

Accepted Manuscript

Title: Space-, Time- and Spin-resolved Photoemission

Author: Gerd Schönhense Katerina Medjanik Hans-Joachim Elmers



PII: S0368-2048(15)00124-3

DOI: <http://dx.doi.org/doi:10.1016/j.elspec.2015.05.016>

Reference: ELSPEC 46452

To appear in: *Journal of Electron Spectroscopy and Related Phenomena*

Received date: 19-2-2015

Revised date: 25-5-2015

Accepted date: 26-5-2015

Please cite this article as: G. Schönhense, K. Medjanik, H.-J. Elmers, Space-, Time- and Spin-resolved Photoemission, *Journal of Electron Spectroscopy and Related Phenomena* (2015), <http://dx.doi.org/10.1016/j.elspec.2015.05.016>

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Space-, Time- and Spin-resolved Photoemission

Gerd Schönhense¹, Katerina Medjanik^{1,2} and Hans-Joachim Elmers¹

¹ *Institut für Physik, Johannes Gutenberg-Universität, 55128 Mainz, Germany*

² *MAX IV Laboratory, Ole Römers vag 1, 22363 Lund, Sweden*

Abstract

This article reviews photoemission experiments that simultaneously resolve at least two of the following degrees of freedom: space (real and momentum space), time (intrinsic time scale of a fast experiment or time-of-flight) and spin. In the *spatiotemporal* domain, imaging of fast processes by PEEM gives direct insight into plasmon dynamics or magnetization processes. In the category *real space & spin* the novel concept of imaging spin filters is discussed. In the *time & spin* chapter we address time-of-flight spin detectors and ultrafast spin processes that are accessible by pump-and-probe techniques. A main part of the paper is devoted to the resolution of *momentum-space & time*. This is implemented in form of the time-of-flight momentum microscope, a very recent development of which the first instrument has been in operation since 2014. In an extended outlook chapter, the potential of new developments and of a novel, highly parallelized delay-line type electron detector will be discussed. The combination of all three degrees of freedom *k-space, time & spin* is emerging through the combination of the ToF momentum microscope with imaging spin filter.

Outline

1. **Introduction**
2. **Space and time: Imaging of fast processes using PEEM**
 - 2.1 Imaging magnetic polarization dynamics
 - 2.2 Imaging electric polarization dynamics
3. **Space and spin: Multichannel spin detection**
4. **Time and spin**
 - 4.1 Ultrafast spin processes
 - 4.2 Spin detectors with time-of-flight energy dispersion
5. **k-space and time**
 - 5.1 Time-of-flight momentum microscopy
 - 5.2 3D mapping of the electronic structure
 - 5.3 Ultrafast processes in the electronic band structure

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