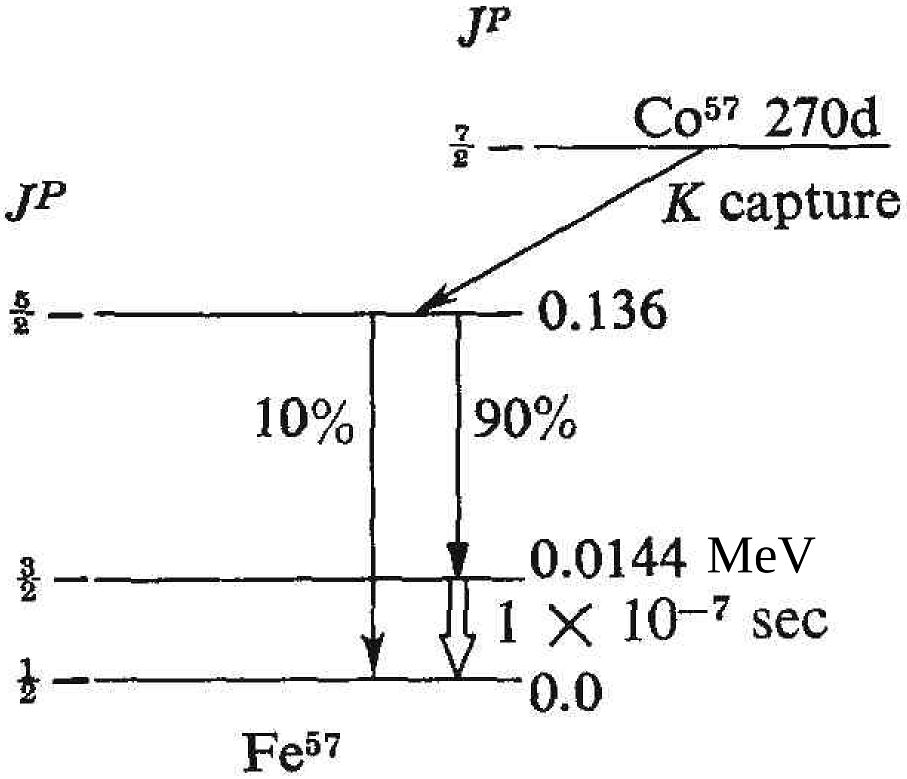


Fig. 38
Einteilchen γ-Übergangswahrscheinlichkeiten für verschiedene Multipolstrahlungen; nach [Mos 65]

Decay scheme of ^{57}Fe



$$\Gamma = \frac{1}{\tau} = 4.7 \cdot 10^{-9} eV$$

Small width and small probability of resonant γ absorption

Fraction of recoilless transitions

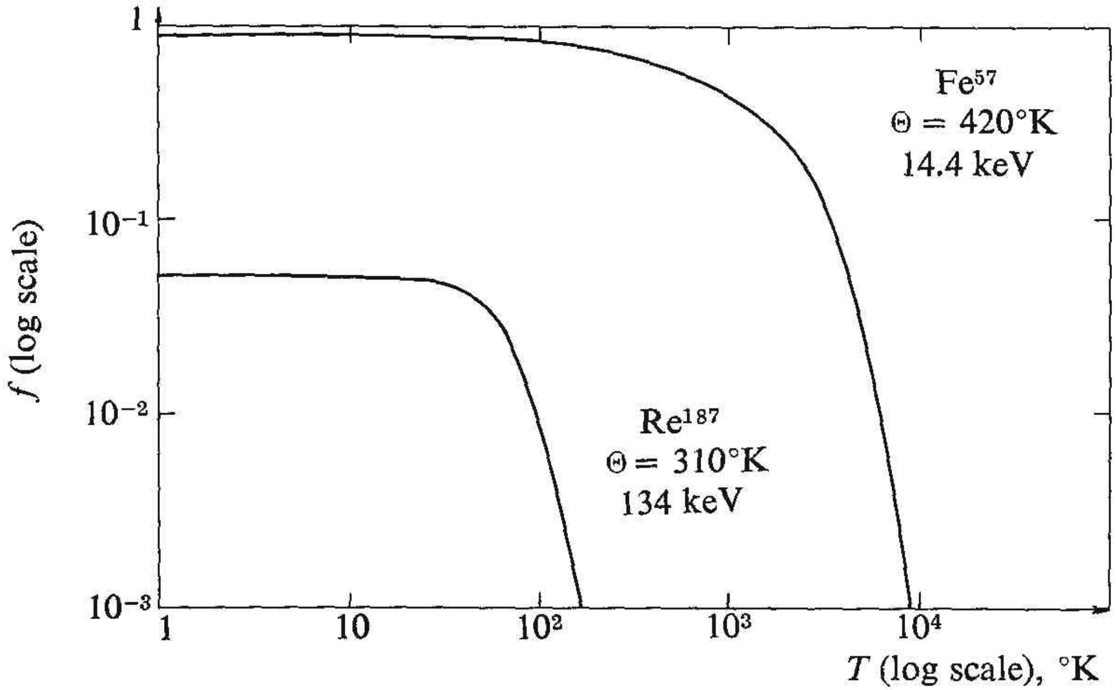


Figure 8-16 Fraction of recoilless transitions in iron or rhenium as a function of the temperature. [R. L. Mössbauer, *Ann. Rev. Nucl. Sci.*, **12**, 123 (1962).]

