Exercise sheet 11
Theoretical Physics 2: SS2016
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Exercise 1 (30 points): Magnetic field of point charge

Using the expression for the Lienard-Wiechert potential find the magnetic field $\mathbf{B}$ of a moving point charge. Prove that $\mathbf{B}$ can be expressed as $\mathbf{B} = \hat{\mathbf{r}} \times \mathbf{E}$.

Exercise 2 (40 points): Synchrotron radiation

Consider a charged particle moving along the circular ring. Choose the coordinate system to have for a fixed time $\mathbf{v}' || \mathbf{e}_x$ and $\mathbf{a}' || \mathbf{e}_z$.
(a)(15 points)
Find the angular dependence of the energy flux of radiation $\frac{dP}{d\Omega}$.
(b)(15 points)
Integrating over the solid angle find the total flux

$$P = \frac{1}{6\pi} \frac{e^2 a'^2}{c^3} \gamma^4, \tag{1}$$

write down this result for the ultra relativistic particle ($E \gg mc^2$) through the energy E, the mass m and the radius R of the ring. How large are energy

losses per one turn (assume $v \sim$ c)?

(c)(10 points)

In the proton-proton collider LHC with the radius of 4.3 km protons are accelerated up to energy 7 TeV $= 7 \cdot 10^{12}$eV (1eV $= 1.602 \cdot 10^{-19}$J). How large are energy losses per one turn? Compare the energy losses of protons with the energy losses of electrons. The value of the proton mass is $m_p = 938\text{MeV/c}^2$ and the value of the electron mass is $m_e = 511\text{keV/c}^2$.

Exercise 3 (30 points): Bremsstrahlung

Bremsstrahlung occurs when a charged particle brakes in the direction of movement. Compute the angular distribution of the radiated energy $\frac{dP}{d\Omega}$ and the angle of maximum radiated energy $\theta_{\max}$. Which value of the angle $\theta_{\max}$ corresponds to the case of a nonrelativistic particle?