Course: BSO 203 Instructor: S. Raychaudhuri

Session 2002-2003, Semester I

# QUIZ II

1. Calculate the image force on an electron one Bohr radius away from a conducting surface. No numerics are needed. **(1)**

   **Answer**: The image is an equal and opposite charge located one Bohr radius within the surface. Thus, writing the Bohr radius as $a_0$, the image force is

   $$F = \frac{e^2}{4a_0^2} = \frac{e^4 m_e}{4\hbar^2}$$

   in Gaussian units, using $a_0 = \hbar^2/e^2 m_e$.

   In SI units, the image force is

   $$F = \frac{e^2}{16\pi\epsilon_0 a_0^2} = \frac{e^4 m_e}{4\hbar^2}$$

   using $a_0 = 4\pi\epsilon_0\hbar^2/e^2 m_e$.

   The final result is independent of the choice of units.

2. To observe a Compton effect, is it necessary for the electron to be at rest initially? **(1)**

   **Answer**: No, because one can always have a Lorentz transformation to the rest frame of the electron. The only difference between the two results may be explained in terms of a Doppler shift of the initial and final photon wavelengths.

3. What is the primary cause of instability in planetary models of the atom? **(1)**

   **Answer:** The primary cause of instability is the energy loss due to *synchrotron radiation* emitted by accelerated electrons in a planetary orbit.

4. In a sample of pure cesium, all the bright lines were observed to be finely split into doublets, one intense and one faint. The ratio of wavelengths in each doublet came out to be the same for all such doublets. Can you suggest why this could be so? **(2)**

   **Answer:** Cesium is an alkali metal and hence a hydrogenic atom with $Z = 55$. Since all the bright lines, which come from transitions of the outermost electron, are split, the source of both lines must have the same quantum structure. So this cannot be a spin or orbital effect. Since the ratio of wavelengths is the same it can only be due to a difference in the Rydberg constant. Since the sample is pure cesium, with the same $Z$ for every atom, the difference in Rydberg constant must be arising from a difference in the reduced mass of the electron. This means that the cesium sample must contain two isotopes. Since one line is intense and the other is faint, one of the isotopes must be present in low concentration.