PhD proposals:
Isotropic-Resolution Tomographic Diffractive Microscopy:
4Pi TDM and Mirror-Assisted TDM

Tomographic Diffractive Microscopy (TDM) represents state-of-the art in unlabeled optical microscopy, in terms of resolution, and for quantitative measure of sample's optical properties. This technique is even now commercially available, but in simplified versions. Institut Fresnel and IRIMAS collaborate via an ANR grant, in view of further improving the technique.

In particular, the importance of working with isotropic-resolution images is vastly overlooked [1]. Even simple quantities such as volumes cannot be accurately measured at micrometric scale in transmission-only microscopy, because of the so-called "missing-cone" problem [2]. Consequently, index of refraction, or species concentrations are even more difficult to measure with precision [3-5]. Figure 1 illustrates these limitations, depicting an optical fiber, tapered using the heat-and-pull technique. The lateral view Fig. 1(a) clearly depicts the small tip, but the section Fig. 1(b) highlights a non-circular shape, with a strong elongation along the optical (vertical) axis. With reflection setups, Fresnel has already obtained very promising results in synthetic confocal-, and reflection TDM, Fig. 1(c,d), thanks to advanced inversion methods [3].

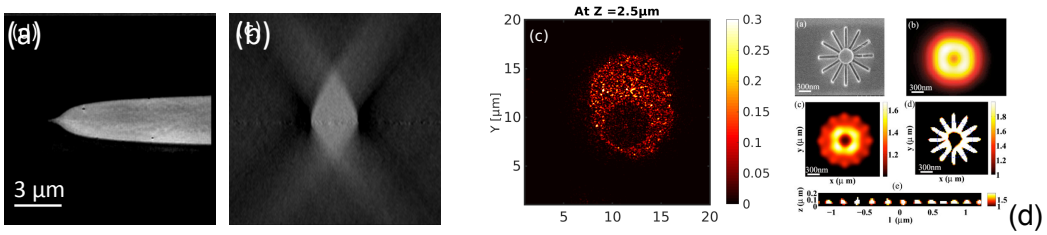

Fig. 1: (a) x-y and (b) x-z views of a tapered optical fiber. (c,d): high-resolution images obtained at Fresnel in synthetic confocal TDM and in reflection TDM.

We propose 2 PhD theses *within the framework of the joint IRIMAS-Fresnel ANR TARANIS grant* (1 at IRIMAS and 1 at Fresnel) to study isotropic-resolution TDM. Several approaches are possible: combining sample and illumination rotations as in [1], using a 4Pi setup, as proposed in [2], or using mirror-assisted TDM approach, as demonstrated in [4,5]:

The selected candidates will join recognized and active groups in the domain, and will:

1) Study the underlying principles of TDM (bibliography), become familiar with the operation of the present IRIMAS and Fresnel systems, as well as with the various data reconstruction methods already implemented in the laboratories.

2) Participate to the construction of 4Pi / mirror-assisted TDM setups

3) Write advanced reconstruction codes, adapted to these peculiar configurations

Regular scientific visits are planed for PhD students in both Fresnel and IRIMAS institutes.

Expected skills: autonomy, resourcefulness and creativity, strong analytical skills (Physics, Optics), experimental optics and computational skills (Matlab, C/C++ and/or Python).

1. Simon, B., *et al.,* Tomographic diffractive microscopy with isotropic resolution, Optica 4, 460 (2017)
2. Lauer, V., New approach to optical diffraction tomography yielding a vector equation of diffraction tomography and a novel tomographic microscope, Journal of Microscopy 205, 165 (2002)
3. Zhang, T., *et al.,* Far-field diffraction microscopy at λ/10 resolution, Optica 3, 609(2016)
4. Mudry, E., *et al.,* Mirror-assisted tomographic diffractive microscopy with isotropic resolution, Optics Letters 35, 1857 (2010)
5. Foucault, L., *et al.,* Versatile transmission reflection tomographic diffractive microscopy approach, Journal of the Optical Society of America A 36, C18 (2019)

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