Radiometric Quantities & Interaction Coefficients

Objective

To discuss about various radiometric quantities and associated concepts such as interaction coefficients (for example attenuation coefficients and cross section)

Content

- Radiation field
- Fluence (rate)
- Energy fluence (rate)
- Cross section and example curves
- Linear attenuation coefficient
- Mass attenuation coefficient
- Mass stopping power

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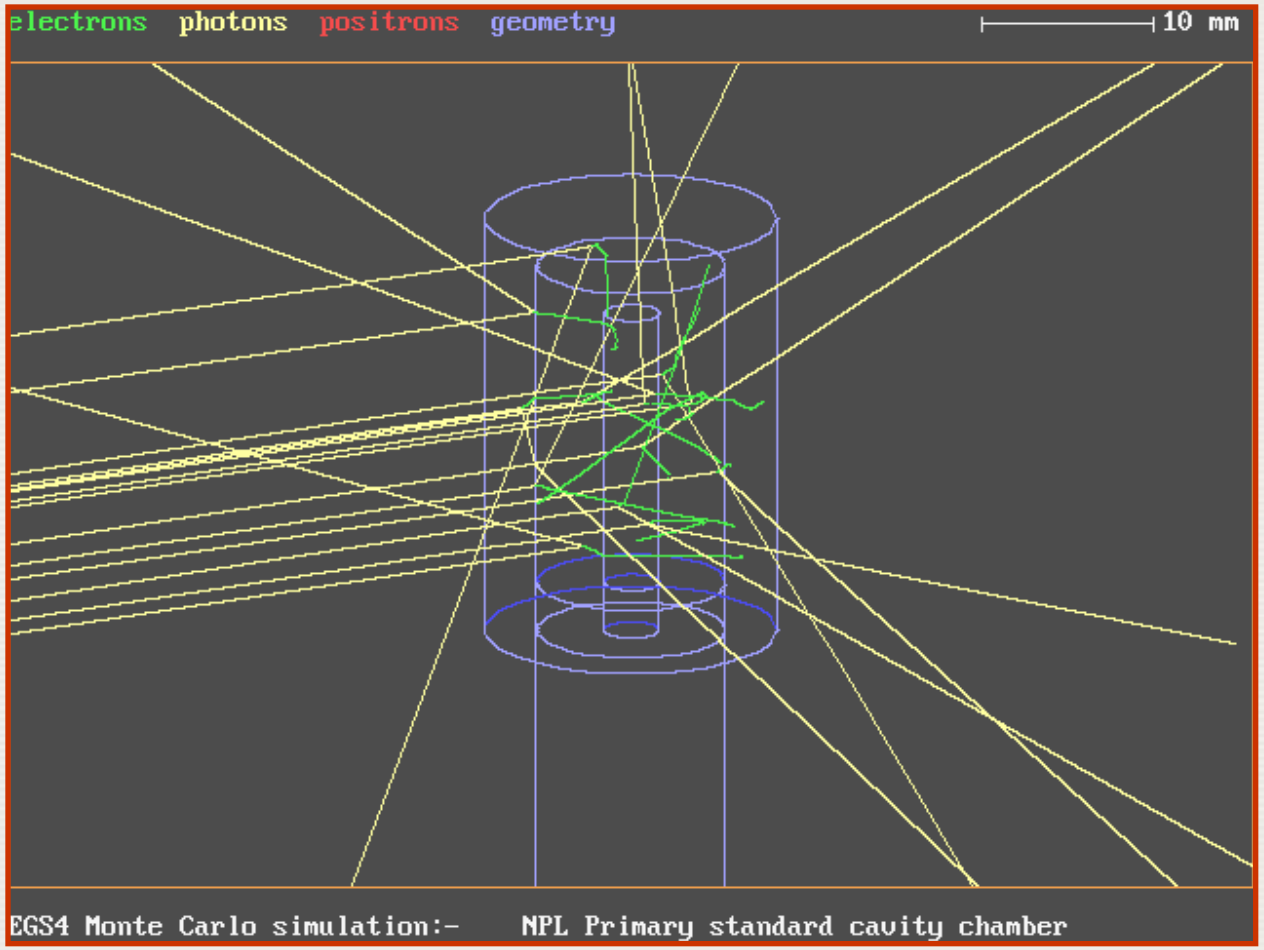
Radiation Field



