Max-Planck-Institut für Struktur und Dynamik der Materie

Max Planck Institute for the Structure and Dynamics of Matter

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Seminar rooms II, III, CFEL, Blgd. 99

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Linear and nonlinear phononics with quasi-monochromatic phonon-wavepackets

Phonons are often regarded as delocalized quasiparticles with certain energy and momentum. The anharmonic interaction of phonons determines macroscopic properties of the solid, such as thermal expansion or thermal conductivity. Although phonon-phonon scattering processes depicted in simple wave-vector diagrams are the basis of theories describing these macroscopic phenomena, experiments directly accessing these coupling channels are scarce.

We synthesize monochromatic acoustic phonon wave packets with only a few cycles to introduce nonlinear phononics as the acoustic counterpart to nonlinear optics. Control of the wave vector, bandwidth, and consequently spatial extent of the phonon wave packets allows us to observe nonlinear phonon interaction, in particular, second harmonic generation [1], in real time by ultrafast wave-vector-sensitive Brillouin scattering with x-rays and optical photons.[2]

We show different ways of preparing quasi-monochromatic phonons by multipulse-excitation or superlattice-excitation.[3] We carefully monitor the preparation and decay of these wavepackets and compare the results to numerical and analytic models.[4]

We also use a combination of ultrafast x-ray diffraction (UXRD) and ultrafast reciprocal space mapping (URSM) at laser-driven sources and synchrotrons with time-domain-Brillouin-scattering (TDBS) to observe the conversion of phonons at lattice-defects [5] and the nonlinear interaction with domain-walls [6].

Most of the results presented are on perovskite oxide nanolayers composed of $SrRuO_3$, $La(Sr_xMn_{1-x})O_3$, $Pb(Zr_xTi_{1-x})O_3$ and SrTiO3, but I will shortly show results on photoactive polymers and on the antiferromagnetic rare-earth Dysprosium.

[1] *Phys. Rev. Lett* 115, 195502 (2015)
[2] *Opt. Express*, 21, 21188 (2013)
[3] *Phys. Rev. B* 87, 184301 (2013)
[4] *Structural Dynamics* 1, 064501 (2014)
[5] *Phys. Rev. Lett.*, 110, 095502 (2013)
[6] Phys. Rev. Lett., 114, 047401 (2015)

Host: Michael Först / Andrea Cavalleri

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