Description and influence of the IR probe field in attosecond spectroscopy of solid surfaces

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The fastest electronic processes in matter occur at an attosecond time scale [1]. A technique called RABBITT (Reconstruction of Attosecond Beating By Interference of Two photon Transition) [2] has allowed studying electron dynamics by measuring photoemission delays in gases [3] and on solid surfaces [4,5]. In RABBITT, electrons are excited by an XUV laser pulse and probed by an IR field that leads to a formation of sidebands (SB) (Fig.1a). We simulated the IR field distribution on a copper-vacuum interface with a finite-element method (FEM) for two incident angles of 15° and 75° with respect to the surface normal. Both specular geometries lead to total reflection and the field inside the metal is described by a strongly damped evanescent wave that decays towards the bulk (Fig. 1b). The interference between incident and reflected IR beams outside the metal leads to formation of a transient grating with an incidence-angle-dependent field distribution. Intensity and phase of the effective field were studied by illuminating the sample surface at an attosecond beamline in a two-foci configuration [6] at the two angles of incidence mentioned above. RABBITT traces in neon and on the Cu(111) surface were recorded simultaneously and the corresponding photoemission phases were extracted from SB oscillations. The resulting phase difference (Fig. 1c) for grazing and almost normal incidence of the IR beam is in accordance with simulations based on the Fresnel equations and confirms their validity for the description of electromagnetic fields at the surface for atomic length- and attosecond timescales.

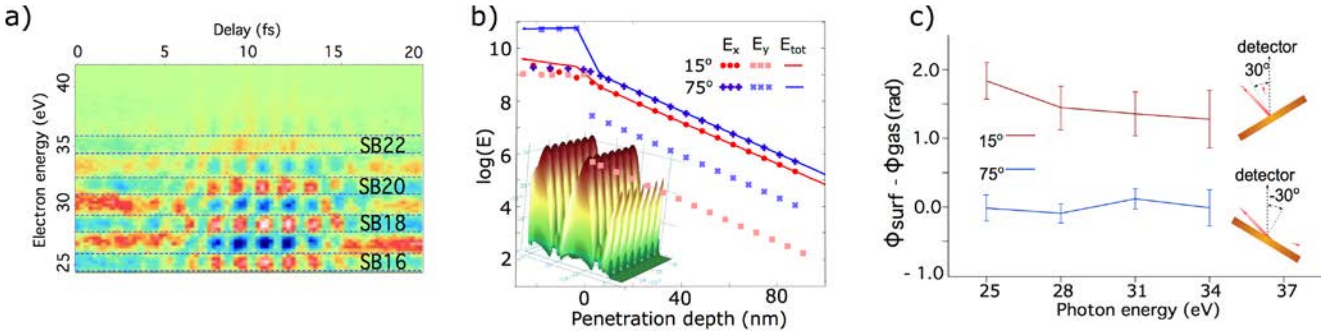

Fig.1. a) *Normalized RABBITT trace from Cu(111) surface.* ***b)*** *Electric field strength vs. penetration depth for 15° and 75° angles of incidence. Inset: FEM simulated total electric field distribution at 75°.* ***c)*** *Surface specific phases of Cu(111) for 15° and 75° incidence (30° and -30° between surface normal and detector).*

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