

Problem Set I

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1 Proton Number, Neutron Number, Mass Number

Nuclei	Z	N	A	Applications
Carbon-14	6	8	14	Radio-dating up to 50,000 years
Phosphorus-32	15	17	32	Radio-tagging DNA segments metabolic Pathway Tracing
Cobalt-60	27	33	60	Hard Gamma Emitter Sterilize Medical Equipment My favorite isotope
Technetium-99	43	56	99	Meta-Stable (^{99m}Tc) used widely for medical imaging
Lead-208	82	126	208	Ratio of Pb-208:Pb-204 used to determine past presence Radio-Nuclides: Uranium/Thorium/Plutonium.
Radium-226	88	138	226	Daughter of ^{238}U Decay A Leading Cause of Lung Cancer
Uranium-235	92	143	235	Naturally in Uranium Ore 0.72% When Enriched to a high percent of Uranium Can be used on Nuclear Power Plants Or Nuclear Weapon

Reaction	Z	N	Pos
$^{226}\text{Ra} \rightarrow ^{222}\text{Rn} + \alpha$	$88 = 86 + 2$	$138 = 136 + 2$	Yes
$^{235}\text{U} + n \rightarrow ^{138}\text{Xe} + ^{94}\text{Sr} + 4n$	$92 + 1 \neq 54 + 38 + 0$	$143 + 0 \neq 84 + 56 + 4$	No
$^{239}\text{Pu} \rightarrow ^{140}\text{Cs} + ^{98}\text{Zr} + n$	$94 \neq 55 + 40 + 1$	$145 \neq 85 + 58 + 1$	No

2 Cyclotron

Given: $p = 200\text{MeV}$, $m = 938\text{MeV}$, $\Delta T = 100\text{KV}$, $k = e$

$$E^2 = p^2 + m^2 \quad (1)$$

$$T = E - m \quad (2)$$

$$T = \sqrt{p^2 + m^2} - m \quad (3)$$

$$T = \sqrt{(200\text{MeV})^2 + (938\text{MeV})^2} - 938\text{MeV} = 21.1\text{MeV} \quad (4)$$

$$T = kn\Delta T \quad (5)$$

$$n = \frac{T}{k\Delta T} \frac{21.1\text{MeV}}{e * 100\text{KV}} = 211 \quad (6)$$

211 Revolutions

3 Cross section of a Disk

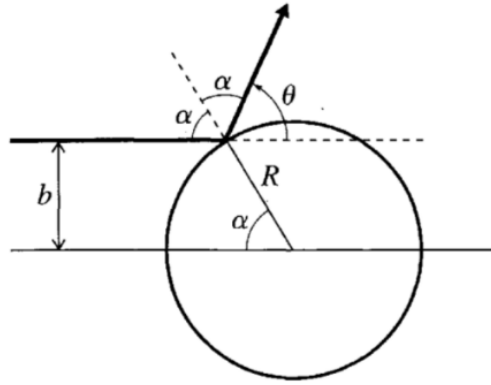


Figure 1: Credit to <http://web.physics.ucsb.edu/~fratus/phys103/LN/Scattering.pdf> for image.

A particle traveling towards a disk of radius R . Travelling parallel to an axis passing through the center of the disk. At a distance b from the axis.

$$b = R \sin \alpha \quad (7)$$

$$\Theta = \pi - 2\alpha \quad (8)$$

$$\alpha = \frac{\pi - \Theta}{2} \quad (9)$$

$$b = R \sin \frac{\pi - \Theta}{2} \quad (10)$$

$$\frac{db}{d\Theta} = -\frac{R}{2} \sin \frac{\Theta}{2} \quad (11)$$

$$\int_{-2\pi}^0 -\frac{R}{2} \sin \frac{\Theta}{2} = 2R \quad (12)$$

This means that for the entire scattering range, b must cover the whole range of $(-R, R)$. Or that the target size is equal to the Length $2R$.

4 Spherical Cross Section

We can plug equation (10) into $d\sigma = b \cdot db \cdot d\alpha$ to get:

$$d\sigma = R \sin \frac{\pi - \Theta}{2} \cdot db \cdot d\phi \quad (13)$$

$$\oint d\sigma = \int_0^{2\pi} \int_0^R R \sin \frac{\pi - \Theta}{2} \cdot db \cdot d\phi \quad (14)$$

$$\sigma = 2\pi R^2 \sin \frac{\pi - \Theta}{2} \quad (15)$$

$$\frac{d\sigma}{d\Theta} = \pi R^2 \sin \frac{\Theta}{2} \quad (16)$$

$$\oint \frac{d\sigma}{d\Theta} = \int_{\pi}^0 -\pi R^2 \sin \frac{\Theta}{2} d\Theta \quad (17)$$

$$\sigma = \pi R^2 \quad (18)$$

Therefore the apparent cross-section of a sphere is the area of the circle cast by it.