SCATTERING

The wavelength limits the resolution of microscopes.

- The wavelength of visible light is ~ 100 nm
  $100 \cdot 10^{-9}$ m
- X-rays have a wavelength of 2-4 nm
- Electron microscope < 1 nm

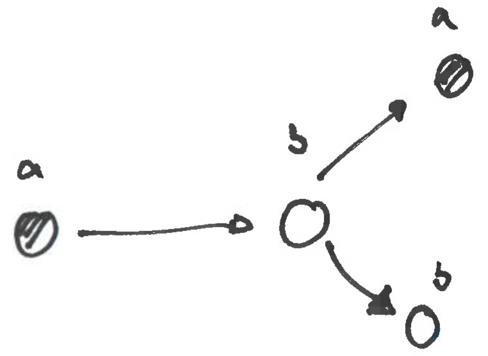
de Broglie wavelength $\boxed{\lambda = \frac{h}{p}}$

$p = m_e v$

The higher the momentum, the smaller the wavelength.

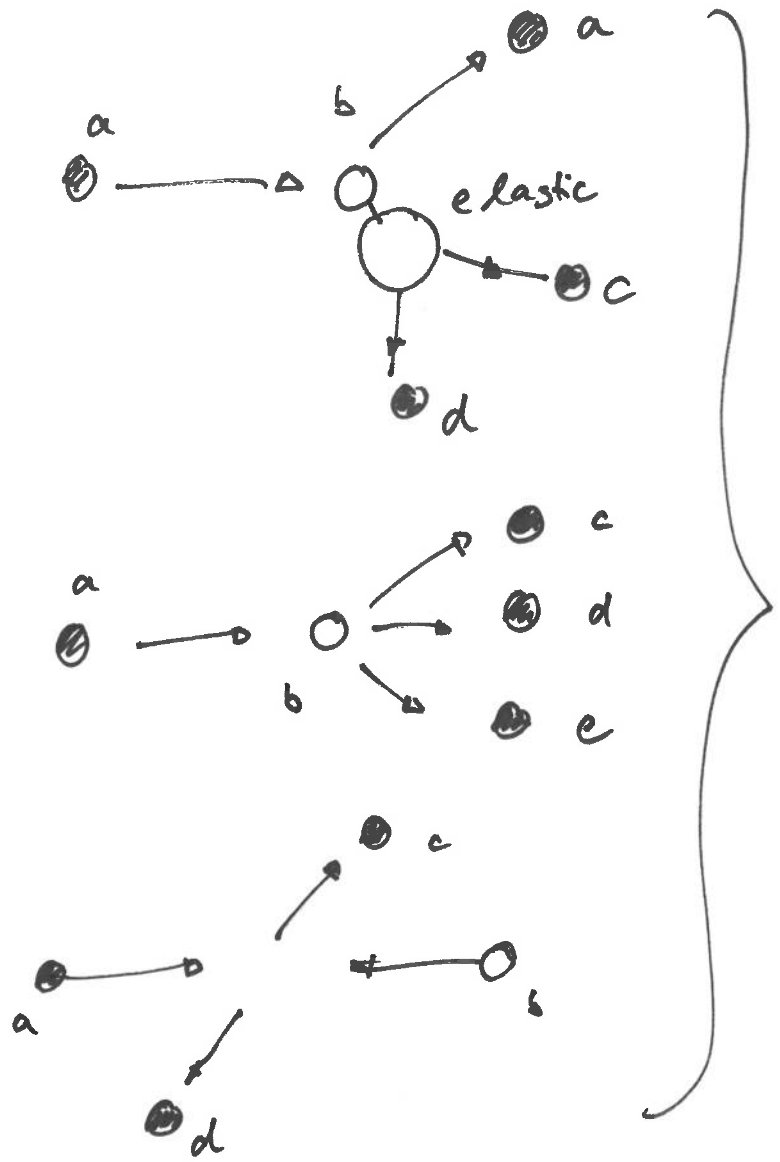
The larger p, the deeper we can "see" inside the structure.

