Modelling and optimization of interactions of vortex vector optical beams with planar plasmonic structures

The research planned in the project is directed, by using advanced theoretical, numerical and experimental methods, towards optimization of interactions of optical vector vortex beams with planar, in general multilayered, horizontally periodic or aperiodic, plasmonic nanostructures. The structures will be modelled, optimized and constructed in configurations suitable for further technological applications. It will be primarily shown, how to optimize the beam-structure configuration by a proper choice of parameters of the incident vortex beam and the scattering structure. The analysis should result, among others, in the maximal beam intensity at its focus, enhancement of surface plasmon polaritons excited by the incident beams, as well as in resolution increase of an optical system controlled by the such properly modelled plasmonic structures.

The shape of the beams under consideration will be mainly of the Laguerre-Gaussian and Hermite-Gaussian beams of complex argument, that is in their elegant version, within the paraxial range as well as the nonparaxial range, modelled with use of exact analytical solutions for these beams. The research programme proposedhas an innovatory character –optical beams of these types have been rather rarely used till now in tailoring and optimisation of nanostructure actions.

The research will be focused mainly on two-dimensional horizontally periodic or aperiodic planar structures. The cells of the structures will be preferred to be of cylindrical symmetry, for instance in the form of Fresnel zone plates for example, especially for their strong focusing properties. These configurations match the best to the field symmetry of Laguerre-Gaussian beams under their incidence on the individual cell.

The analysis will pertain to normal modes of the structure, excitation of plasmon, resonance and guided modes within the structure, phenomena of cross-polarization coupling, extraordinary transmission, reflection enhancement and the like. Influence of these phenomena on the structure action will be qualitatively described, quantitatively parameterized and physically interpreted. Experimental part of the project will be performed by methods of near-field optics.

The sequence of the research tasks – modelling of an incident field, designing of nanostructures and optimisation of beam-nanostructure interactions – is commonly used in treating problems of this type. Results of such analysis are applied in nanophotonics, nanoelectronics and nanotechnology, especially in nanovisualisation, spectroscopy and Raman scattering, detection, sorting, trapping and self-organization of nanoelements, nanolithography or in construction of effective solar cells.