PhD THESIS DEFENSE: Probing structural coherence across a light-induced double phase transition

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June 11, 2025
10:00
ICFO Auditorium

Strongly-correlated materials have emerged as one of the most active areas of research in Condensed Matter Physics. Interests in these materials arise mainly from the pliability of their properties, offering the possibility of tailoring these materials for specific applications. This is, in turn, due to the rich interplay of interactions between electronic, orbital and lattice degrees of freedom. This complex coupling of the different degrees of freedom, on the other hand, makes strongly-correlated materials difficult to understand.
Ultrafast spectroscopy offers the possibility of resolving this bottleneck and provides insight into aspects of correlated materials crucial for enhancing our understanding of these materials. One such aspect is photoinduced phase transitions, where light drives a symmetry change in a material. To date, research has focused on using light to force materials to cross

a single structural transition. In this work, we investigate the possibility of making multiple phase jumps with a single pulse of light. A suitable system for such study is the manganite, Pr0.5Ca1.5MnO4, which despite its prospects remains less explored. This layered manganite exhibits multiple phase transitions of electronic, orbital and structural origins, as a function of temperature. The presence of more than one phase transition in Pr0.5Ca1.5MnO4 allows us to examine the possibility and mechanism of multi-phase transition, an aspect of photoinduced phase transition that has hitherto not received much attention. The physics of the manganites is strongly dictated by the dynamics of Jahn-Teller phonons, which occur at a very high frequency (>15 THz). Studies involving these phonons thus call for setups with a very high time resolution.

This thesis first discusses the construction of a novel setup that makes use of few-cycle pulses from the visible to the near infrared wavelength regions. Then, leveraging on the capabilities of this setup, we undertake ultrafast measurements on Pr0.5Ca1.5MnO4 in two parts: the linear and nonlinear pumping regimes. In the linear regime, we perform broadband, low-fluence measurements to characterize the sample. From this, we identify key structural and electronic changes that occur during the thermal transition pathway, allowing us to map out the sample into different symmetry regions, in agreement with literature. In the nonlinear pumping regime, we study the fluence dependence of the changes identified from the linear regime. By analyzing the coherent lattice response, we find indications of both single and double phase transitions occurring.

Wednesday June 11, 10:00 h. ICFO Auditorium
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Hosted by: Academic Affairs