Contribution ID: **3** Type: **Talk**

Phase rigidity and power law decay for large-amplitude coherent phonons in bismuth

Tuesday 5 April 2011 09:30 (20 minutes)

Fully symmetric A1g coherent phonons of bismuth have been investigated in a wide range of pump pulse intensities by the ultrafast pump-probe technique. It has been shown that in the linear regime, implemented only for low pump intensities, the coherent amplitude is proportional to the pump intensity, whereas the relaxation rate of the coherent state and its frequency remain unchanged. In the nonlinear regime, which can be divided into superlinear and sublinear regions, the relaxation rate of a photoinduced lattice state can be approximated by a two-component response, where only one component depends strongly on the pump intensity. Using coherent control method it has been shown that large-amplitude A1g coherent phonons exhibit the "rigidity" of the phase, which is absent at a small amplitude. The impossibility of changing the phase of coherent oscillations appears at the excitation strength at which their amplitude relaxation law changes from exponential to power. The modification of the phase properties and relaxation law of the excitations of the crystal lattice can be understood in terms of the concept of the condensation of phonons (that is a realization of "coherent crystal"), which occurs with an increase in the excitation strength.

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Session Classification: Charge density waves I