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Fourier transform inelastic x-ray scattering from phonons using Free Electron Laser pulses MARIANO TRIGO, SLAC/Stanford University, THOMAS HENIGHAN, Stanford University, DAVID REIS, SLAC/Stanford University — We demonstrate that ultrafast x-ray scattering at Free Electron Lasers (FELs) provides a new approach for measuring phonon dispersion relations spanning the entire Brillouin zone, without the need for complex monochromators and spectrometers. Our method uses an ultrafast optical laser as pump and the dynamics are probed using femtosecond x-ray pulses from an FEL. We obtain the entire transverse acoustic phonon dispersion in germanium with ~ 0.5 meV energy resolution by a simple Fourier transform of the oscillatory dynamics of the scattered x-ray intensity. Using coherent control with a pair of pump pulses, we show that the femtosecond laser couples to pairs of phonons, analogous to a second order Raman scattering mechanism, which also explains the excitation of large-wavevector phonons by the long wavelength (optical) pump pulse. This shows that the generation mechanism is quite general and thus this ultrafast approach could be applicable as a general spectroscopic tool of phonons near to and far from equilibrium.

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