Exercise 7 (online: 12.06.2023. Return by: **Mo 19.06.2023 10:00**) **9P**

1. **Decay Length for Surface Plasmons** 5P

   The length over which the intensity of surface plasmons decreases by the factor e, the decay length l, can be determined from the imaginary part of the wavevector along the direction of propagation $\beta = k_x$ (note that $\omega/c = 2\pi/\lambda$), *i.e.*, $l = 1/(2\,\mathrm{Im}(k_x))$. Consider gold with $\epsilon_2 = -11.7 + 1.3\mathrm{i}$ illuminated with laser light with a wavelength $\lambda = 633\,\mathrm{nm}$ (He-Ne-laser).

   (a) Calculate l in gold at the interface to air with $\epsilon_1 = 1$.(2P)

   (b) Calculate l in gold at the interface to a dielectric substrate with $\epsilon_1 = 2.1$. (2P)

   (c) How can one increase l in practical applications (*e.g.*, which different materials or geometry)?(1P)

2. **Particle Plasma Resonances** 4P

   Sketch in a single diagram I vs. λ the qualitative resonance spectra, which are observed for the following gold nanoparticles under perpendicular illumination (the aspect ratio is defined as the ratio of the long axis to the short axis). The intensity of each spectrum should be normalised to $I_{max} = 1$. The refractive index of the substrate is assumed to be identical for all particles. The medium is always air, if not specified otherwise. Label the individual spectra.

   (a) Unpolarised excitation of a circular gold disc with an aspect ratio of 1:1.(1P)

   (b) Unpolarised excitation of the identical gold disc like in (a), but embedded in a medium with refractive index 1.5(1P)

   (c) Unpolarised excitation of an elliptical gold disc with the same area as the circular discs and an aspect ratio of 2:1(1P)

   (d) Excitation of the elliptical gold disc like in (c) with the electric field vector aligned along the short axis.(1P)