# NEUTRON CROSS SECTIONS

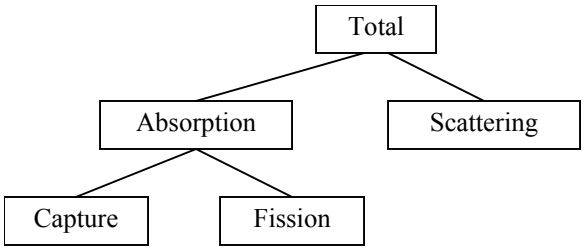
Cross Sections

The *microscopic cross section* (σ) is a property of a given nuclide; σ is the probability per nucleus that a neutron in the beam will interact with the nucleus; this probability is expressed in terms of an equivalent area that the neutron "sees." The *macroscopic cross section* (Σ) takes into account the number of those nuclides present

$$\Sigma = N\,\sigma \quad [\mathrm{cm}^{-1}] \tag{1}$$

The mean free path is $mfp = \lambda = 1/\Sigma$. The microscopic cross section is measured in units of barns (b): 1 barn equals $10^{-24}$ cm$^2$ = $10^{-28}$ m$^2$.

Cross Section Hierarchy




$$\begin{aligned} \sigma_t &= \sigma_s + \sigma_a = \sigma_s + (\sigma_c + \sigma_f) \qquad \text{where } \sigma_c \approx \sigma_\gamma \\ \Sigma_t &= \Sigma_s + \Sigma_a = \Sigma_s + (\Sigma_c + \Sigma_f) \end{aligned} \tag{2}$$

For mixtures of isotopes and elements, the Σ's add. For example

$$\begin{aligned} \Sigma_a^{H_2O} &= \Sigma_a^H + \Sigma_a^O = N_H\,\sigma_a^H + N_O\,\sigma_a^O \\ &= 2\,N_{H_2O}\,\sigma_a^H + N_{H_2O}\,\sigma_a^O = N_{H_2O}\,(2\sigma_a^H + \sigma_a^O) \end{aligned} \tag{3}$$

1/*v* Law

For very low neutron energies, many absorption cross sections are 1/*v* due to the fact the nuclear force between the target nucleus and the neutron has a longer time to interact

$$\sigma_a \propto \frac{1}{v} \propto \frac{1}{\sqrt{E}} \propto \frac{1}{\sqrt{T}} \tag{4}$$

Energy dependence of cross sections

- $\sigma_s$ is independent of thermal energy (and temperature)
- $\sigma_a$ ($\sigma_f$ and $\sigma_c$) is energy dependent

$$\frac{\sigma_a(E)}{\sigma_{a0}} = \frac{v_0}{v(E)} = \sqrt{\frac{E_0}{E}} = \sqrt{\frac{T_0}{T}} \tag{5}$$