Studies of Dispersion and Soliton Formation of Longitudinal Acoustic Phonons in Crystalline Solids

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We have used the picosecond ultrasonic technique to study the effects of dispersion and elastic non-linearity on the shape of longitudinal acoustic pulses propagating in crystalline solids. In these experiments, a sub-picosecond light pulse (pump pulse) is used to generate an acoustic pulse at one surface of the sample. After propagation through the sample, the shape of this acoustic pulse is modified. When the amplitude of the pump pulse is sufficiently low, non-linear effects can be neglected and a measurement of the acoustic pulse shape can be used to determine the phonon dispersion. This measured phonon dispersion is compared with various lattice dynamical models. When the pump pulse intensity is high, the non-linear effects become strong enough to balance the dispersion, and acoustic solitons emerge from the original acoustic pulse. Measurements of the characteristics of these solitons are in agreement with the results of computer simulations based on the Korteweg-de Vries equation.

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