Time-resolved 3D imaging opportunities with XMPI at ForMAX

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With the advent of fourth-generation diffraction-limited storage rings (DLSRs), the brightness of synchrotron light sources has increased by several orders of magnitude compared to their predecessors, opening new opportunities for time-resolved X-ray imaging. This enables novel X-ray imaging approaches and opens up previously inaccessible temporal and spatial regimes.

X-ray Multi-Projection Imaging (XMPI) [1] is a method that benefits from the increase in photon flux density at DLSRs, i.e., the number of photons per unit of area and time. It enables the acquisition of time-resolved three-dimensional data (4D) without requiring sample rotation by splitting the incident beam into multiple beamlets that illuminate the sample from different angular directions and are detected simultaneously. Thus, key limitations of conventional time-resolved tomography, such as centrifugal forces and constraints on rotation speed, can be circumvented.

This presentation will discuss the implementation of XMPI at the ForMAX beamline at MAX IV [2], the first operational DLSR. We will present experimental results from representative applicationswith acquisition rates up to one order of magnitude higher than the current limit of time-resolved tomography (1 kHz) [3] with micrometer resolution. Particularly, we will show sample dynamics such as in situ tensile loading of cellulose fibers and wood-adhesive joints, multiphase flows, and additive manufacturing. These examples highlight the potential of XMPI for capturing fast dynamics in complex systems, taking into account their respective spatiotemporal regimes.

We further discuss key technical challenges associated with XMPI, including the design and performance requirements of X-ray beamsplitters, the heat load imposed on the beamsplitters and the image reconstruction from a limited number of projections. Finally, we outline future prospects for XMPI at ForMAX, paving the way for insights into dynamic processes in materials and life sciences.

References

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[2] Rogalinski, Julia Katharina, et al. ”Time-resolved 3D imaging opportunities with XMPI at ForMAX.”Synchrotron Radiation33.2 (2026).
[3] García-Moreno, Francisco, et al. ”Tomoscopy: time-resolved tomography for dynamic processes in materials.” Advanced Materials 33.45 (2021): 2104659.