Acoustic phonon generation by aluminum thin film under femtosecond optical excitation

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We investigate electron-phonon interaction in the context of metal film transducers in pump-probe experiment. Under high fluence femtosecond laser pulse, we need accurate description of the evolution of electron and phonon populations and their contribution to the sudden mechanical strain launching acoustic waves in the sample.

In this experiment we witness the apparition and propagation of acoustic solitons. We demonstrate how their shape and time distribution provides accurate information on nonlinear generation of strain pulses in picosecond acoustics. Indeed, we emphasize the influence of the initial strain profile on the solitons distribution. Such profile, which depends on the generation layer and pump parameters only, is directly connected to the observed characteristics of the soliton train.

This measurement-based technique provides reliable data on the initial strain profile to indicate which model of electron-phonon interaction best describes nonequilibrium states at ultrashort times.

Fermi- Surface Shrinking and Interband Cuopling

in Iron-based Superconductors

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Measurements of the Fermi surface with de Haas–van Alphen oscillations [1] in LaFePO showed a shrinking of the Fermi pockets with respect to first-principle calculations, suggesting an energy shift of the hole and electrons bands with respect to local-density approximations. We show that this shift is a natural consequence of the strong particlehole asymmetry of electronic bands in pnictides, and that it provides an indirect experimental evidence of a dominant interband scattering in these systems[2].

References

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Ab initio method for the electron-phonon scattering times in semiconducting nanostructures.

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Parameter-free description of the electron-phonon coupling is crucial for the simulation of the electron and thermal transport in materials, especially nanostructured ones. Recently, we have developed an *ab initio* approach which allows to calculate the electron-phonon constants and scattering times for collisions of carriers in the conduction band with short-wavelength phonons [1,2].

We will present our results on the electron-short-wavelength phonon interaction in silicon, which enables us, on one hand, to shed new light on the transitions between shallow donor levels in doped Si [2], and, on the other hand, to improve the description of its electronic mobility [3]. Finally, we will discuss the effect of the material nanostructuring on the electron-phonon coupling constants, e.g. in semiconducting superlattices.

References

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Superconductivity in Nickel Analogues of Iron Superconductors

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The iron superconductors and their nickel analogues have similar structure based upon Fe/Ni square lattice. Since Ni and Fe are ambient temperature ferromagnets and many Fe and Ni compounds show magnetism, it is plausible to expect that Ni can fill in the role of Fe in these compounds. However, Ni compounds seem to lie further from magnetic instabilities and have lower superconducting transition temperature. We use first principles calculations on LaNiPO and BaNi2As2 to show that unlike the Fe supercondutors, superconductivity in Ni based materials is readily explained by standard electron-phonon mechanism.

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Ab initio study of electronic properties of bismuth

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Bismuth, a group-V element which crystallizes in the rhombohedral A7 structure, is a well-known semimetal, and the archetype of thermoelectric materials. Our purpose is to interpret a behavior of the plasma frequency with respect to the pumb/probe delay in photoexcited bismuth. The first-principles calculations are performed in the framework of the density functional theory with the generalized gradient approximation, using a plane wave basis set and pseudopotential scheme. Satisfactory agreement with reported experimental results have been obtained. In particular, we show that the role of spin-orbit coupling effect has been found to be crucial to satisfactory obtain both the electron and hole pockets at the Fermi level.

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Electron-phonon coupling in icosahedral boron-rich solids

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In this work, I will focus on the understanding gained from the investigation of the strength of the electron-phonon coupling in icosahedral boron-rich solids with theoretical methods based on the density functional theory and on the density functional perturbation theory.

In particular, icosahedral boron carbides are hard ceramics, and the idea of combining this hardness and the superconductivity has emerged. I will show results on the electron-phonon coupling in $B_{13}C_2$ [1] and in α-boron under high pressure.

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