But for large p, the target system changes.
We distinguish



Elastic Scattering

The particles escape unscathed from the reaction, only energy and momentum change.



inelastic scattering

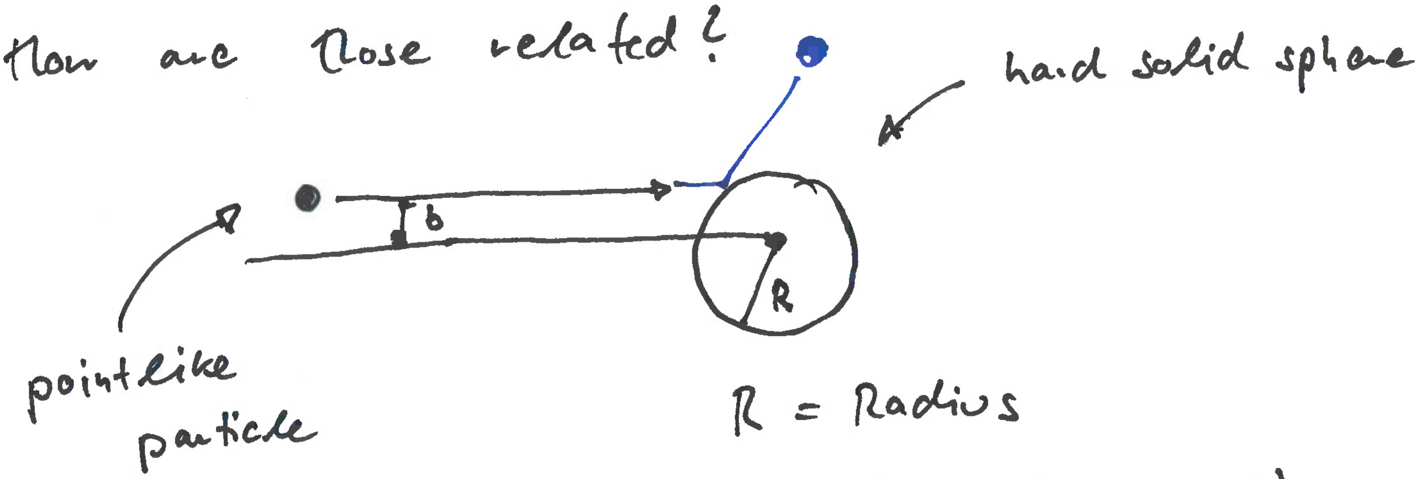
At least one particle is changed, destroyed or created

1. CROSS SECTION

There are 2 meanings to the term cross section

- The cross section is the area transverse to the relative motion within 2 particles must meet to scatter from each other
- The cross section is a measure of the probability that a specific process will take place in the collision of 2 particles

How are those related?

