DIABOLO-SHAPED OPTICAL TRANSFER FUNCTION FOR MICROTOMOGRAPHY WITH SAMPLE ROTATION

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In transmission microscopy, the observation of non-labeled transparent samples poses a real challenge because of their inherent low contrast in refractive index. Diffraction microtomography with coherent light is a promising technique to image transparent living samples in three dimensions without staining [1]. In comparison to conventional microscopy, diffraction microtomography makes it possible to obtain the complex optical refractive index distribution within the observed sample by mapping a 3 dimensional support in the spatial frequency domain [2,3]. The technique can be implemented in two configurations, namely, by varying the sample illumination with a fixed sample [3] or by rotating the sample using a fixed illumination [4]. The first method permits a better lateral resolution, and using a fixed sample may have some advantages in terms of specimen preparation and handling. However, as for any transmission microscope, a so-called "missing cone" appears in the Optical Transfer Function (OTF), which precludes very efficient 3-D reconstruction of the specimen.
When rotating the specimen, the reconstruction of the refractive index distribution of transparent samples is usually obtained by back-projecting the measured sample phase using the Radon transform [4]. The obtained spatial resolution is then isotropic and no information is missing along the rotation axis. However this reconstruction by back-projection assumes negligible diffraction, and may lead to artifacts in the reconstruction [5]. A more precise reconstruction is obtained taking into account the curvature of the detected frequency space (Ewald's sphere). We show in that case, that while a more precise reconstruction is obtained, the resolution is, contrary to first thought, not isotropic. Indeed the OTF also presents some missing information along the rotational axis, this missing region having a shape similar to that of a diabolo. We study its effects when reconstructing 3-D images of small specimens.

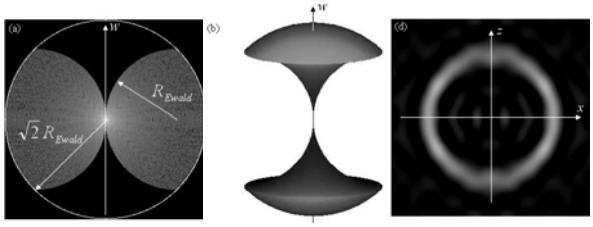

Fig. 1: (a): diabolo shaped OTF for diffractive tomography with rotating sample. (b): 3-D view of the missing part of the OTF. (c): reconstruction of a 3-D membrane-like object.

Figure 1 displays (a) the diabolo OTF for rotation of the specimen along the *z*-axis and (b) a 3-D view of the missing information in the frequency domain. Figure 1(c) shows the simulated effects of the missing information when reconstructing a small specimen such as a spherical membrane-like object.

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