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A time-dependent order parameter for photo-induced ultrafast phase transitions

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The exploration of the subtle interaction of structural and electronic degrees of freedom in strongly correlated electron systems on the femtosecond time scale is an emerging area of research. One goal of these studies is to advance our understanding of the underlying correlations, another is to find ways to control on an ultrafast time scale the technological relevant properties of these materials. Perovskite manganites, prototypical examples of strongly correlated materials, exhibit properties such as colossal magnetoresistance and insulator-to-metal transitions that are intrinsically related to symmetry changes of the atomic lattice and to fascinating ordering patterns of the spins, charges and orbitals. Here we report on a recent study on the dynamics of photoexcited epitaxial film of Pr0.5Ca0.5MnO3 using femtosecond resonant x-ray diffraction. Taking advantage of the high flux of the LCLS free electron laser we are able to access different classes of superlattice reflections, each with sensitivity to different components of the phase transition. We find that although the actual change in crystal symmetry associated with this transition occurs over different time scales characteristic of the many electronic and vibrational coordinates of the system [1-3], the dynamics of the phase transformation can be well described using a single time-dependent 'order parameter'that depends exclusively on the electronic excitation.

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