Name:

Physics 51

Homework #12

October 13, 2016

32-P10, SUP21, SUP22

32-P10 In Bohr's theory of the hydrogen atom, the electron can be thought of as moving in a circular orbit of radius r about the proton. Suppose that such an atom is placed in a magnetic field, with the plane of the orbit at right angles to $\vec{\mathbf{B}}$.

(a) If the electron is circulating clockwise, as viewed by an observer sighting along $\vec{\mathbf{B}}$, will the angular frequency increase or decrease?

(b) What if the electron is circulating counterclockwise? Assume that the orbit radius does not change [Hint: The centripetal force is now partially electric ($\vec{\mathbf{F}}_E$) and partially magnetic ($\vec{\mathbf{F}}_B$) in origin.]

(c) Show that the change in frequency of revolution caused by the magnetic field is given approximately by

$$\Delta f = \pm \frac{Be}{4\pi m}.$$

Such frequency shifts were observed by Zeeman in 1896. (Hint: Calculate the frequency of revolution without the magnetic field and also with it. Subtract, bearing in mind that because the effect of the magnetic field is very small, some–but not all–terms containing B can be set equal to zero with little error.)

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SUP21 Consider a rectangular wire loop of sides a and b carrying a current i. The current-carrying loop is immersed in a uniform magnetic field B. The loop is oriented so that side b is perpendicular to the magnetic field and side a is tilted at some angle, so that the angle between the magnetic field and $\hat{n}$ the normal to the loop is θ. Show that the torque on the current loop is given by:

$$\vec{\tau} = \vec{\mu} \times \vec{B}$$

where $\vec{\mu} = iab\,\hat{n}$ is called the *magnetic dipole moment* of the loop.

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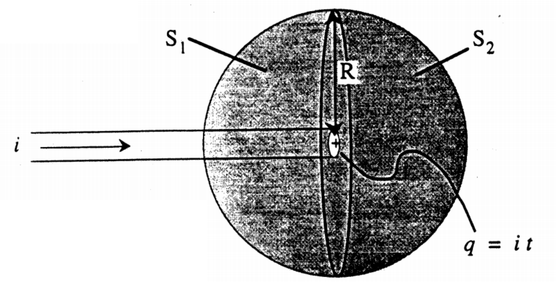
SUP22 A current i flows in a thin semi-infinite wire. At the cut-off end of the wire, assume the flowing charge builds up in a point-like accumulation. Determine the magnetic field at a perpendicular distance R from the wire end using the following three approaches, verifying that they give the same results:

(a) Use Ampre's Law with the hemispherical surface S_1 (see diagram) that intersects the wire.

(b) Use Ampre's Law with the hemispherical surface S_2 that *does not* intersect the wire.

(c) Use the Biot-Savart Law.



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