Experimental Physics III

Submission due: December 08, 2022, before the lecture starts

Exercise Sheet 8

8.1

Horizontally polarized light impinges on a polarization film. It is experimentally determined that solely 15 % of the initial light is transmitted. Calculate which angle the polarization film has with respect to the horizontal axis.

8.2

Given is a linearly polarized plane wave in the laboratory frame described by

$$\vec{E}\,(\vec{r},t) = E_0\,(\vec{e}_x + \vec{e}_y)\,\mathrm{e}^{i(kz-\omega t)} \tag{1}$$

with E_0 being a real number.

- Calculate the real part of the electric field of this wave and name its polarization.
- Assume an optical element such that the electric field along the y-axis is retarded by a quarter wavelength, whereas the electric field along the x-direction remains unchanged. Calculate the real part of the resulting electromagnetic wave and state its polarization.
- Now assume an optical element that retards the electric field along the y-axis by half a wavelength, whereas the electric field along the x-direction remains unchanged. Calculate the real part of the resulting wave and state its polarization.

8.3

A transversal electromagnetic wave in vacuum is circularly polarized:

$$\vec{E}(\vec{r},t) = E_0\left(\cos(kz-\omega t)\vec{e}_x + \sin(kz-\omega t)\vec{e}_y\right), \tag{2}$$

where $\vec{e}_x$ and $\vec{e}_y$ are the unit vectors in x- and y-direction, respectively. It is thus traveling in z-direction.

- Calculate the magnetic field vector $\vec{B}(\vec{r},t)$ of this wave.
- Calculate the Poynting vector $\vec{S}(\vec{r},t)$.

8.4

A harmonic electromagnetic wave in vacuum has the form

$$\vec{E}(\vec{r},t) = \vec{E}_0\cos(kx-\omega t). \tag{3}$$

Show that the mean intensity of the wave is given by

$$\langle I\rangle = \left(\frac{c\epsilon_0}{2}\right)E_0^2. \tag{4}$$

(Hint: Assume that $T\omega \gg 1$, where T is a time that contains many oscillation periods of the wave.)

8.5

A small sphere with radius R and density ρ shall be hold in suspense against the gravitational force using the radiation pressure of a vertically aligned laser beam (see Figure 1). Calculate the required intensity of the laser that is assumed to be constant over the cross section of the sphere. Assume the sphere having a reflectivity of 100 %.

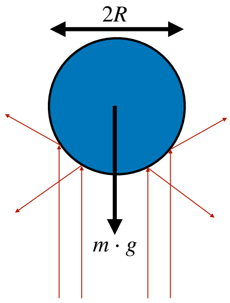

Figure 1: Sphere of radius R and density ρ levitates in the gravitational field due to a laser beam (red lines).