ÉCOLE POLYTECHNIQUE
FÉDÉRALE DE LAUSANNE

Seminars of Condensed-Matter Physics

Monday, 11th of June 2012 – CE1 100 – 12h15

Ultrafast dynamics in photoexcited Bismuth surface and bulk states

E. Papalazarou[1], J.Faure[2], J. Mauchain[1], M. Marsi[1], I. Timrov[3], N. Vast[3], B. Arnaud[4], L. Perfetti[3]

[1]Laboratoire de Physique des Solides, UMR 8502, Université Paris Sud, Orsay, France
[2]Laboratoire d'Optique Appliquée, Ecole Polytechnique/ENSTA/CNRS UMR 7639, Palaiseau, France
[3]Laboratoire des Solides Irradiés, Ecole Polytechnique/CEA/CNRS UMR 7642, Palaiseau, France
[4]Institut de Physique de Rennes, UMR 6251, Rennes

The structure of the A7 compounds may be described as a distorted simple cubic structure, where the (111) planes of atoms have an alternating displacement along the (111) direction. In one dimension, this type of distortion is well known as Peierls distortion [1]. Bismuth is an A7 semimetal where Peierls instability causes a symmetry breaking along the trigonal (111) direction. Due to this distorted nature of the ground state photo-induced excitation of valence electrons increases the electronic density in the conduction band thereby reducing the energy gain of the Peierls distortion. This renders the Peierls distortion unstable and a phase transition towards an undistorted phase stands possible within a timescale *inferior* to that required for the electron-phonon coupling thermalization.

Nowadays, although the atomic motion in Bismuth following the photo-induced excitation by femtosecond laser pulses is well understood [2], the temporal evolution of its electronic states has never been directly measured. To this end, we have performed time-resolved and angle-resolved photoemission experiments in bismuth (111) that allowed us to directly observe electron-phonon coupling with individual Bloch state wavevectors. Our measurements confirmed that the electronic structure of bismuth displays a rich combination of bulk-like bands, surface states and surface state resonances. We found that the binding energy of bulk-like bands oscillates with the frequency of the A_{1g} phonon mode whereas surface states are rather insensitive to the coherent motion of the lattice [3]. A strong dependence of the oscillation amplitude on the electronic wavevector is correctly reproduced by *ab initio* calculations of electron-phonon coupling. Besides these oscillations, all the electronic states display a photo-induced shift towards higher binding energies whose dynamics follows the evolution of the electronic temperature.

[1] R. E. Peierls, "More Surprises in Theoretical Physics", Princeton University Press, New Jersey, (1991).
[2] Y. Giret *et al.*, Phys. Rev. Lett. **106**, 155503 (2011).
[3] E. Papalazarou *et al.*, accepted in Phys. Rev. Lett. (arXiv:1112.3949v1).