Aix*Marseille université

Master 2 internship

Name of host organization : Institut Fresnel, Marseille
Mail address **: www.fresnel.fr**

Title: Quantitative phase microscopy with isotropic super-resolution

Name of the supervisor(s): Guillaume Maire
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Summary of the subject :

3D imaging at the sub-micrometer scale is a key challenge for modern biology and material science. Optical microscopy has proven to be an invaluable tool, thanks to its unique properties for imaging living specimens, possibly over long periods. In biology, most of works deal with fluorescence microscopy, which has tremendous advantages, but still presents drawbacks like difficulty of labelling, induced photobleaching or phototoxicity problems, and difficulty to perform rapid imaging. Improvements in resolution led to what is called fluorescence nanoscopy and were awarded the 2014 Nobel Prize in Chemistry.

However, **the low resolution along the optical axis (which is at last three times worse than the transverse resolution) limits dramatically the potential of optical microscopy for 3D imaging.** This major issue originates from the fundamental asymmetry of most microscopy set-ups: illumination and detection are performed only on one side of the sample, either the same side for reflection microscopes, or opposite sides for transmission microscopes.

Institut Fresnel has received a research grant joined to IRIMAS in Mulhouse to develop 3D phase microscopes with isotropic resolution, based on a label free modality called tomographic diffractive microscopy (TDM) [1]. Two geometries will be studied : a 4π geometry where the sample is placed between two objectives facing each other and used for both illumination and detection. And a mirror-assisted geometry where the sample is placed in the vicinity of a mirror so that it is illuminated and observed simultaneously from both its front- and back-side [2]. The two geometries provide the same information, but the 4π one permits to record sequentially the data in transmission and reflection with a quite sophisticated set-up, whereas the mirror geometry is simpler but mixes the two data and necessitates more elaborated reconstruction techniques.

During the internship, the student will work on the development of the mirror assisted geometry from the TDM set-up presently running at Institut Fresnel. She/he will have the opportunity to perform measurements on reference samples to obtain first assessments of the performances of the technique, and use specific reconstruction algorithms developed in the SEMO team of Institut Fresnel to retrieve iteratively the 3D refractive index map of the samples.

The internship period is of at least four months between beginning of March and end of August, depending on the student availabilities.
A 3 years grant is already available to continue on the same subject during a PhD.

1. Haeberlé, O., *et al.,* Tomographic diffractive microscopy : basics, techniques and perspectives, *J. of Modern Optics* 57, 686 (2010)
2. Mudry, E., *et al.,* Mirror-assisted tomographic diffractive microscopy with isotropic resolution, *Optics Letters* 35, 1857 (2010)