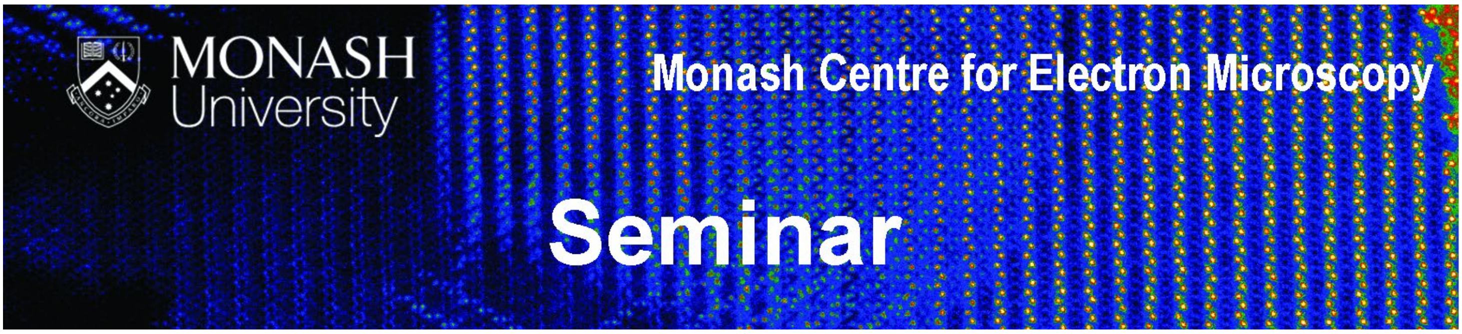

Recent advances in spatially-resolved spectroscopy combining photon and monochromated electron beams in a STEM

Friday 10 February, 2023

3.00pm

Lecture Theatre S1

16 Rainforest Walk, Monash Clayton Campus

This Seminar will also be available on **ZOOM** via this link
https://monash.zoom.us/j/81728250357?pwd=RXRQc1UrWnlMcS9EdjEwQzRoeVo0QT09
Passcode731616

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Abstract

In scanning transmission electron microscopy (STEM), following the advent of aberration correctors, a more recent breakthrough has been the development of new-generation monochromators, preserving the brightness of electron sources, and thus opening the way to new applications in Electron Energy-Loss Spectroscopy (EELS). More than just improving spectral resolution (now available in combination with atomic resolution), monochromation in EELS has given access to a whole new range of low-energy elementary excitations (down to the infrared range) with nanoscale resolution. The field of nano-optics using fast electron beams has been booming in recent years, boosted by recent developments in experiments combining photons and electrons in the microscope: cathodoluminescence (EELS), electron energy-gain spectroscopy (EEGS), photon-induced near-field electron microscopy, etc. Further advances are still to be expected by pushing the limits of time resolution, both as instrumentation advances and for accessing new physical information. I will review some of our latest results obtained in the field.

This will encompass the observation by monochromated EELS/CL combined measurements of the nanoscale modification of WS_2 monolayers trion emission by local electromagnetic environment [1] the mapping of high-quality plasmons in copper nanostructures [2] or the three-dimensional vectorial imaging of surface phonon polaritons in MgO nanocubes [3].

Very recently, we have developed new acquisition schemes making use of a Timepix3 direct electron detector providing sub 10 ns time resolution over arbitrary EELS energy ranges [4]. In parallel, we are developing new schemes aiming at synchronizing a continuous electron beam with (in some cases pulsed) photon beams, as a complement to approaches using a pulsed electron gun. I will put the emphasis on two recently developed spectroscopies:

- Electron Energy-Gain Spectroscopy [5] and ultra-high EEGS with sub meV (100 μeV) energy resolution
- a new type of time-correlated experiments based on coincidence (time-correlated) measurements between inelastic electron scattering (EELS) and photon emission (CL) events. I will show how this newly developed spectroscopy (so called CathodoLuminescence Emissision spectroscopy) can image energy transfer pathways at the nanometer scale [6].

1] N Bonnet *et al*, *Nano Lett.* **21** (2021) 10178
https://doi.org/10.1021/acs.nanolett.1c02600
[2] V. Mkhitaryan *et al*, *Nano Lett.* **21** (2021) 2444
https://doi.org/10.1021/acs.nanolett.0c04667
[3] X Li *et al*, *Science* **371** (2021) 1364
https://www.science.org/doi/10.1126/science.abg0330
[4] Y. Auad *et al.*, *Ultramicroscopy* **239** (2022) 113539, https://doi.org/10.1016/j.ultramic.2022.113539
[5] P. Das *et al.*, *Ultramicroscopy* **203** (2019) 44, https://doi.org/10.1016/j.ultramic.2018.12.011
[6] N. Varkentina, Y. Auad *et al.*, *Science Advances* **8** (2022) https://www.science.org/doi/10.1126/sciadv.abq4947

The Presenter

Odile Stéphan is a Professor of physics at Paris-Saclay University, a former member of the Institut Universitaire de France and is currently the head of the Physics Graduate Schools of Paris-Saclay University.
She received a PhD in Condensed Matter Physics from Université Paris-Sud, for a work on electron microscopy applied to carbon nanostructures. She then worked at NIMS, Tsukuba Japan, as a post-doctoral researcher before going back to France as a lecturer at Université Paris-Sud.
She is a member of the STEM group at the Orsay Solid State Physics Laboratory.
Her research interests span from growth mechanisms to optical and electronic properties of various nanostructures and nanomaterials. She focuses on the development and the use of Electron Energy-Loss Spectroscopy in a Transmission Electron Microscope and derived innovative spectroscopy techniques to probe at the nanometer scale the structural electronic and optical properties of original nanostructures like nanotubes and 2D materials, nanophotonics objects, oxide heterostructures or to explore new physics phenomena at low dimensions (plasmon coupling, electron magnetic field confinement and exaltation, 2D electron gas in correlated materials…).

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Visitors are most welcome. Monash University Clayton campus map can be found at: http://www.monash.edu.au/pubs/maps/3-Claytoncolour.pdf. Please note the parking arrangements. There is a designated Visitors Car Park (N1) clearly ground-marked by white paint. Payment for parking is make using the CelloPark app.