Fundamentals of Optical Sciences

WS 2015/2016 **5 . Exercise** **16.11.2015**

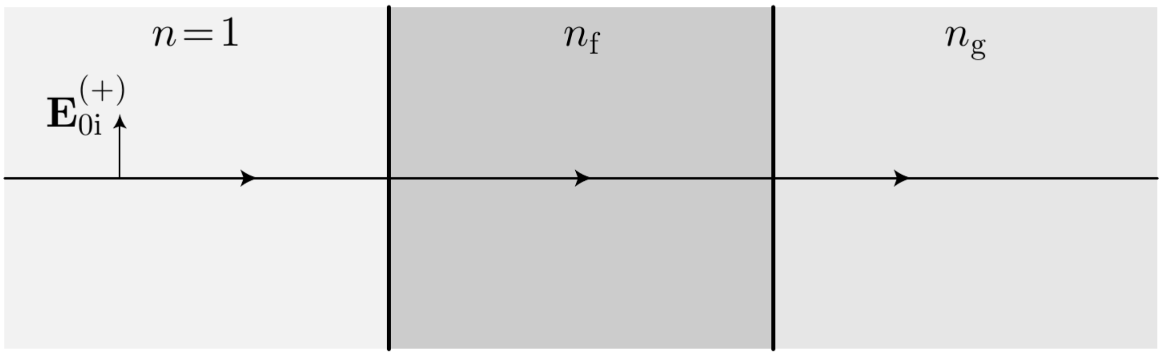
Lecture: Prof. Dr. Alejandro Saenz, Prof. Dr. Oliver Benson

Prepare your answers for the exercise on 23.11.2015.

Exercise 1

Reflection single dielectric thin film

Light of wavelength λ_0 is incident from air ($n = 1$) onto a single dielectric thin film (of index n_f, and thickness $\lambda/4$, where λ is the wavelength inside the film), which covers a glass substrate (index n_g).



a) Write down an expression for the film reflectance, assuming the light is at normal incidence, using the results of the reflection-summation formalism.

b) Derive the value of n_f that makes a perfect anti-reflection coating.

Exercise 2

Plot the intensity reflection coefficients as a function of λ_0 for light incident from air onto crown glass with a double-layer antireflection coating. The thin-film stack consists of a $\lambda/4$ layer of ZrO_2 ($n = 2.1$) directly on top of the crown glass, followed by a $\lambda/4$ layer of CeF_3 ($n = 1.65$). Assume a design wavelength of 550 nm (in vacuum) and extend the plot over the visible spectrum (400-700 nm). Consider only the case of normal incidence. How thick are the layers in nm?

Exercise 3
Show that the Liénard-Wiechert potentials

$$V(\mathbf{r},t) = \frac{1}{4\pi\epsilon_0}\,\frac{q\,c}{(\mathscr{r}\;c - \boldsymbol{\mathscr{r}}\;\cdot v)}$$

and

$$\mathbf{A}(\mathbf{r},t) = \frac{\mu_0}{4\pi}\,\frac{q\,c\,\mathbf{v}}{(\mathscr{r}\;c - \boldsymbol{\mathscr{r}}\;\cdot v)} = \frac{\mathbf{v}}{c^2}\,V(\mathbf{r},t)$$

for a point charge moving with constant velocity v are no longer dependent on the retarded variables $\boldsymbol{\mathscr{r}}$ and t_r. Here $\boldsymbol{\mathscr{r}} = \mathbf{r} - \mathbf{w}(t_r)$ with $\mathbf{w}(t)$ being the position of the point charge q at time t and (see figure 1).

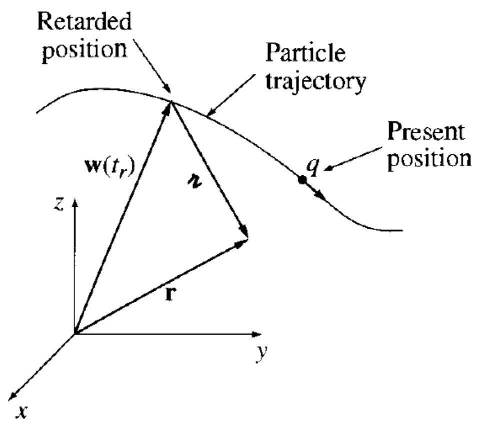


Figure 1

Exercise 4
In Bohr's theory of hydrogen, the electron in its ground state was supposed to travel in a circle of radius 5 Å, held in orbit by the Coulomb attraction of the proton. According to classical electrodynamics, this electron should radiate, and hence spiral into the nucleus.

a) Show that $v \ll c$ for most of the trip.

b) Calculate the lifespan of Bohr's atom assuming that each revolution is essentially circular.