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Meeting-report

Live Data Processing of 4D STEM Experiments: LiberTEM Meets ARINA Hybrid-Pixel Detector

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TEM instrumentation advances over the last few years have been improving 4D STEM experiments performance and accessibility. Among them are the fast direct electron detectors based on hybrid-pixel technology, which can record high-dynamic range diffraction patterns at speeds nearing conventional STEM dwell times (10 µs) [1]. Differently from conventional STEM imaging, 4D STEM data can only be interpreted by data processing due to its multidimensional aspect. Prompt extraction of meaningful 2D images from the collected diffraction patterns is helpful to guide the experiments during TEM operation and ensure collection of high-quality data. In addition, more intricate 4D STEM experiments involving center of mass (CoM) analysis [2] and ptychography benefit from experimental TEM parameters adjustments aided by live results calculation.

Live 4D STEM data processing represents a current challenge with the increasing data rate incoming from dedicated electron detectors and with the complexity of data analysis workflows. This work presents the LiberTEM framework [3] development to support live data processing and visualization of fast 4D STEM experiments. Flexible user defined functions (UDF) were employed for some of the most relevant 4D STEM data processing applications. These included the visualization of incoming diffraction patterns and real-time synthesis of multiple virtual STEM images with arbitrary detector configurations, and the live calculation of a CoM vector field and its respective gradient and curl. These calculations resulted in images with contrast connected to local atomic potentials and charge density. A dedicated UDF for live single side band ptychography reconstruction [4] was used as well, allowing for interactive optimization of TEM experimental setup and SSB reconstruction parameters during continuous frame acquisition of up to 50'000 Hz (Figure 1).

The developed UDFs were successfully tested in 4D STEM experiments with a DECTRIS ARINA detector, which provided incoming frame rates of up to 120'000 Hz and data rates of up to 10 Gbit/s. This high speed is essential for an interactive user experience with 4D STEM, enabled by scaling the computation to modern multi-core CPU servers, with near-term plans for full support of multi-GPU systems. The implementation of live 4D STEM data processing and visualization supports the perspective of enhanced experiments with real-time and preliminary data assessment up to the fastest frame rate currently available. With its open platform software concept, LiberTEM allows both offline and live processing, can be extended to further 4D STEM applications, and supports other detector technologies.

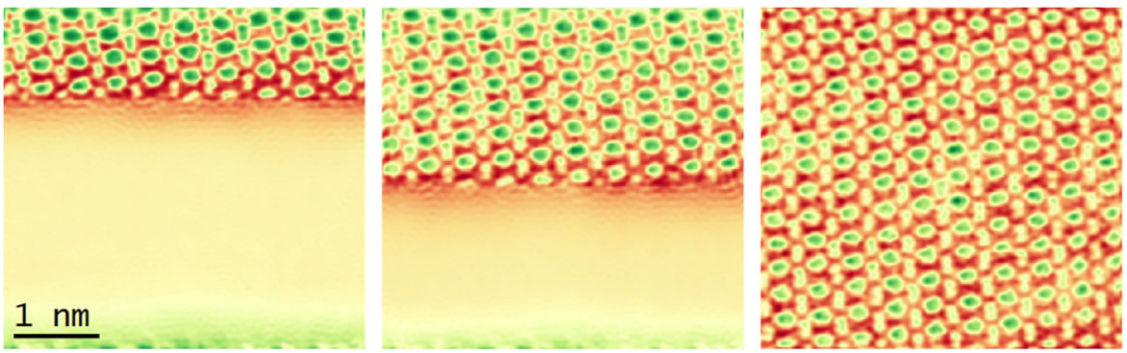

Fig. 1. Snapshots of the reconstructed phase from live single side band ptychography, imaging a SmB_6 nanocrystal along the <110> zone axis.

References

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