BRNO UNIVERSITY OF TECHNOLOGY
FACULTY OF MECHANICAL ENGINEERING

Assignment Bachelor's Thesis

Institut:	Institute of Physical Engineering
Student:	**Martin Ošmera**
Degree programm:	Physical Engineering and Nanotechnology
Branch:	no specialisation
Supervisor:	**Ing. Andrea Konečná, Ph.D.**
Academic year:	2021/22

As provided for by the Act No. 111/98 Coll. on higher education institutions and the BUT Study and Examination Regulations, the director of the Institute hereby assigns the following topic of Bachelor's Thesis:

Optical dichroism in vortex electron energy–loss spectroscopy

Brief Description:

Transmission electron microscopy is one of the fundamental techniques suitable not only for imaging samples with atomic resolution but it can also be used together with spectroscopic techniques, such as electron energy–loss spectroscopy, which is capable of detecting energy transfer between the electron beam and probed sample. One of the new possibilities is to employ vortex electron beams, which in the interaction with samples exchange energy and also orbital angular momentum that is manifested in dichroism in electron energy–loss spectra. The use of electron vortices is especially suitable for probing chiral or magnetic samples whose response would be otherwise undetectable.

In this thesis, the interaction of vortex electrons with chiral nanostructures (e.g. plasmonic antennas of special shapes) will be explored. Both numerical and analytical descriptions will be used in limiting cases. One of the possible goals will be to find experimental conditions and parameters (e. g. focusing of the beam, magnitude of the orbital angular momentum, initial beam energy) for maximization of the detected dichroic signal.

Bachelor's Thesis goals:

1) Review of electron energy–loss spectroscopy (EELS) and vortex electron beams (VEBs). Study the possibilities of theoretical description of inelastic interaction of VEBs with different types of samples.
2) Model analytically EELS for VEBs interacting with point chiral objects. Try to find computationally suitable experimental parameters for the maximisation of dichroic EELS signal.
3) Get to know existing programmes for the numerical solution of Maxwell's equations (e.g., Comsol Multiphysics, MNPBEM toolbox for Matlab) and try to implement the interaction of VEBs with chiral nanostructures within these programmes.

Recommended bibliography:

GARCÍA DE ABAJO, F. J. Optical excitations in electron microscopy. Rev. Mod. Phys., 82 (2010), 209-275.

ASENJO-GARCÍA A., and GARCÍA DE ABAJO, F. J. Dichroism in the interaction between vortex electron beams, plasmons, and molecules. Phys. Rev. Lett., 113 (2014), 066102.

ZANFROGNINI, M., et al. Orbital angular momentum and energy loss characterization of plasmonic excitations in metallic nanostructures in TEM. ACS Photonics, 6 (2019), 620-627.

Deadline for submission Bachelor's Thesis is given by the Schedule of the Academic year 2021/22

In Brno,

L. S.

prof. RNDr. Tomáš Šikola, CSc. Director of the Institute	doc. Ing. Jaroslav Katolický, Ph.D. FME dean