Convergent Beam X-Ray Diffraction Using Multilayer Laue Lenses — An Exploration Following In John's Footsteps

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John Spence, my Ph.D. advisor, has many scientific achievements and accolades in his fruitful career, as a scientist and an educationist. His contributions and interests span multiple fields and disciplines, from electron microscopy, condensed matter physics, material science to bio-molecular imaging using X-ray free electron lasers. One representative of his work is the convergent beam electron diffraction (CBED)1. The method has been used for accurate measurement of sample thickness, lattice constants, structure factor amplitudes and phases, determination of symmetry and strain mapping on a local scale and etc. When the coherent probe comes down to subnanometer size, local defect and lattice imaging becomes possible on atomic scale. The relevant theory was developed by Spence and Cowley in 1970s and 1980s2,3. With the rise of bio-molecular imaging using XFELs, Spence et al. extended and proposed the concept of CBD for time-resolved X-ray studies in order to reduce the required data volume and capture the changes in structure factor phases in dynamic processes4. However, the X-ray CBD experiments has not been viable due to the lack of efficient focusing devices for hard X-ray until very recently. The recently developed multilayer Laue lens (MLL) in Bajt and Chapman group5 has been demonstrated to focus hard X-ray with high efficiency and numerical aperture (NA). This advancement brings new opportunities for X-ray crystallography and 3D diffraction microscopy.

We explore various imaging modes from the same CBD data set which provide information at multiple length scales. Finally, we discuss prospects of advancing this technique to 3-D imaging at atomic resolution for material and life sciences.

References

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