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Vector Microscopy – A 4D Reconstruction of Electrical Fields on a Flat Gold Surface

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Laser-based non-linear photoemission microscopy has been established as an excellent tool to investigate nano-optical fields at surfaces, in particular the fields of surface plasmon polaritons (SPPs). In our experiments, a femtosecond laser pulse is used to excite SPPs at grooves in an Au film (pump-pulse), and the photoemission image is mostly created by a second laser pulse (probe-pulse). In normal-incidence geometry [1] the contrast mechanism resembles a second order cross-correlation between probe-laser pulse and SPP pulse, which allows imaging in the same manner SPPs that propagate in different directions. The contrast, however, crucially depends on the polarization of the probe-laser pulse [2]: after exciting an SPP by a pump-laser pulse, the electric field of the probe-laser pulse interferes constructively with that part of the electric field of the SPP that is aligned with the polarization of the probe laser pulse. Here, we demonstrate that using two probe laser pulses with orthogonal polarization at the same delay time between pump- and probe allows us to measure the in-plane-component of the electric field of complex SPP interference fields, composed of SPPs that propagate in different directions [3]. The out-of plane-component of the SPP – and of course the entire magnetic field vectors– follows from Maxwell's equations. In the poster we will discuss the details of the method, how to use Fourier methods to extract a signal that is proportional to the SPP field strength, how the polarization of pump- and probe-pulses are made freely adjustable, and how the SPP's electric field can be reconstructed. We demonstrate the technique using plasmonic skyrmions. These are topological plasmon fields with a particular spin structure. Not only are we able to reconstruct the skyrmionic field in time and space, we can also experimentally determine the skyrmion number and compare it to theoretical expectations.

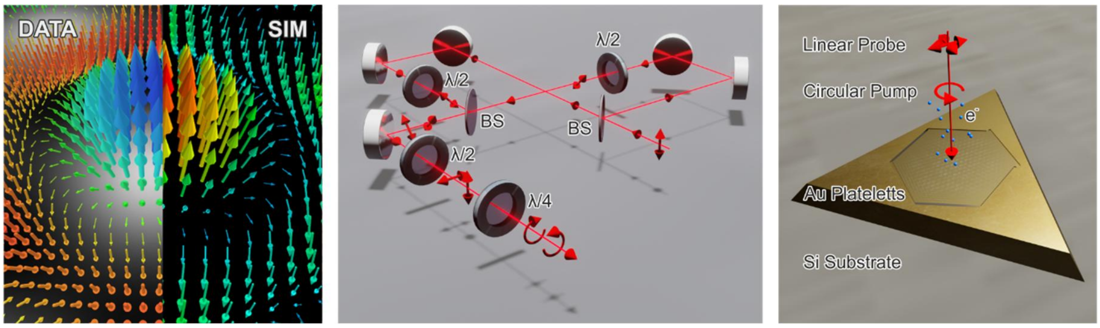

Figure 1. The first image shows reconstructed data and simulations of an optical skyrmion. The second image shows a visualization of the used interferometric setup. The third image is a representation of the photoemission in the performed pump-probe experiment.

References
[1] P.Kahl et al. Plasmonics **9**, 6 (2014)
[2] D.Podbiel, P. Kahl, F.-J. Meyer zu Heringdorf Appl. Phys B **122**, 90 (2016)
[3] T. Davis et al. Science **368,** 6489 (2020)