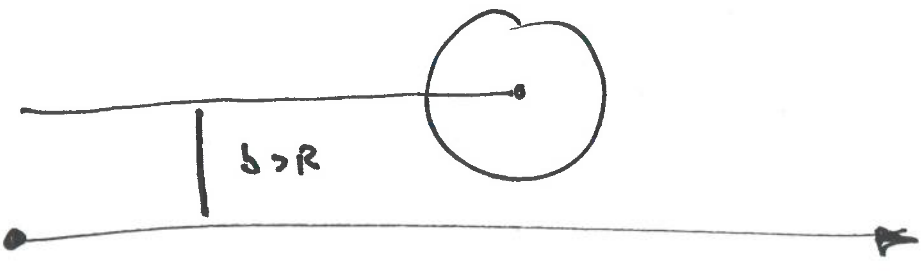


R = Radius

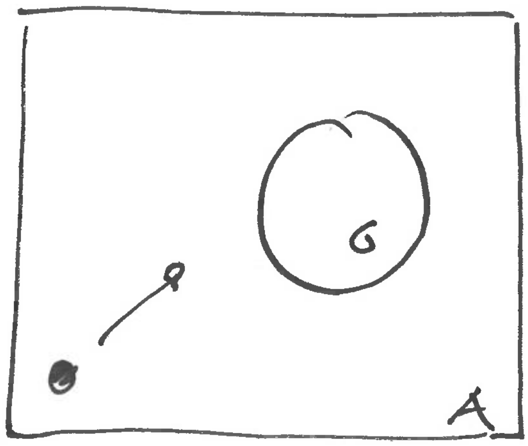
b = impact parameter

If $b > R$ we do not expect scattering

If $b \leq R$ we do expect scattering



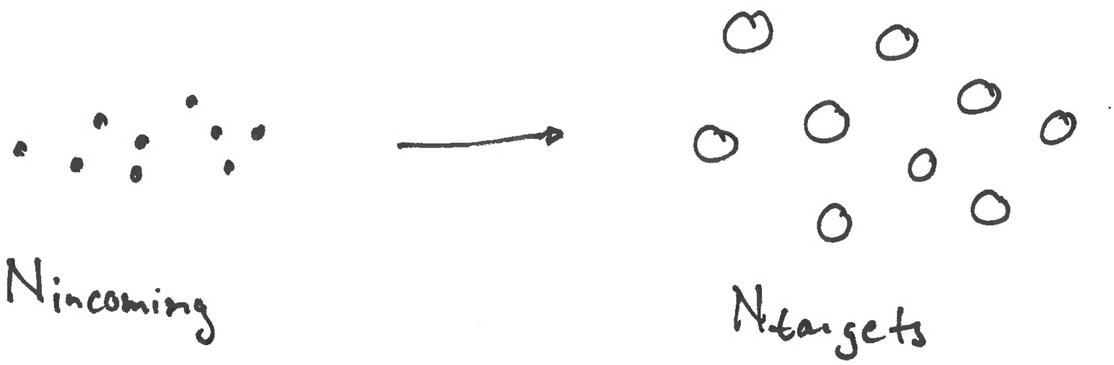
The probability to hit the sphere if the projectile moves randomly through an area A is given by

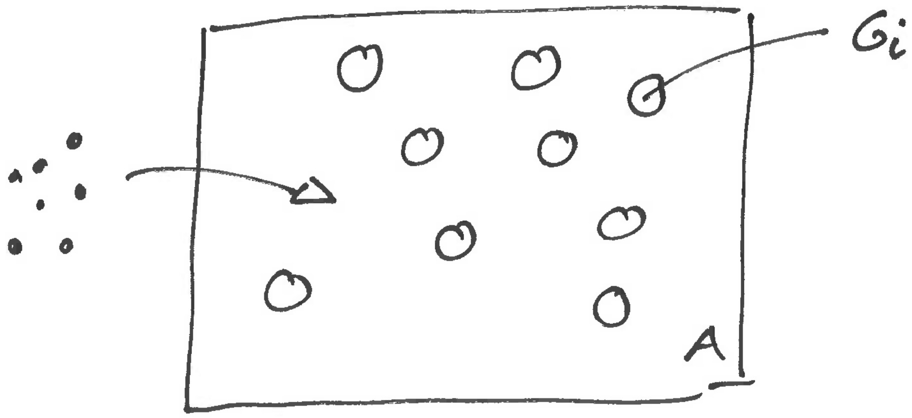


$$P = \frac{G}{A}$$

where $G = \pi R^2$ is blocked out from the point of view of the particle.

In a more realistic scenario we do not have a single projectile or a single target. We generalise:





The probability for each projectile to scatter from any target is

$$P = N_{target}\,\frac{\sigma_i}{A}$$

$$\frac{N_{scattered}}{t} = \frac{N_{incoming}}{t}\,P = \frac{N_{incoming}}{t}\,\frac{N_{target}}{A}\,\sigma_i$$

$$\frac{dN_{scattered}}{dt} = N_{incoming}\,\frac{N_{target}}{V}\,\underbrace{\frac{ds}{dt}}_{V_{incoming}}\,\sigma_i \equiv \mathcal{L}\,\sigma_i$$

where we have defined the luminosity

$$\mathcal{L} \equiv N_{incoming}\,\frac{N_{target}}{V}\,V_{incoming}$$

which only contains exp. specified quantities, whereas the cross section can be theoretically predicted.

