# Spin-resolved Photoelectron Spectroscopy with the Momentum Microscope

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By using a photoelectron emission microscope (PEEM) we commonly look at strongly magnified images of a sample's surface in the real space on length scales ranging from a few 10nm to several µm. With the addition of imaging energy filters information about surface topography, work function, and chemical composition can be gained. Likewise, a momentum microscope utilizes the principles of cathode lens microscopy to form a high resolution image of the distribution of electronic states in reciprocal (i.e., momentum-) space [1]. Such two dimensional ($k_x$,$k_y$) maps of the photoelectron distribution represent sections through the valence electronic states in the full surface Brillouin zone, and give a comprehensive and intuitive access to the electronic properties of a material [2].

As a fundamental quantum mechanical property, the spin of the electron plays an important role in the description of electronic states in solids. Through inherently spin dependent interactions like spin-orbit couping or exchange interaction, the electron spin manifests in many tangible phenomena. A few examples are ferromagnetism, superconductivity, and new topological states of matter with unique physical properties due to the fundamental conservation of time-reversal invariance. A complete photoemission experiment therefore not only aims at characterizing electron states with respect to their binding energy and crystal momentum within the Brillouin zone, but also with respect to the spin degree of freedom. With the introduction of imaging spin analyzers [3] the efficiency of spin-resolved measurements experienced a tremendous boost, such that the electron spin now becomes routinely accessible in momentum microscopy.

This tutorial will recall the principle of momentum resolved imaging with a cathode lens microscope, and discuss applications and prospects of advanced momentum microscopy [4]. In a second part, we will review the principle of imaging spin filters, and discuss modern applications to spin resolved photoemission spectroscopy by the use of parallel imaging electron microscopes such as PEEM or momentum microscopy.

**References**

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