

Phys 110C: Problems for HW 8

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1 HW8 1: One Atom Scatters Light

Recall from HW4 that, for the Lyman- α transition, $2\pi c/\omega_\alpha = \lambda_\alpha = 121$ nm, oscillator strength $f_\alpha = 0.416$, and $\gamma_\alpha = 10^{-7}\omega_\alpha$.

- Find the cross-section for scattering by this transition for an electromagnetic wave with vacuum wavelength equal to λ_α .
- Find the cross-section for scattering by this transition for radiation with vacuum wavelength in the visible, $\lambda_v = 500$ nm.

2 HW8 2: Radiation Field

This is a problem from the final exam last year, slightly enhanced in part b.

a) Consider the vector potential:

$$\vec{A} = A_0 \left\{ \frac{\cos(kr - \omega t)}{kr} - \frac{\sin(kr - \omega t)}{k^2 r^2} \right\} \hat{\phi}$$

- State the Lorentz Gauge condition.
- Find the form of the scalar potential V , if the potentials are in the Lorentz Gauge.
- Could you omit the second term in \vec{A} ($\propto 1/r^2$), and still have a valid solution to Maxwell's Equations? Why is this term present?

b) Find the fields for your potentials:

- Find the electric field \vec{E} for your \vec{A} and V .
- Find the magnetic field \vec{B} .
- Identify the radiation part of the fields: that is, find the electric and magnetic fields in the limit $kr \gg 1$.

c) A small conducting loop of radius $a \ll \lambda = 2\pi/k$ is positioned at a position X on the x -axis, far away from the origin, but in the \vec{E} and \vec{B} fields from part b.

- What should be the orientation of the loop so that the emf induced in the loop is maximum? (Please give the direction of the normal to the loop).
- What is the induced emf, for this orientation? Give the induced emf as a function of time!

3 HW8 3: Transform of Acceleration

Extend the results of 12.38 to make them useful in finding the power emitted from an accelerated charged particle: Suppose that K' is a frame in which the particle is instantaneously at rest ($\vec{v} = 0$), and has 3-acceleration \vec{a}' . In a frame K traveling at velocity \vec{v} relative to K' , the 3-acceleration is \vec{a} . Show that the components of acceleration parallel and perpendicular to \vec{v} in the two frames are related by:

$$\begin{aligned} a'_{\parallel} &= \gamma^3 a_{\parallel} \\ a'_{\perp} &= \gamma^2 a_{\perp}. \end{aligned} \tag{1}$$

4 Problems from Griffiths

12.38, 12.56, 10.23, 10.25