MONASH University
Centre for Electron Microscopy

MICROSCOPY NETWORK VICTORIA

# SEMINAR

## Fast imaging - electrons or X-rays ?


### Professor John C. H. Spence

**Physics Department, Arizona State University, U.S.A**


**PLEASE NOTE CHANGE OF DATE, TIME AND VENUE**

***Wednesday 12 October, 2011***
***4.00pm – 5.00pm***
***Science Lecture Theatre S14, Building 29***

## Abstract


The relative strengths and weaknesses of X-ray and electron beams for fast, high-resolution imaging will be discussed, toward the goal of making a molecular movie. Aspects of the comparison include the following :
i). The much higher scattering cross section of electrons, and resulting multiple scattering.
ii) The existence of aberration-corrected lenses for electrons, providing sub-Angstrom probes.
iii) Field-emission sources are brighter than current-generation synchrotrons. Our measurements of degeneracy for a field-emitter, and our laser-driven photofield fast source will be reviewed.
iv) A cold field-emitter generates perhaps a hundred electrons per picosecond, insufficient to form an image. Hence the need for "stroboscopic" methods where a triggerable, repetitive process can be found. Multiple delays and projections are needed for a 3D movie. An X-ray free electron laser produces about 1E13 photons in 20 fs, but practically all either do not interact with the sample, or are annihilated in production of damaging photoelectrons. Hard X-rays minimize multiple scattering. EELS allows parallel detection, impossible with X-rays
v) The search for triggerable, repeating processes in materials science. First results from our time-resolved pump-probe diffraction at the LCLS free-electron hard X-ray laser will be shown.
vii) Differences in time resolution between the methods. Current XFELs produce 10 fs pulses at a repetition rate of about 120 Hz, with correspondingly fast detector readout.
viii) The effects of coulomb interactions on electron beams in producing unwanted energy spread and beam divergence, and the reduction of these effects at high energy due to relativistic effects.
ix). The discovery that radiation damage can be avoided by using a sufficiently fast X-ray pulse which terminates before damage begins (1). (Can we outrun knock-on damage with electrons ?).
x). XFEL diffraction from protein nanoxtals provides atomic resolution and femtosecond time resolution, opening up new possibilities for structural biology: (1) For solution of the phase problem (2). Single-shot patterns from many identical viruses in random orientations can be merged and reconstructed in 3D.
xi) Is the use of scattering from many identical molecules, randomly oriented in solution, a better approach, in the light of the work of Z. Kam (4), which does not require modelling ?

Recent experimental results from the latest fast XFEL imaging of photosynthetic membrane proteins and the cathepsin enzyme will be reviewed (5). High-energy (3 MeV) fast electron diffraction results, with 7E5 electrons per 100 fs pulse and a 500 micron diameter beam, will also be shown and discussed (6), in addition to electron diffraction movies of the CDW in $TaS_2$.



1 H. Chapman et al. "Femtosecond protein nanocrystallography". Nature 470 73 (2011).
2 J. C. H. Spence et al. "Phasing XFEL nanoxtal data". Optics Express. 19, 2866 (2011).
3 M. Seibert et al "Single Mimivirus imaged on-the-fly with X-ray laser. Nature 470, 78 (2011)
4. D. Saldin et al . Phys Rev Letts. 106, 115501 (2011).
5 J.C.H. Spence. X-ray lasers for biology. Rep Prog Phys. (2012). In preparation.
6 Y. Murooka et. al. Appl Phys Letts 98, 251903 (2011)



Convenor: Associate Professor Joanne Etheridge
Email: mcem@monash.edu
Tel: 9905 5563


*Visitors are most welcome: Please note that there is a designated Visitors Car Park (S2) clearly ground-marked by white paint and tickets, at a cost of $3.50/hour for up to 3 hours, available from a dispensing machine. This high-rise car park is located on the following Clayton Campus Map, Ref. E3.*

Printable version of the Clayton campus map (pdf 833 kb) (Please right click to open link)