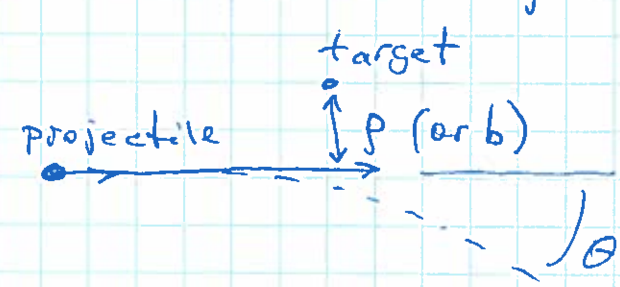
L23 # Collision Theory

* collision (scattering) experiments – main tool in particle physics.
  - Rutherford's experiment – scattering of α-particles on gold: confirmed nuclear model of the atom
  - scattering of high energy electrons on protons (p) – discovered the structure of a proton → quarks & gluons
  - colliding beams of electrons and protons all recent modern experiments:
    - LHC @ CERN, Belle @ Japan, SLAC, etc.

* other types of collision experiments.
  - collision of two billiard balls.
  - comet scattered by the Sun.
  - collision of two neutron stars & black holes.

Collision Theory: conserned with statistical description of interaction of many projetiles and targets, rather than with a single projectile & target.

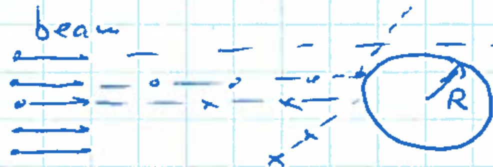


* Impact parameter.
* scattering angle
  - large ρ → θ small
  - small ρ – θ large (up to $\theta = \pi$) head on collisio

particle experiments:
θ – easy to measure
ρ – never measure

L23 Cross Section.

- single collision: little we can say, unless ρ is known (but we never know it)
  - need many collisions to investigate the nature of the projectile, target and their interaction.



- usually use multiple targets ~~too~~

- if target has radius $r \to \sigma = \pi r^2$ its area (cross section) (but only for contact interaction like between 2 billiard balls)

if our target assembly of area A contains nA targets with cross-section σ the total area is $nA\sigma$ where n is the density of targets per unit area.

for a point-like projectile the probability to hit a target is $p = \frac{nA\sigma}{A} = n\sigma$

for N_p incident projectiles $N_s = N_p \sigma n$ are scattered. Since we can measure N_p, N_s and n it gives us σ - effective area of interaction between projectile & target or cross-section $\to$ measured in barns $1b = 10^{-28} m^2$

- rates. $R_p = \frac{N_p}{\Delta t}$ $\quad R_s = \frac{N_s}{\Delta t}$ $\quad R_s = R_p n \sigma$

Example 14.2 $\quad 10^5\ n \to ||_{0.1mm}$ $\quad \rho = 2.7 g/cm^3$

1a.m. $= 1.66 \cdot 10^{-27} kg$. $\quad$ Atomic mass 27

$$n = \frac{\rho t}{m} = \frac{2700\ kg/m^3\ 10^{-4} m}{27 \cdot 1.66 \cdot 10^{-27} kg} = 6 \cdot 10^{24} m^{-2} \qquad \sigma = 1.5\ b.$$

$$N_s = N_p n \sigma = 10^5 \cdot 6 \cdot 10^{24} \cdot 1.5\ 10^{-28} = 90$$