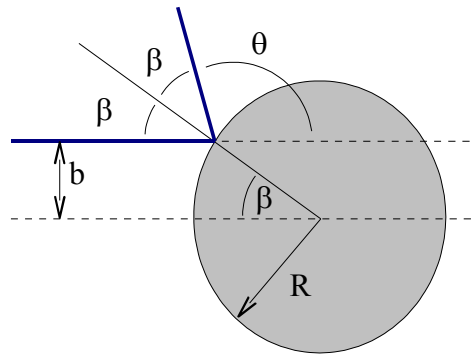


Homework VI

due October 13th 2006

- 1) A small shot of negligible radius hits a stationary smooth, hard sphere of radius R , making an angle β with the normal to the sphere. It is reflected at an equal angle to the normal. The scattering angle is $\theta = \pi - 2\beta$.
 - a) Express the relation between the impact parameter b and the scattering angle θ
 - b) Express the cross section for scattering at angle $\theta > \frac{\pi}{2}$ as a function of R
 - c) Express the cross section for scattering at angle $\theta > 0$ as a function of R (note that I do not mean $\theta \geq 0$. By the way, what is the cross section for $\theta = 0$?)
 - d) Comment on the fact the Rutherford cross section for scattering angles $\theta > 0$ is infinite or at least much much much larger than the area of the nucleus.



- 2) Geiger and Marsden used α ($Q_\alpha = 2e$) particles with kinetic energy 7.7 MeV and found they were scattered by Gold atoms in a way that is precisely described by Rutherford's scattering formula.
 - a) From this fact compute an upper limit on the radius of the Gold nucleus ($Q_{\text{Gold}} = 79e$).
 - b) From this result and the fact that the atomic mass of Gold is $197u$, compute a lower limit on the mass density of nuclear material.
 - c) What would be the radius of the Sun ($M_{\text{Sun}} = 2 \times 10^{30} \text{ kg}$) if its density were so great?

- 3) A Hydrogen molecule consists of two Hydrogen atoms separated by a distance $R = 2r_0 = 0.5 \times 10^{-10} \text{ m}$ each with a mass of $M_H = 1.674 \times 10^{-27} \text{ kg}$.
 - a) What is the moment of inertia of the molecule with respect to the point half way between the two atoms? You do not need to provide a numerical answer. Explain the reason why you can consider the atoms as point like objects.
 - b) Write the kinetic energy in terms of the angular momentum of the molecule. Assuming the angular momentum is an integer multiple of \hbar , express the rotation energy level of the Hydrogen molecule (You do not need to carry numerical application).
 - c) What is the wavelength corresponding to the lowest energy transition?