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Fluence

Fluence, Φ, is the number of particles incident on a sphere of cross-sectional area dA

$$\Phi = \frac{dN}{dA}$$

Unit: m^{-2}

Fluence Rate

Fluence rate, is the number of particles incident on a sphere of cross-sectional area dA per unit time

$$\frac{d\Phi}{dt}$$

Unit: $m^{-2}\ s^{-1}$

Energy Fluence

Energy Fluence, Ψ, is total energy carried by the "rays" striking a infinitesimal sphere of area dA

$$\Psi = \frac{dR}{dA}$$

where $R = EN$, so $\Psi = E\Phi$

Unit: J m^{-2}

Energy Fluence Rate

Energy Fluence rate is the total energy carried by particles striking an infinitesimal sphere of cross-sectional area dA per unit time

$$\text{Energy fluence rate} = \frac{d\Phi}{dt}$$

Unit: J m^{-2} s^{-1}

Cross Section

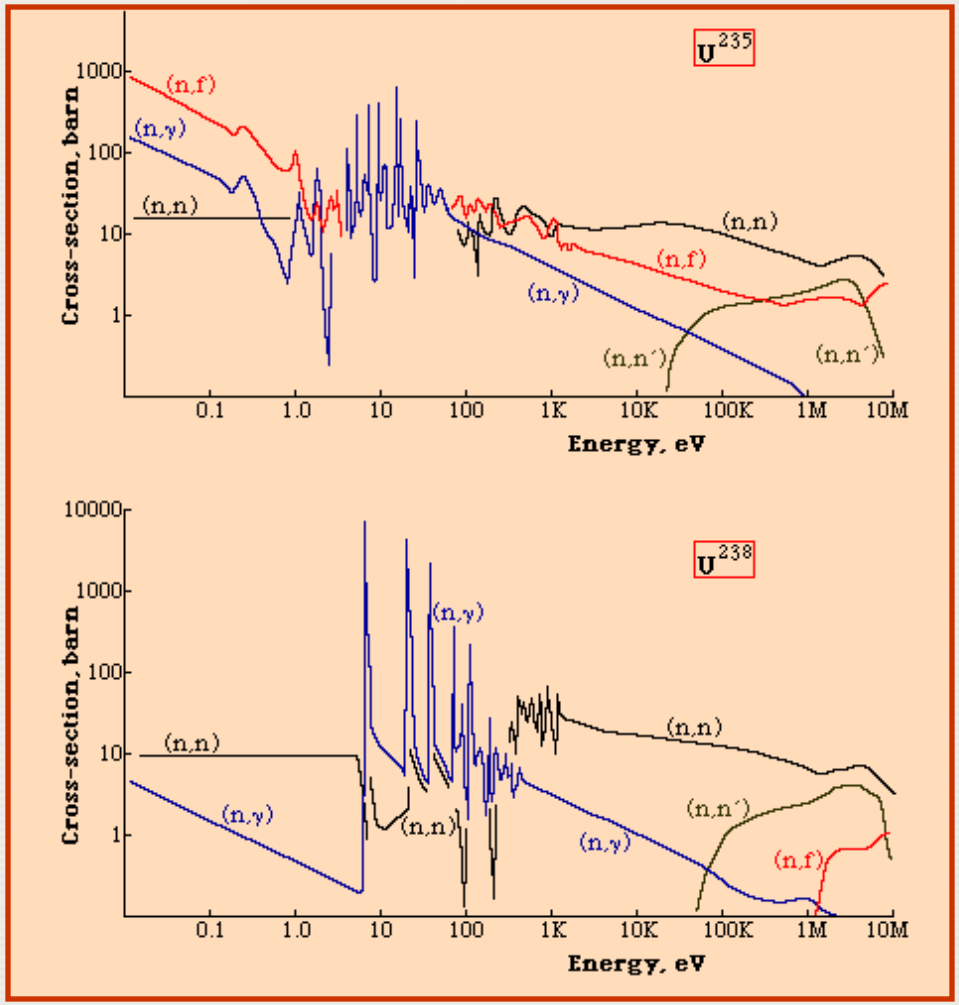
$$\sigma = \frac{R}{I}$$

where σ = cross section

R = number of reactions per unit time per nucleus

I = number of incident particles per unit time per unit area

Cross Sections for Neutron Capture in Uranium



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Attenuation Coefficients

There are two types of attenuation coefficients:

- **Linear Attenuation Coefficient (LAC) provides a measure of the fractional attenuation per unit length of material traversed**

- **Mass Attenuation Coefficient (MAC) provides a measure of the fractional attenuation per unit mass of material encountered**

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Mass Attenuation Coefficient

The relationship between LAC and MAC is:

LAC = MAC x density

$$\frac{1}{cm} = \frac{cm^2}{g} \times \frac{g}{cm^3}$$

Stopping Power

- The amount of energy deposited will be the sum of energy deposited from hard and soft collisions
- The "stopping power," S, is the sum of energy deposited for soft and hard collisions
- Most of the energy deposited will be from soft collisions since it is less likely that a particle will interact with the nucleus

Stopping Power

- The stopping power is a function of the charge of the particle, the energy of the particle, and the material in which the charged particle interacts

Summary

- Radiometric quantities and interaction coefficients were discussed
- participants learned about a radiation field, fluence (rate), energy fluence (rate), fluence differential in energy, cross section, mass attenuation coefficient, and mass stopping power

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Where to Get More Information

- **Cember, H., Johnson, T. E, Introduction to Health Physics, 4th Edition, McGraw-Hill, New York (2009)**

- **International Atomic Energy Agency, Postgraduate Educational Course in Radiation Protection and the Safety of Radiation Sources (PGEC), Training Course Series 18, IAEA, Vienna (2002)**

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