Phys106, II-Semester 2018/19, Assignment 8

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1. Electrostatic potential energy is $U = \frac{Q_{gold} \times Q_{alpha}}{4\pi\epsilon_0 r}$, where r is the distance between the two charges. Determine the distance of closest approach of 1 MeV α-particles on Gold nuclei.

2. Derive the Rutherford scattering formula, Eq. (68) following the discussion in the text book or any other book.

3. If an electron would be in a classical stable orbit around a nucleus, like discussed in the lecture, but the nucleus has a charge Ze (heavy ion) and not e (proton), how do the expressions for orbital size, velocity and energy change?

4. An electron (considered classically) moves within a spatially extended homogeneous positive charge distribution of total charge $Q = Ze > 0$ within a sphere of radius R. This is as in the Thompson model, compare also tutorial 8. The electric field it feels is $E(r) = \frac{1}{4\pi\epsilon_0}\frac{Zer}{R^3}$ within that sphere. Show that the electron should undergo harmonic motion and find its frequency ω. For Hydrogen $Z = 1$, compare the energy with typical electronic energies of the Hydrogen atom.

5. Find the quantum number for the earth's orbit around the sun. ($m_{earth} = 6 \times 10^{24}$ kg, orbital radius $r = 1.5 \times 10^{11}$ m, orbital speed $v = 3 \times 10^4$ m/s. Discuss your answer.

6. Find the wavelength of the spectral line arising due to the following transitions of a Hydrogen atom. Which part of the spectrum is this? (i) $n = 10 \rightarrow n = 1$, (ii) $n = 6 \rightarrow n = 3$, (iii) $n = 5 \rightarrow n = 2$.