Coherent Phonon-Polaritons and Subluminal Čerenkov Radiation

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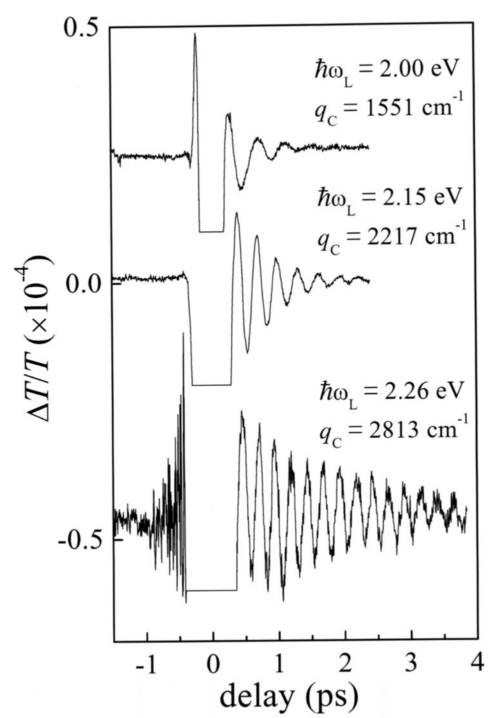
Abstract: Impulsive stimulated Raman scattering can be used to generate a wide range of coherent low-lying excitations [1] and, in particular, phonon-polaritons which are hybrid modes resulting from the coupling of infrared-active transverse optical phonons to infrared photons. In most cases reported in the literature, phase matching is achieved by using the so-called traveling grating geometry involving two pump beams [2]. Here, we show that coherent polaritons can also be generated using a single pump beam, provided the group velocity of the optical pulse is below a certain threshold defined by the infrared phase velocity at zero frequency, c_0 [3]. We also show that the condition for phase matching is identical to that for producing Čerenkov radiation at subluminal speeds and, more generally, that phase-matched excitation of phonon- polaritons by ultrashort pulses and dipolar Čerenkov emission are the same physical phenomenon [3].

Our experiments were performed using the standard pump-probe setup on a single crystal of ZnSe at 10K. We used a laser system that produces 90 fs pulses in the range 1.8-2.3 eV by pumping an optical parametric amplifier with a Ti:sapphire regenerative amplifier at a repetition rate of 200 kHz and heterodyne detection methods. Time-domain results are shown in the accompanying figure. At central energies $\hbar\omega_L > 1.97$ eV, the group velocity of the optical pulse is less than c_0 and the differential transmission reveal oscillations associated with the generation of coherent polaritons at a frequency that increases with ω_L. Such a behavior is consistent with a Čerenkov field created by a quasi-one-dimensional distribution of dipoles.



Normalized differential transmission as a function of pump-probe delay. The top and bottom traces were shifted vertically.

1. R. Merlin, *Solid State Commun.* **102**, 207-220 (1997).
2. See, e.g., H. J. Bakker, S. Hunsche and H. Kurz, *Rev. Mod. Phys.* **70**, 523 (1998), and references therein.
3. T. E. Stevens, J. K. Wahlstrand, J. Kuhl and R. Merlin, *Science* **291**, 627 (2001).