Debye-Waller Factor

$$f \approx \exp\left[-\frac{E_r}{k\theta}\left(\frac{3}{2}+\frac{\pi^2 T^2}{\theta^2}\right)\right]$$

$$\theta = \frac{\hbar\omega_{\max}}{k}$$

Mössbauer's original set-up

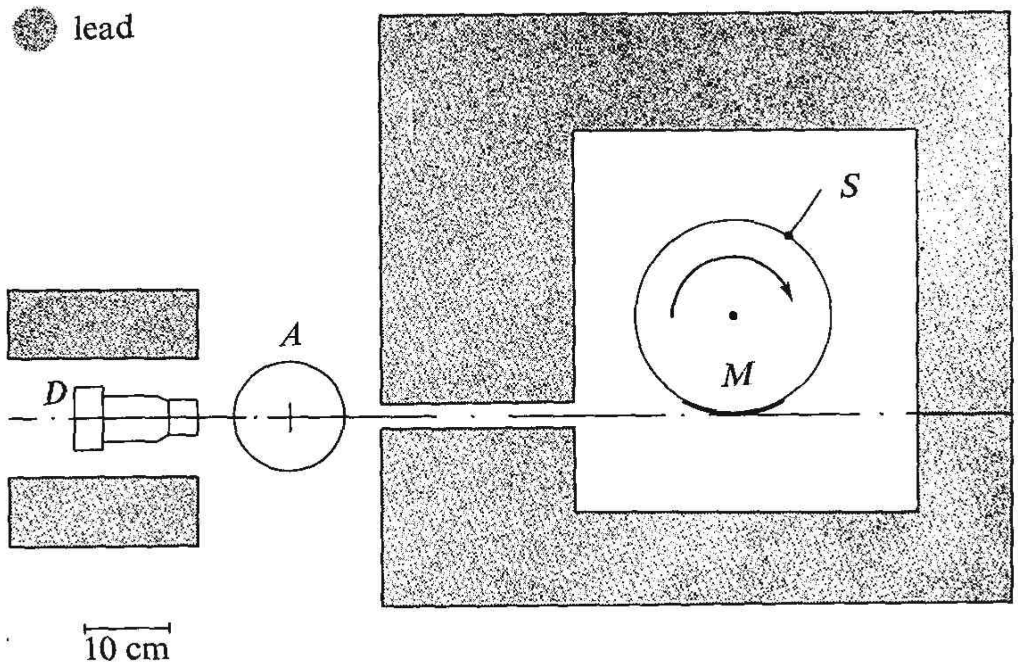


Figure 8-17 Experimental arrangement: *A*, cryostat of absorber; *S*, rotating cryostat with source; *D*, scintillation detector; *M*, region in which the source is seen from *D*. [R. L. Mössbauer, *Naturwiss.* **45,** 538 (1958).]

