Ultrafast Coherent Control of Electric Currents at Metal Surfaces

Ulrich Höfer

Fachbereich Physik und Zentrum für Materialwissenschaften
Philipps-Universität Marburg, D-32032 Marburg, Germany

The electric conductivity of most materials is limited by scattering processes of electrons which usually occur on a subpicosecond time scale. Conventional conductivity measurements cannot access this time scale because available electronic equipment can neither produce trigger signals nor detect transients that are shorter than tens of picoseconds. Recently, we have introduced an experimental technique to measure the dynamics of electrical currents on the femtosecond timescale. The technique combines methods of coherent control with photoelectron spectroscopy. Our setup is contact free. Coherent optical excitation at the frequencies ω_a and $\omega_a/2$ is used to induce the current whose direction is controlled by the relative phase between the phase-locked laser excitation pulses. Time- and angle-resolved photoelectron spectroscopy affords a direct image of the momentum distribution of the excited electrons as function of time (Figure).

For demonstration purposes we have applied this optical current generation and detection scheme to electrons in so-called image-potential states which are bound perpendicular to the metal surface by the Coulombic image potential whereas they can move almost freely parallel to the surface. For the (n=1) image-potential state of Cu(100) we find a decay time of 10 femtoseconds due to electron scattering with steps and surface defects.