High-Intensity / Relativistic Optics

Problem set 6—Production of secondary radiation

1. **Exercise:** Betatron frequency. In a laser-plasma based electron accelerator, an electron bunch becomes accelerated inside a plasma channel. This plasma channel can be described as a cylindrically symmetric volume from where the laser has radially expelled the fraction η of all electrons with density $n_{\mathrm{e}0}$ whereas the rest $(1 - \eta)$ contributes to a forward current—the accelerated electron bunch. This configuration results in radial electric fields and azimuthal magnetic fields inside the channel. Computing the transverse component of the equation of motion of the electron bunch gives an expression for their so-called Betatron frequency.

2. **Exercise:** Undulator radiation. A beam of relativistic electrons propagates through an undulator with an alternating magnetic field $\boldsymbol{B}(z) = \boldsymbol{e}_{\mathrm{y}} B_0 \cos\left(\frac{2\pi}{\lambda_{\mathrm{U}}} z\right)$. λ_{U} denotes the wavelength corresponding to the undulator period. Starting out from a description of the electron velocity in transverse direction v_{x}, the wavelength of the electron's radiation can be determined.

3. **Exercise:** Thomson back-scattering. Our bunch of relativistic electrons now oscillates in the field of a counter-propagating laser pulse and hence becomes inelastically scattered. Calculate the wavelength of the scattered light pulses.