# Homework for Chapter 1

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**1. 若卢瑟福散射用的 $\alpha$ 粒子是放射性物质镭 C′ 放射的，其动能为 $7.68\times10^6$ 电子伏特．散射物质是原子序数 $Z=79$ 的金箔．试问散射角 $\theta=150^\circ$ 所对应的瞄准距离 $b$ 多大？**

From Rutherford's scattering

$$C=\frac{Ze^2}{2\pi\varepsilon_0}$$

$$\cot\frac{\theta}{2}=\frac{2E_0b}{C}$$

So that

$$b=\frac{1}{2E_0}\frac{Ze^2}{2\pi\varepsilon_0}\cot\frac{\theta}{2}=3.97\times10^{-15}\ \mathrm{m}$$

**2. 已知散射角为 $\theta$ 的 $\alpha$ 粒子与散射核的最短距离为**

$$r_m=\left(\frac{1}{4\pi\varepsilon_0}\right)\frac{2Ze^2}{MV^2}\left(1+\frac{1}{\sin\frac{\theta}{2}}\right).$$

**试问上题 $\alpha$ 粒子与散射的金原子核之间的最短距离 $r_m$ 多大？**

$$r_m=\left(\frac{1}{4\pi\varepsilon_0}\right)\frac{2Ze^2}{2E_0}\left(1+\frac{1}{\sin\frac{\theta}{2}}\right)=3.01\times10^{-14}\ \mathrm{m}$$

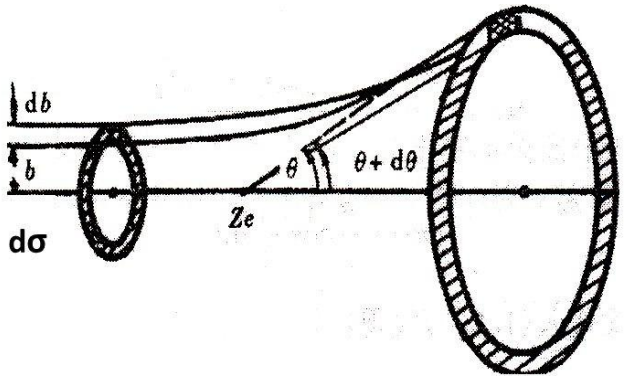
**4. 钋放射的一种 $\alpha$ 粒子的速度为 $1.597\times10^7$ 米/秒，正面垂直入射于厚度为 $10^{-7}$ 米、密度为 $1.932\times10^4$ 公斤/米$^3$ 的金箔．试求所有散射在 $\theta>90^\circ$ 的 $\alpha$ 粒子占全部入射粒子的百分比．已知金的原子量为 197．**

What we have already known is:

$$b = \frac{1}{2E_0}\frac{Ze^2}{2\pi\varepsilon_0}\cot\frac{\theta}{2}$$

We take the derivative

$$\mathrm{d}b = \frac{1}{2E_0}\frac{Ze^2}{2\pi\varepsilon_0}\frac{\cos\dfrac{\theta}{2}}{\sin^3\dfrac{\theta}{2}}\,\mathrm{d}\theta$$




$$\frac{\mathrm{d}n}{n} = Nt\,\mathrm{d}\sigma = Nt\cdot 2\pi b\,\mathrm{d}b = \frac{\rho N_A t}{Z}\pi\left(\frac{1}{4\pi\varepsilon_0}\right)^2\left(\frac{2Ze^2}{mv^2}\right)^2\frac{\cos\dfrac{\theta}{2}}{\sin^3\dfrac{\theta}{2}}\,\mathrm{d}\theta$$

$$\frac{\Delta n}{n} = \frac{\rho N_A t}{Z}\pi\left(\frac{1}{4\pi\varepsilon_0}\right)^2\left(\frac{2Ze^2}{mv^2}\right)^2\int_{\frac{\pi}{2}}^{\pi}\frac{\cos\dfrac{\theta}{2}}{\sin^3\dfrac{\theta}{2}}\,\mathrm{d}\theta = 8.5\times 10^{-6}$$

**5. α 粒子散射实验的数据在散射角很小（$\theta\leqslant 15^\circ$）时与理论值差得较远，是什么原因？**

This is partly because that we assumed there was only one layer of gold atoms in gold foil, and the alpha particles would only be scattered once. But in fact, there are several layers of gold atoms. For small angle scattering results, since the result was accumulated by some small angle scatterings, each cannot be ignored and contributes to a large proportion of error.