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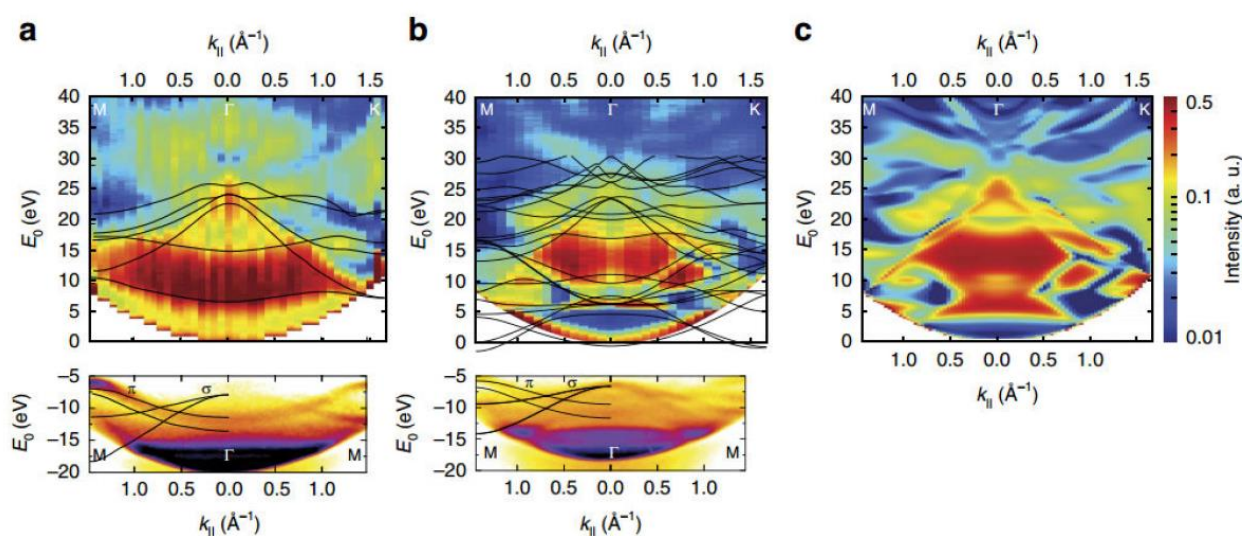
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# Spectroscopy of 2D Materials with Low Energy Electron and Photo Electron Emission Microscopy

It is well known that Low Energy Electron Microscopy (LEEM) and Photo Electron Emission Microscopy (PEEM) are powerful methods for high-resolution imaging of surfaces and interfaces, both in static and in dynamic situations. Time resolution in pump-probe type experiments can be on the order of picoseconds, spatial resolution below 2 nm has been demonstrated in aberration-corrected instruments, and spin-resolved instruments are capable of imaging magnetic domain structures. In recent years, these instruments have also seen rapid development of a range of spectroscopic capabilities that greatly expand and enhance their utility and application range. Many of these novel capabilities have been developed in the context of 2D materials science and exploration. Examples include structure analysis and correlated workfunction measurements of inhomogeneous 2D systems, surface potentiometry in simple 2D device structures, quantitative determination of 2D strain fields in epitaxial 2D materials, Electron Energy Loss Spectroscopy (EELS), area-selected Angle-Resolved Photo-Electron Spectroscopy (ARPES) as well as state-selected imaging of electron states below the Fermi level, and Angle-Resolved Reflection Electron Spectroscopy (ARRES) of electron states above the vacuum level. For example, figure 1 shows ARPES and ARRES spectra obtained in the same instrument on graphite and hexagonal boronitride (hBN), compared with band structure calculations [1]. In this talk I will give an overview of recent developments and results.

## Reference

J. Jobst, A.J.H. van der Torren, E.E. Krasovskii, J. Balgley, C.R. Dean, R.M. Tromp, S.J. van der Molen; Nature Comm. 7 (2016) 13621



**Figure 1:** ARPES (lower panels) and ARRES (upper panels) spectra on graphite (a) and hBN (b). Solid lines show theoretical bandstructures. (c): Theoretical ARRES spectrum for bulk hBN. Red regions (high reflectivity) correspond with bandgaps in the unoccupied valence band. A close correspondence with seen with the experiment result in (b).