Orbital and spin signatures in the ultrafast lattice vibrations of a Mott insulator \( \text{Ca}_2\text{RuO}_4 \) MIN-CHEOL LEE, CHOONG H. KIM, INHO KWAK, Institute for Basic Science (IBS), C. W. SEO, Y. S. LEE, Chungbuk National University, C. H. SOHN, IBS, F. NAKAMURA, Kurume Institute of Technology, C. SOW, Y. MAENO, Kyoto University, E.-A. KIM, Cornell University, T. W. NOH, IBS, K. W. KIM, Chungbuk National University — Only within a short period of a decade, ultrafast spectroscopy has dramatically expanded its field in physics. Its unique ability to investigate time-resolved dynamics offers new insight into an interaction between quantum degrees of freedom, such as charge, lattice, orbital and spin. As one of the most interesting ultrafast features, coherent phonon oscillations provide oscillation-phase resolved information revealing a coupling of lattice to various order parameters. However, the oscillation-phase itself has been overlooked because it has been believed to be robustly determined by generation mechanism. In this talk, I will discuss a novel response from the coherent phonon oscillation depending on the orbital and spin degrees. Surprisingly, the orbital and spin orders in \( \text{Ca}_2\text{RuO}_4 \), one of the best known 4d Mott insulator, influence a coherent \( A_g \) phonon mode with dramatic changes of its phase such that the oscillation even flips across the orbital order. DFT calculations and a careful inspection of the crystal structure indicate that an unusually large antipolar distortion of apical oxygen is an essence of the orbital order and the extraordinary phase variations. We suggest that such phase observation in the ultrafast lattice vibrations can offer a new opportunity to single out a crucial but veiled aspect of the lattice.