J04E.3—Thomson Scattering

Problem

A particle of mass m and charge q moves at a constant, nonrelativistic speed $|\boldsymbol{u}|$ in a circle of radius a. The plane of the orbit coincides with the x-y plane This motion is caused by a plane circularly polarized electromagnetic wave, which propagates in the z-direction. At any moment of time the magnetic field of the electromagnetic wave is parallel to the velocity $\boldsymbol{u}$.

Since the acceleration of the particle $\dot{\boldsymbol{u}}$ differs from zero, the particle emits radiation. For nonrelativistic particles the radiation electric field $\boldsymbol{E}_{rad}$ at point $\boldsymbol{R} = \boldsymbol{n}r,\ r \gg a$ can be computed from

$$\boldsymbol{E}_{rad} = \frac{q}{rc^2}\boldsymbol{n} \times (\boldsymbol{n} \times \dot{\boldsymbol{u}}),$$

where $\boldsymbol{n}$ is the direction of the emission vector (The origin is at the center of the orbit).

a) Detemine the power emitted per unit solid angle in the direction at angle θ relative to the z-axis.

b) What is the spectrum of the emitted radiation?

c) By relating the emitted power to incident flux of the plane electromagnetic wave find the total cross section for Thomson scattering of unpolarized radiation and express it in terms of m and q.