Fundamentals of Optical Sciences

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

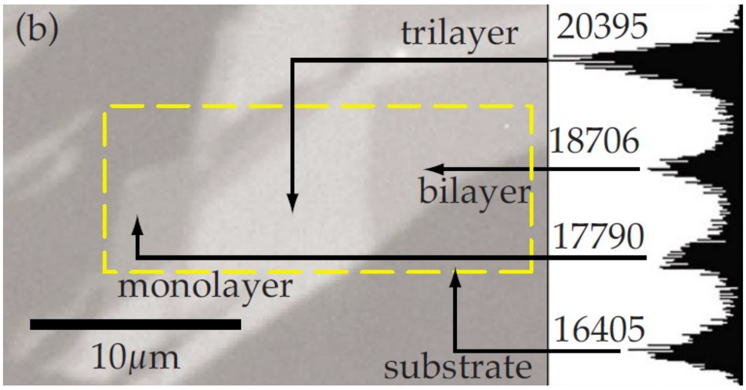
Lecture: Prof. Dr. Alejandro Saenz, Prof. Dr. Oliver Benson

Prepare your answers for the exercise on 23.11.2015.

Exercise 1

Exfoliated graphene on glass

Exfoliation of single graphene flakes from graphite is a wide-spread preparation technique. A simple tool to find and characterize even such thin layers is optical microscopy (see figure taken from DOI: 10.1063/1.3115026). Use the reflection-summation model to calculate



the contrast of a single graphene flake in an ordinary light microscope. Assume, that graphene was exfoliated onto perfectly smooth (and infinitely thick) glass. For simplicity neglect all illumination and detection angles other than normal incidence. Further, restrict the illuminating wavelength to only green light of 550 nm. For this wavelength consider a refractive index for glass of $n_{\text{glass}} = 1.5$, for graphene of $n_{\text{gr}} = 2.5 - i1.5$ and for air of $n_{\text{air}} = 1$, respectively. Find potential further relevant numbers at Wikipedia.

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).

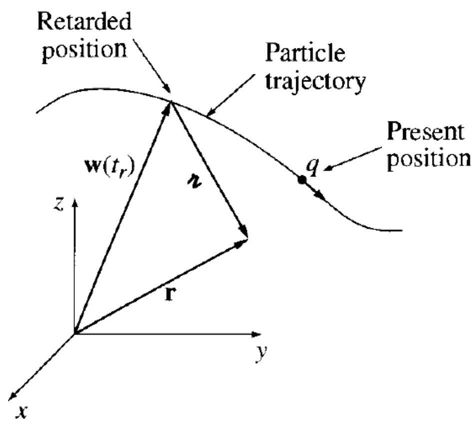


Figure 1

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.