Since

$$[\sigma_i] = m^2$$

$$[\mathcal{L}] = \frac{1}{m^2\,s}$$

The integrated luminosity

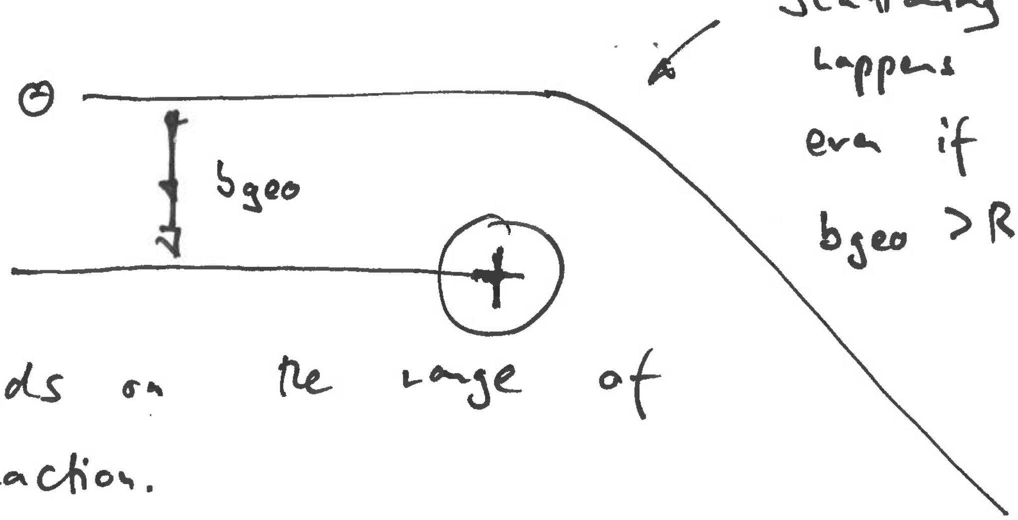
$$L = \int \mathcal{L}\,dt \qquad [L] = \frac{1}{m^2}$$

Since the size of a nucleus is 1 - 10 fm.
(fm = 10^{-15} m). Cross sections are measured in
barns

$$(10\,\text{fm})^2 = 10^{-28}\,\text{m}^2 = 1\,\text{b}$$

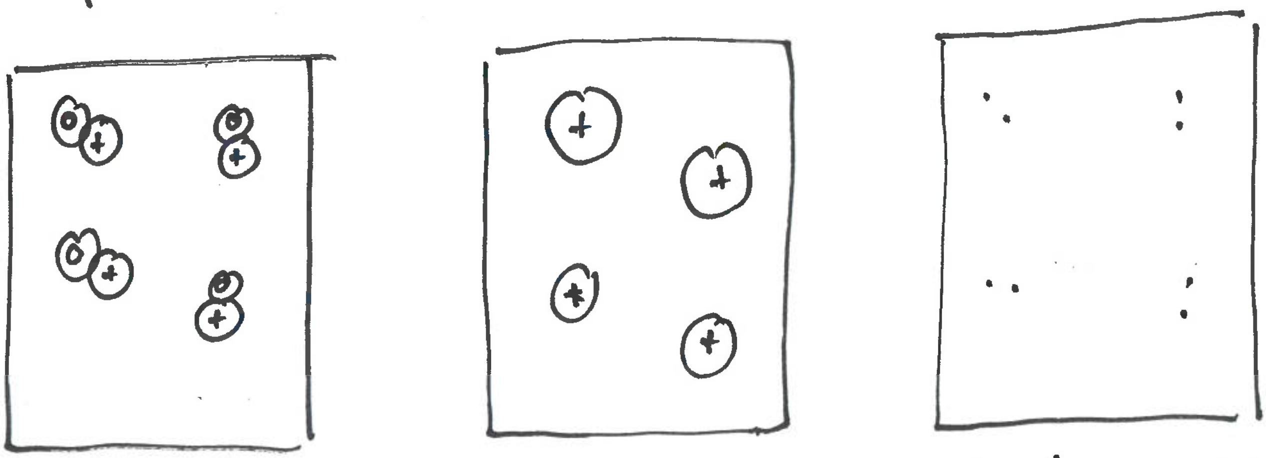
Here we have neglected several factors:

- the incoming particle also has an area σ_j
- the cross-section may depend on the energy E
- the effective cross-section is not equal to the geometric cross-section.



It depends on the range of the interaction.

Example:



Deuterium target

e^- beam

ν beam

In a realistic experiment it is impossible to measure the cross-section