Coherent $A_{1g}$ Phonon in thin Film Superconductor FeSe$_{0.5}$Te$_{0.5}$: $\pi/2$ Phase Difference over Superconducting Phase Transition\(^1\) JIMIN ZHAO, YANLING WU, MINHUI HU, YICHAO TIAN, LIXIN CAO, RUI WANG, Institute of Physics, Chinese Academy of Sciences — Coherent $A_{1g}$ phonon mode in a thin film superconductor FeSe$_{0.5}$Te$_{0.5}$ was generated and detected using ultrafast laser pulses. At below and above the transition temperature $T_c$, the coherent lattice oscillation we observed exhibited a $\pi/2$ phase difference, manifesting a “displacive limit ~ impulsive limit” transition upon crossing a phase transition within the same sample. We ascribe this $\pi/2$ phase difference to the different lifetimes ($\tau_c$) of excited charge density components that couples to the fully symmetric $A_{1g}$ phonon mode, i.e. the different strength of electron-phonon couplings. In the superconducting and paramagnetic metallic states the lifetimes of such carrier excitations are largely different. Our investigation reveals possible correlation of superconducting electrons with zone-center optical phonons. Our 170nm thin film sample contains tension stress, which leads to enhanced $T_c$ and thus facilitated our measurements.

\(^1\)Financially supported by the National Basic Research Program of China (2012CB821402), the NSFC (11274372, 10974246) and the External Cooperation Program of Chinese Academy of Sciences (GJHZ1403).