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Trends and challenges in synchrotron-based X-ray tomographic microscopy Multiscale – Multimodal – Dynamic experiments

Abstract

Synchrotron based X-ray tomographic microscopy provides quantitative volumetric information on a large variety of opaque samples in a fast and non-destructive manner with micrometer spatial resolution for samples of a few mm in diameter. The high brightness of synchrotron radiation at third generation sources and new fast camera and readout systems [1] have triggered, over the past few years, the advancement of dynamic tomographic studies, to a point where processes can be followed in 3D up to speeds of 20 tomograms (i.e., 3D volumes) per second at a few microns in resolution [2]. Multiscale studies have also been benefitting from these developments: the investigation of large volumes at high resolution – stitched teravoxel tomography [3] – is for instance also becoming routine.

The coherence of synchrotron radiation sparked instead the development of multi-contrast imaging techniques, including phase contrast and dark-field imaging. In this respect, we introduced in 2016 omnidirectional Talbot interferometry [4] to efficiently measure structural anisotropy in 2D. Ongoing work aims at pushing this novel technique to 3D and 4D unlocking access to nano- and microscopic structural information over larger (up to cm^3) volumes in a time-resolved manner.

In this contribution, we will first address the challenges faced in the efficient reconstruction, quantitative analysis and visualization of TB-size tomographic datasets, either long, time resolved sequences with hundreds of time steps or hierarchical studies of large volumes investigated at multiple spatial resolutions. In the second part, we will discuss recent work on a tomographic approach reconstructing the local scattering tensor for each voxel of the study object from projection data acquire with an omnidirectional Talbot interferometer.

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