MONASH University

Monash Centre for Electron Microscopy

Seminar

Future Developments for Transmission Electron Microscopy

Wednesday May 1, 2019	**Dr Colin Ophus**
12.00pm– 1.00pm	**National Centre for Electron Microscopy**
Lecture Theatre S9, 16 Rainforest Walk, Monash Clayton Campus	**Molecular Foundry Lawrence Berkeley National Laboratory**

Abstract:

In this seminar, I will primarily cover three topics related to transmission electron microscopy (TEM) and scanning TEM (STEM). The first is the implementation and development of atomic electron tomography (AET), where we can measure the three-dimensional position and species of every atom in a nanoscale sample, even over a time series. Our initial AET experiments have all been performed using annular dark field (ADF)-STEM, and I will discuss the strengths and weaknesses of this imaging mode for AET. One of the primary weaknesses of ADF-STEM is the poor electron dose efficiency, which is why we have also developed an atomic-resolution tomography reconstruction method for phase contrast plane-wave TEM. Our method directly tackles multiple (dynamical) scattering, one of the hardest problems in optics.

The second topic I will discuss is how modern high speed direct electron detectors have enabled many new experimental methods that fall under the umbrella of 4D-STEM, where a 2D image of the diffracted electron beam is recorded at a 2D grid of probe positions. 4D-STEM enables measurement of atomic-scale information about a sample's structure, orientation, deformation, composition, three-dimensional defect crystallography and more. I will also discuss phase contrast implemented using 4D-STEM, for 2D and 3D imaging of weakly scattering samples. I will also demonstrate a new simulation algorithm targeted at 4D-STEM named PRISM that is orders of magnitude faster than the multislice method.

Finally, I will show how we plan to apply exciting ideas from the field of quantum metrology (QM) to TEM and STEM instruments. Once we have highly-optimized microscope hardware, and have implemented phase contrast incorporating advanced computational imaging, the final barrier for low dose imaging is the "shot noise limit," where the Poisson noise statistics limit the achievable signal-to-dose ratio. Surprisingly however, this limit can be surpassed using QM. I will show calculations of how implementing these methods into TEM can reinvent it as a quantum electron microscopy (QEM), which can image past the shot noise limit to approach the true physical limit of imaging – the Heisenberg limit.

Biography:

Colin Ophus received his PhD in Materials Engineering from the University of Alberta in Canada. He was then awarded a Postdoctoral Research Fellowship from NSERC Canada, which was used for a joint position between the National Center for Electron Microscopy (NCEM) at Lawrence Berkeley Lab and the MatSci and Eng Department at the University of California Berkeley. He then became a project staff scientist at NCEM, and later a research scientist. Colin works primarily on developing methods, algorithms and codes for simulation, analysis and instrument design for high resolution and scanning transmission electron microscopy (HRTEM and STEM). He also provides computational support to facility users for quantitative analysis of electron microscopy experiments. In 2018, he was awarded a Department of Energy Early Career Award to study the application of Quantum Metrology to Electron Microscopy.

Convenor: Professor Joanne Etheridge

Email: mcem@monash.edu Tel: 9905 5563