First observation of Mössbauer effect in ^{191}Ir

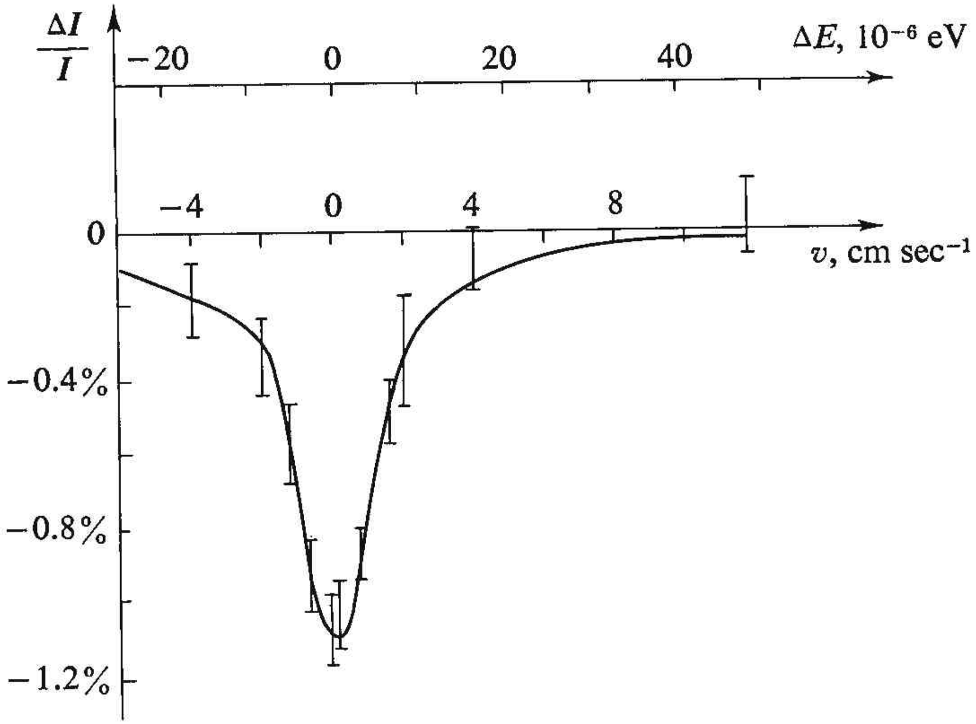
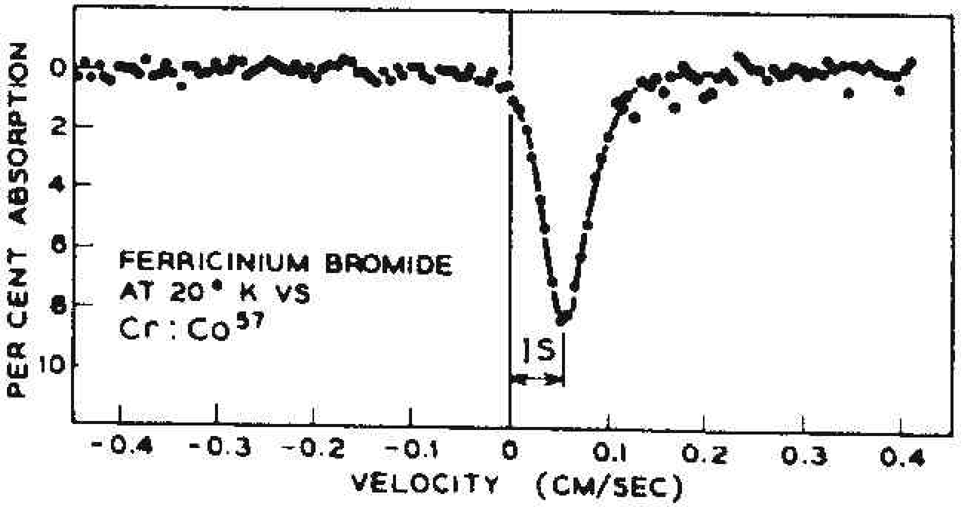
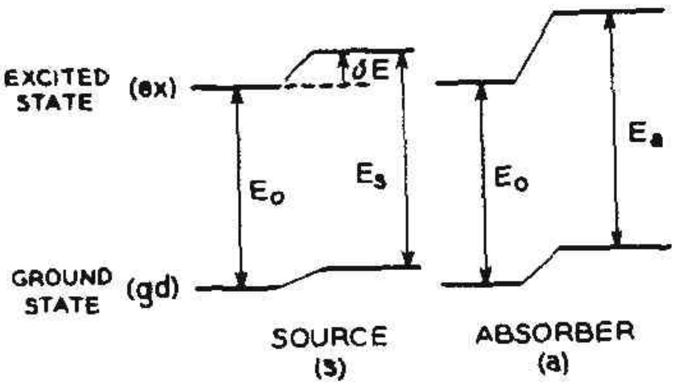


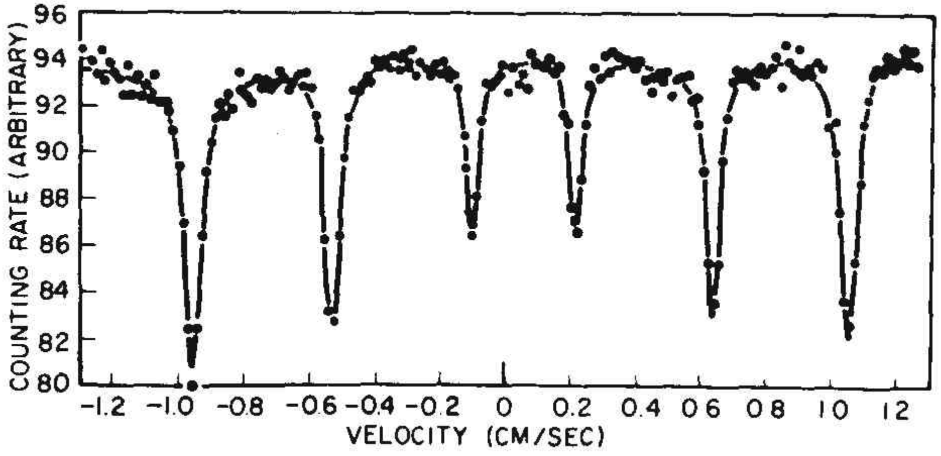
Figure 8-18 Fluorescent absorption in Ir^{191} as a function of the relative velocity between source and absorber. The upper scale on the abscissa shows the Doppler energy that corresponds to the velocity on the lower scale. $T = 88°K$. [R. L. Mössbauer, *Naturwiss.*, **45**, 538 (1958).]

