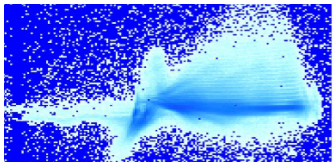

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Multibeam Ptychography up to 20keV: Opportunities and Challenges

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X-ray ptychography stands out as a robust phase-retrieval coherent imaging technique, well-suited for investigating samples with diverse scale structures. However, its scanning nature necessitates a delicate balance between achieving high resolution and accommodating a large field-of-view (FOV), considering factors such as scanning time, stage travel range, etc. Typically, the FOV and resolution ratio is between 100 and 1,000. For instance, the current high-resolution ptychographic scanning using high-speed multi-pass scanning mode can attain resolution in the tens of nanometers within a $3\mu m$ x $10\mu m$ region in 38 seconds [1]. Nevertheless, scanning over a hundred-μm FOV at such resolutions would extend the time required by a factor of 300. Within this timeframe, conducting ptychographic tomography on large-scale samples at high resolutions (<$50nm$) becomes impractical. A breakthrough addressing this compromise arises with the development of multibeam ptychography (MBP) [2], promising to transcend the current limitations of conventional ptychography and maximize photon utilization. MBP achieves this by employing multiple coded probes simultaneously using a 3D-printed lens array. The speed enhancement in MBP scales directly with the number of probes utilized. By overcoming the speed limitation, MBP offers the tantalizing prospect of conducting 3D nano-imaging on a large scale at high energy.

In our discussion, we will delve into the advancements in MBP development, including the maximum number of probes achieved and demonstrations with various sample systems. While the MBP method presents several opportunities, it also raises concerns regarding the comparisons with conventional ptychography and poses challenges that affect its performance in real-world experiments. Therefore, we will further discuss the quality of reconstruction comparison between single-beam and multi-beam ptychography, as well as how factors such as vibrations and photon statistics impact the data reconstruction quality.

[1] J.Deng, et al., Optics Express 30.15 (2022)
[2] M. Lyubomirskiy, et al., Sci. Rep. 12, 6203 (2022)

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