Strain Waves as a Symmetry-Breaking Field in Photoexcited V O

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Control of light-matter interaction in quantum materials offers a pathway to access non-equilibrium states with emergent functionalities beyond thermal equilibrium [1, 2]. In strongly correlated systems, particularly those involving large volume changes associated or not to a symmetry breaking, ultrafast laser excitation can drive phase transitions [3, 4]. Recent work [5] further highlights the effect of nanoscopic morphology on the mechanism of macroscopic transformation as well as relaxation dynamics.

In this work, we investigate a geometry controlled strain wave dynamics during photoinduced phase transition in morphologically tailored single crystals of V2O3, a prototypical strongly correlated system. Using time-resolved X-ray diffraction and ultrafast optical reflectivity, we track the coupled structural and electronic dynamics during such a transition.

We identify a multistep process after laser excitation, starting with an initial monoclinic-to-hexagonal inverse ferroelastic transition, within ~ 10 ps. At several tens of ps, the propagation of a unidirectional and coherent strain wave perpendicular to the large surface hit by the ultrafast laser induces a symmetry-lowered state with intermediate volume, stabilising a transient monoclinic metallic phase - a long sought missing link in the V2O3 phase diagram. At longer delays, additional strain waves propagating in-plane drive the system towards the hexagonal phase, with a dynamics governed by the speed of acoustic propagation and the crystal lateral size. These results demonstrate that the strain wave mechanism can act as a dynamical symmetry-breaking field enabling control of photoinduced transition pathway and access to emergent phases.

References

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