

Master thesis

Three-dimensional spinning disk microscopy with an electro-optical tunable lens

Modern 3D imaging in microscopy continuously seeks to achieve higher spatial and temporal resolution. Only by the development of concepts and ongoing technical improvements, it is possible to understand the fast processes of living cells. And without understanding their dynamics in response to stress situations, the origins and courses of many cellular diseases remain unclear.

Background: We study the process of phagocytosis, i.e. the uptake of particles such as bacteria into specialized cells (macrophages). The cells wrap their cortex around the particle during the uptake process using tentacle-like protrusions. The precise determination of the 3D shape and contour of filopodia and of the phagocytic cup require fast and high-resolution imaging technology such as confocal spinning disk microscopy. The Yokogawa CSU-X 1 can had is a highly parallelized confocal point scanner head using rotating Nipkow discs (see photo).

Problem: In a standard configuration, the fluorescence distributions of actin-GFP in the cell cortex is only measurable in 2D without moving the object. Therefore, an extended imaging concept is required using fast electro-optical tunable refocusing optics to generate 3D image stacks within less than one second.

DFG project: In this master thesis, the confocal scanning unit needs to be combined with electro-optical tunable lenses (ETL). Here, the ETLs are used to focus the multiple foci produced by the Nipkow spinning disc (SD) into different focal planes within the cell and to refocus it accordingly onto a fast sCMOS camera.

Learning goals and Project: You will get introduced into modern 3D, fluorescence-based microscopy and refocusing technology with electro-optical tunable lenses (ETL). You will design and adjust two visible laser beams paths for fluorescence excitation into the new spinning disc system, which needs to be incorporated into a photonic force microscope. The optimal arrangement of the ETLs has to be designed and several test measurements and system characterizations have to be performed.

Requirements: Knowledge and motivation in optics, programming to control hardware.