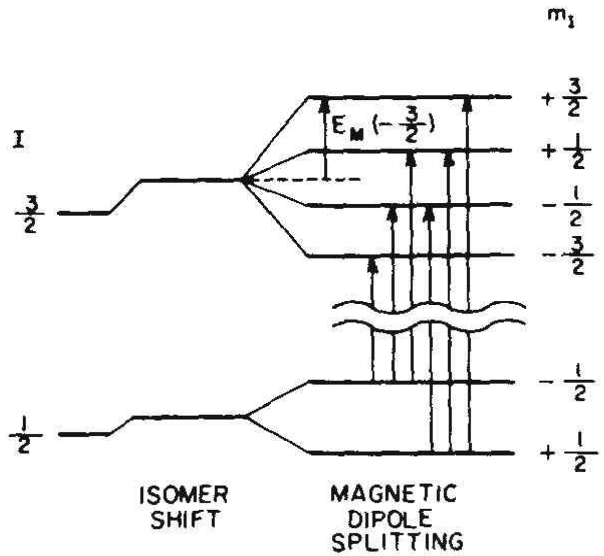
Isomer shift



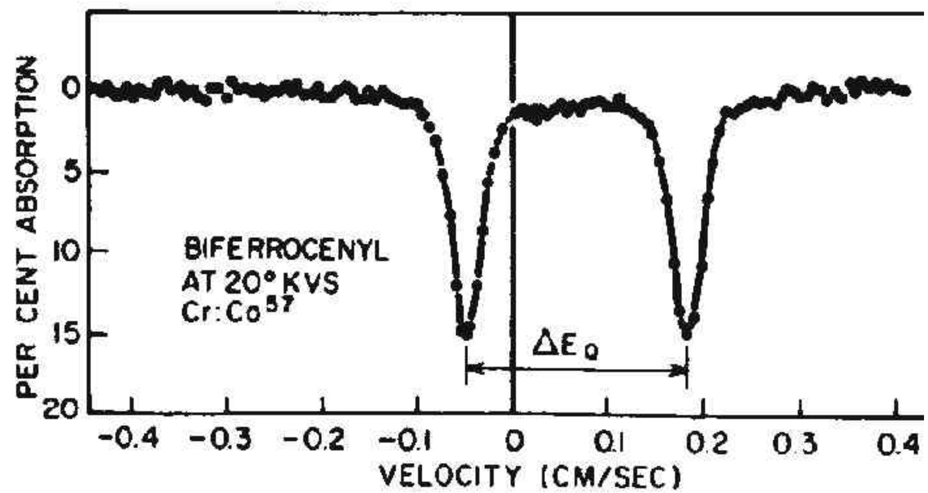


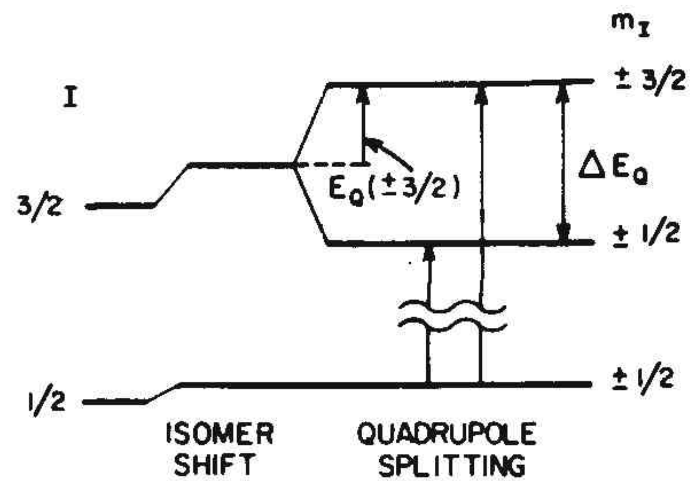
Magnetic dipole splitting





Electric quadrupole hyperfine splitting





$$E_Q(m_I) = eqQ\left[\frac{3m_I^2 - I(I+1)}{4I(2I-1)}\right]$$

$$\Delta E_Q = E_Q(3/2) - E_Q(1/2) = \frac{eqQ}{2}$$

Gravitational red shift experiment

$$\frac{\Delta E_\gamma}{E_\gamma} = \frac{gh}{c^2}$$

^{57}Fe, 14.4 keV photons,
h= 22.5 m --> DE/E=2 10^{-15}