# Cross-sections

Given that I managed to make what was fundamentally a very simple concept incredibly confusing and state that the unit of macroscopic cross-section was inverse are rather than area, I thought I’d send a short explanation of cross sections and their relation to mean free paths and probabilities.

## Microscopic cross-sections

The microscopic cross-section is the effective area that a particle has for a given reaction. The normal unit for microscopic cross-sections is the barn where 1 barn = 10-24 cm2

A way to the think about the microscopic cross-section is as follows. If we consider a beam of neutrons coming from a source towards a target then:

$$σ=\frac{R}{IN}$$

Where R= Reaction rate density (reactions per cm^3 per second), *I* = is the average intensity of the beam of incoming neutrons (neutrons per cm^2 per second) and N is the number density (nuclei per cm^3). That is, the microscopic cross-section is the reaction rate density per unit beam intensity per nucleus in the target.

## Macroscopic cross-sections

The macroscopic cross-section is the sum of the microscopic cross-sections of all the individual particles in the target per unit volume:

$$Σ=σN$$

Where N is as defined before. So the macroscopic cross-section is the total equivalent area of all particles per unit volume that is, it has units of cm-1. This is related to the mean free path λ by:

$$λ=\frac{1}{Σ}$$

The mean free path is just the expected distance between two interactions.

## Relation to probabilities

The pdf for the flight distance, *s* is therefore:

$$f\left(s\right)=Σexp⁡(-Σs)$$

where we assume that there’s just one type of reaction, with cross-section $Σ$. The CDF of this is then:

$$F\left(s\right)=1-exp⁡(-Σs)$$

so we can generate distances travelled by choosing a number $ξϵ[0,1]$ then generate a distance *s* by:

$$s=-\frac{log⁡(1-ξ)}{Σ}$$