Laboratoire Matériaux et Phénomènes Quantiques
Séminaire Général

Vibrational spectroscopy at atomic resolution in the scanning transmission electron microscope

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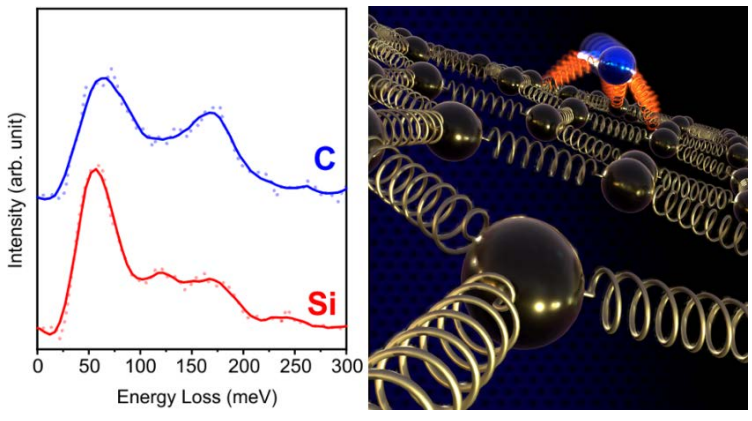
(Zoom link below)

Recent methodological and instrumentation developments have increased the energy resolution of electron energy loss spectroscopy (EELS) in the scanning transmission electron microscope (STEM) to a mere few meV, opening up the vibrational spectroscopy regime [1]. Unlike conventional infra-red (IR) or Raman spectroscopies, which can capture details of functional groups and lattice dynamics in relatively large sample volumes, vibrational STEM-EELS has enabled the observation of spectral signatures of phonons polaritons [2], molecular vibrations and even isotopes [3] with nm sensitivity.

By balancing spatial and momentum resolution, ultra-high energy resolution EELS can also be used to study the dispersion of phonons (and other quasi-particles beyond phonons) in solids and around nano-scale defects [4], a capability vital to the emerging field of quantum materials. Arguably, however, the true promise of vibrational STEM-EELS was only realized with the observation of a phonon signature localized at a single atom defect, bringing meV-EELS to the single atom level [5]. It is expected that building on these recent achivements, further improvements in energy resolution and the introduction of new direct/hybrid electron detectors will widen the range of chemistries that can be spectroscopically and spatially resolved, providing the ideal spectroscopic tool to understand the nanoscale organisation of organic and metal-organic bonding and complex interfacial structures in emerging hybrid composite materials [6].



Single atom vibrational spectroscopy in the STEM: the background subtracted spectrum from a single Si impurity in graphene exhibits a unique signature when compared to a neighbouring C atom.

[1] O. L. Krivanek, T. C. Lovejoy, N. Dellby *et al.*, *Nature*. **514**, 209–212 (2014)
[2] M. J. Lagos, A. Trügler, U. Hohenester, P. E. Batson, *Nature*. **543**, 529–532 (2017).
[3] J. A. Hachtel, J. Huang, I. Popovs *et al.*, *Science*. **363**, 525–528 (2019).
[4] F. S. Hage, R. J. Nicholls, J. R. Yates *et al.*, *Science Advances* **4**, eaar7495 (2018).
[5] F. S. Hage, G. Radtke, D. M. Kepaptsoglou, M. Lazzeri, Q. M. Ramasse, *Science* **367**, 1124 (2020).
[6] S.M. Collins, D.M. Kepaptsoglou, J. Hou *et al.,* Nano Letters **20***, 1272–1279 (2020).*

Resp. séminaires : Alexandre LE BOITÉ & Damien ALLOYEAU

ZOOM INVITATION

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