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Direct structural characterization of photo-induced coherent phonon oscillations in BaFe2As2 via ultrafast x-ray diffraction

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Insight into the relationship between the intertwined lattice, spin and orbital degrees of freedom is vital for the understanding of high-temperature superconductivity in iron-based materials. We address this question by using ultrafast x-ray diffraction at the Linac Coherent Light Source (LCLS) to measure the time-evolution of a lattice Bragg peak in photo-excited BaFe2As2. Upon excitation with a femtosecond optical laser pulse, we observe an ultrafast increase and oscillation of the Bragg peak intensity. The frequency of this oscillation is 5.5 THz, which is consistent with the coherent excitation of an A1g phonon mode. This mode modulates the As-Fe-As bond angle that is crucial for determining the underlying electronic structure and also correlated with the superconducting transition temperature. We estimate the variation of the bond angle in this photo-induced coherent state by modeling the scattering form factor of the Bragg peak in the presence of the A1g phonon mode. The influence on the electronic and magnetic degree of freedom in this photo-excited coherent oscillatory state will be discussed. Our observations provide a direct and unique view on the dynamics of lattice degrees of freedom, which cannot be studied by other means.

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