Research proposal

Title: Optical Excitation and Emission of Coupled Optical Antennas and Quantum Emitters

This PhD thesis will be codirected between Prof. P.M. Adam from UTT in France and P.D. Dai Zhang from University of Tübingen in Germany.

Details of the proposal:

Optical nanoantennas are excellent tools to direct photon energy from propagating electromagnetic waves into a confined spot in the nanometer regime, there enhancing the light-matter interaction to an unprecedented scale. Benefiting from the development of comprehensive modern nanofabrication techniques, nanoantennas can to a large extent be crafted according to specific requirements. Such a combination triggers enormous research interest and applications in the fields of sensors, solar energy conversion, integrated optical nanocircuitry, opto-electronics, density-of-states engineering and etc.

The goal of this project is to investigate the influence of coupling effects on the optical excitation and emission of plasmonic nanoantenna systems. The linear and nonlinear optical excitations, as well as the energy relaxation pathways in strongly and weakly coupled systems will be focused on. Furthermore, quantum systems such as semiconductor nanodots or small dye molecules will be positioned close to these couple optical antennas. The influence of the localized electromagnetic near-field on the relaxation channel of the quantum systems, such as the Purcell factor and the photoluminescence lifetime will be investigated.

Specially tailored nanostructures, such as lateral dimer with small nanogaps or selected materials will be fabricated. Conventional fabrication methods, such as using focus ion beam or helium ion microscope will be implemented to obtain well-defined nanogaps of less than 10 nm. The plasmonic resonances of these nanostructures will be characterized by angle-resolved extinction spectroscopy and dark-field scattering spectroscopy. The electromagnetic coupling-induced influences on the optical excitation and emission of the nanostructures will be studied using angle-resolved emission microscopy. Especially, the second harmonic generation and the two photon photoluminescence properties of the nanostructures will be investigated. To further study the coupling between the nanostructure and the quantum emitter, the ultrafast lifetime imaging technique will be employed.

We aim at understanding light-matter interaction at the sub-wavelength regime. Knowledge obtained from this project will be highly interesting for fields such as optical sensing devices, surface-enhanced spectroscopy, developing high-resolution optical microscopy, and pursuing bright nano-light sources.