Lecture 12 – Exercises

This series is to be handed-out on Moodle by 18.12.2025 at 9:00 (AM).

Implement an RCWA script in python following the details discussed during the lecture. Note that the code seen in the lecture is provided on Moodle in the file `simple_RCWA.py`.

Your code should:

1. Work for a range of wavelengths;
2. Work for a range of incidence angles θ (the angle ϕ may remain constant);
3. Work for TE, TM, RCP and LCP polarizations (TE and TM cases are already implemented);
4. At least be able to make 1D plots of the reflectance/transmittance (RT) versus wavelengths and 2D plots of RT versus incidence angles (θ) and wavelengths;
5. Be able to interpolate dispersive material data (use same procedure as for the TMM script).

Once the code is implemented, reproduce the results seen in lecture 11 and 12. Specifically:

1. Plot the RT versus wavelengths and incidence angles for TE and TM polarized waves for the dielectric GMR structure discussed in lecture 12.
2. Plot the RT versus wavelengths and incidence angles for a TM polarized wave for the gold grating discussed in lecture 11 (slide 18).

Design a half-wave plate (HWP) metasurface. A HWP is a birefringent structure that flips the handedness of circularly polarized waves (see lecture 2). Consider an LCP incident plane wave impinging on the metasurface from the air ($n = 1$) at normal incidence. The metasurface lies on top of a glass substrate ($n = 1.5$). The unit cell of the metasurface is a square lattice with a period of 600 nm and is composed of a rectangular scattering particle with a relative permittivity $\epsilon_\mathrm{r} = 12$. You must find the height (L_z) and the widths (w_x, w_y) of this rectangular scatterer along x and y. To make your design, maximize the conversion efficiency (transmittance from LCP to RCP) by varying $L_z \in [900 - 1100]$ nm, w_x and w_y both within the range $[150 - 450]$ nm. Try to achieve a conversion efficiency of more than 80% in a small wavelength band within the range $\lambda \in [1000 - 2000]$ nm.

To design the metasurface permittivity layer, $\epsilon_\mathrm{r}(x, y)$, use the `rect()` function defined in the provided `simple_RCWA.py` script.

1. Plot the conversion efficiency (transmittance from LCP to RCP) versus wavelength within the specified range.
2. Study how the response of the metasurface changes when the rectangular scatterer is rotated within the unit cell. To do so, select a single wavelength in the specified range for which the conversion efficiency is more than 80%. Then, rotate the scatterer using the `alpha` variable of the `rect()` function. Plot the conversion efficiency and transmission phase (from LCP to RCP) versus the angle `alpha` $\in [0° - 180°]$. Comment about your results.

Write a short PDF report in which you put your plots and comments. Make a zip archive containing your report and your python script (make sure that the script works and that it generates some plots so that I can easily test it). Upload it to Moodle.