OPTIMIZATION OF ILLUMINATION SCANNING IN TRANSMISSION TOMOGRAPHIC DIFFRACTIVE MICROSCOPY

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Tomographic diffractive microscopy (TDM) is a holographic-based imaging technique, which provides the three dimensional images of unstained samples' complex refractive index distribution (RI), by numerically recombining sets of diffracted fields recorded at various illumination angles [1]. Practically, tens [2] to hundreds [3-4] of interferograms are acquired, depending on the required image quality, and the reconstruction algorithms to be used. In general, using small number of interferograms is fast, however, results in a degraded reconstructed image quality due to unrecorded object frequency components in the Fourier space. The use of advanced reconstruction algorithms with limited holograms leads to high-resolution images, however, with a reduced speed of reconstruction.

For high-resolution imaging [3,5,6], collecting enough diffracted fields to optimally fill the Fourier space has a strong dependence on the scanning scheme. Hence, the choice of an appropriate scanning pattern becomes critical. With the aim of optimizing Fourier space filling in the low diffraction regime, we have studied several classes of sample scanning patterns, star-like, grid, annular, spiral, flower, Fermat as well as 3D uniform patterns, and their respective Optical Transfer functions (OTF). We use the Filling Factor as a metric to compare the efficiency of scanning patterns. We found that 3D-uniform sweeping [7] best fills the Fourier space. Annular illumination at maximum angles proves to be of same filling efficiency, but only if peculiar hypotheses about the sample holds, such as non-absorptivity. In that case, applying Hermitian symmetry allows for compensating its otherwise lowest filling factor [8]. As a consequence, 3D-uniform sweeping provides the best-reconstructed simulated images, when considering a phantom made out of a refractive bead with two absorptive inclusions. On the contrary, annular scanning delivers in that case the lowest-quality results, because of its strongly asymmetric OTF, as one cannot apply Hermitian symmetry for this kind of samples [8].

We have also investigated pollen grains [9], which constitute natural 3-D test patterns. Figs. 1(a-d) show views of a Helianthus tuberosus pollen grain reconstructed using: (a): 600 holograms with 3D-uniform scanning, serving as a "ground truth", and (b-c): 60 holograms acquired through star (lowest Fourier space filling), Fermat's spiral (medium filling), and 3D-uniform (best filling) scanning, respectively. Again, 3D-uniform scanning gives the most contrasted image (see arrows), showing that selecting a favorable scanning pattern can indeed help achieving the required image quality with reduced number of holograms [8].

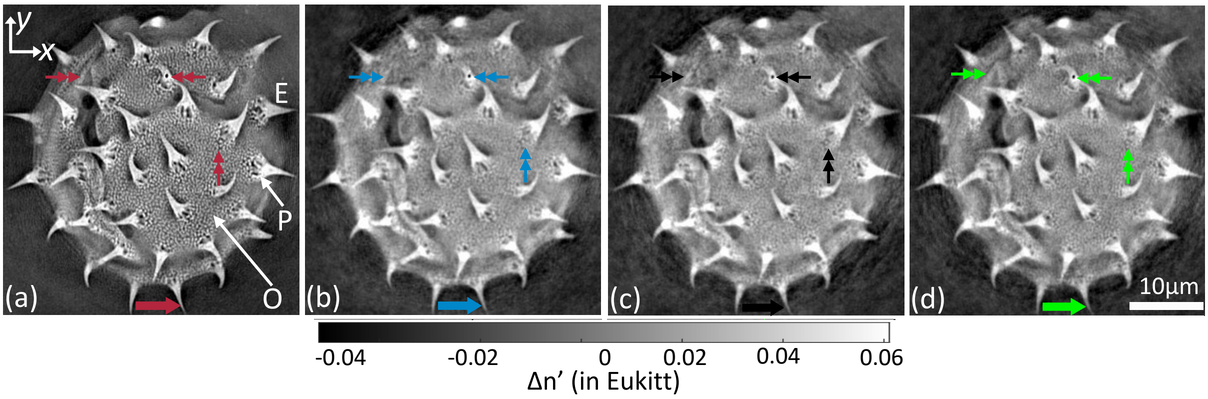

Fig1: TDM images (x-y) slices of external Helianthus tuberosus pollen using: 60 angles of (a) star, (b) Fermat's spiral, and (c) 3D-uniform patterns; (d) index contrast profile along the z-direction

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