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Femtosecond nonequilibrium phase-transition in hard x-ray excited bismuth

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The evolution of the bismuth crystal structure upon excitation of its A1g lattice mode has been intensely studied with short pulse optical lasers. Yet, how fast the phase transition occurs in highly nonequilibrium state above its damage threshold is still an open question. Here we present the observation of an ultrafast phase transition in a bismuth single crystal induced by 5 keV x-ray FEL pulses at high intensities (10^13-14 W/cm2). The lattice evolution was reconstructed using a recently demonstrated x-ray single-shot, serial probing setup. The time resolved measurement of (111) Bragg peak intensity showed strong dependence on the excitation fluence and, above sufficiently high excitation, the peak intensity drops to zero within 300fs - faster than one oscillation period of the A1g mode at room temperature. Our observation excludes interpretations based on electron-ion equilibration process, or on thermodynamic heating process leading to a plasma formation, when taken in light of previous reports on the overall integrity of the crystal measured after optical excitation.

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