Lecture 24: learning objectives

You will be able to define simple structural properties of nuclei.

You will be able to describe radioactivity using the decay rate, decay constant and half-life and identify and contrast the three types of radioactive processes.

You will be able to describe the medical consequences of radiation exposure and some applications of radioactivity.
Atomic nucleus

Atomic nucleus = protons + neutrons.

Proton — positive charge
Neutron — neutral (no charge)
Electron — negative charge

\[ M_p = M_n \sim 2000 \, M_e \]

\[ Z = \text{number of protons} \]
\[ A = \text{total number of nucleons} = Z + \text{number of neutrons} \]

\[ \text{Atomic symbol for isotopes with the given } Z \text{. Isotopes are nuclei with same } Z \text{ but different } A. \]
Types of nuclear decays

Three types of radiation when unstable nuclei decay:

1) Alpha (α) particles: Helium nuclei

\[
\frac{A}{Z}X \rightarrow \frac{A-4}{Z-2}Y + 4\text{He}
\]

2) Beta (β) particles: electrons or positrons (anti-electron)

\[
\frac{A}{Z}X \rightarrow \frac{A}{Z+1}Y + e^- + \bar{\nu}
\]
\[
\frac{A}{Z}X \rightarrow \frac{A}{Z-1}Y + e^+ + \nu
\]

3) Gamma (γ) rays: high energy photons (“particles” of light with zero mass)
Radiation

Alpha particles are easily stopped. Alpha particles outside of your body are no danger. They are stopped by your outer, dead layer of skin. Breathing in an alpha particle source is another matter.

Electrons and positrons are stopped by your skin.

Gamma rays and x-rays can travel through your body.
Decay rate, half life and all that

Decay rate:
Number of decays per second.

\[ R = \left| \frac{\Delta N}{\Delta t} \right| = \lambda N \]

\[ N(t) = N_0 e^{-\lambda t} \]

Decay constant:
The constant of proportionality relating the decay rate and number of nuclei.

Half life:
Time taken for half a given number of radioactive nuclei to decay.