Quantitative phase contrast, retardance imaging and phase tomography by wavefront sensing

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Quantitative phase imaging techniques are now conventionally used in microscopy for measuring specific properties of semi-transparent samples without any labelling. With the differential wavefront measurement we developed, we are able to produce quantitative contrast of samples with a resolution less than 1 nm in their optical thickness. This quantitative phase contrast microscopy can be used to determine dry mass of living cells. By modifying the illumination scheme of the technique by introducing a varying polarization direction of the incident beam, we modulate the phase contrast of images and thus extend the technique to optical retardance imaging. This allows us to enhance specific contrast in order to highlight birefringent parts of living cells, like stress fibers, or collagen fibers inside biological tissues. At last, we demonstrate interest of using incoherent illumination with a high illumination beam numerical aperture to obtain optical sectioning and increased resolution. We use this setup configuration to realize phase-contrast z-stacks images of biological tissues, in order to reconstruct 3D tomography of the samples. Examples of skin tissues, but also brain slices, will be shown. For all these works, the wavefront sensor that is used to provide phase contrast images is simply plugged into the video port of a conventional microscope, like a basic camera, leading to very simple measurement procedures.