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In-House Project - 2025

Tracking Topological Defect Motion Through Temperature at the Atomic Scale

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Strong interactions between electrons in quantum materials give rise to useful and exotic properties such as superconductivity and charge order. The quantum states are shaped by the presence of “topological” defects, which disrupt order on the nanoscale and alter their functional macroscopic properties. Understanding the behavior of these defects is thus crucial to controlling and harnessing strongly correlated materials but measuring them and their dynamics in response to applied stimuli is a significant experimental challenge.

Leveraging PARADIM’s unique cryogenic scanning transmission electron microscopy capabilities and expertise, members of the In-House Research Team performed cutting-edge atomic resolution electron microscopy measurements to track the motion of topological defects as a charge ordered phase melts in an oxide material ($Bi_{1-x}Sr_{x-y}Ca_yMnO_3$). To achieve this, the team used an advanced cryogenic sample holder to track a nanoscale region of interest while simultaneously measuring picometer-scale atomic displacements associated with charge order and controlling the sample temperature to drive the melting transition. These experiments revealed subtle reconfigurations within the network of topological defects which are critical to understanding the responses of correlated electronic phases.

N. Schnitzer, *et al.* [*Phys. Rev. X* **15**(1), 011007 (2025).]

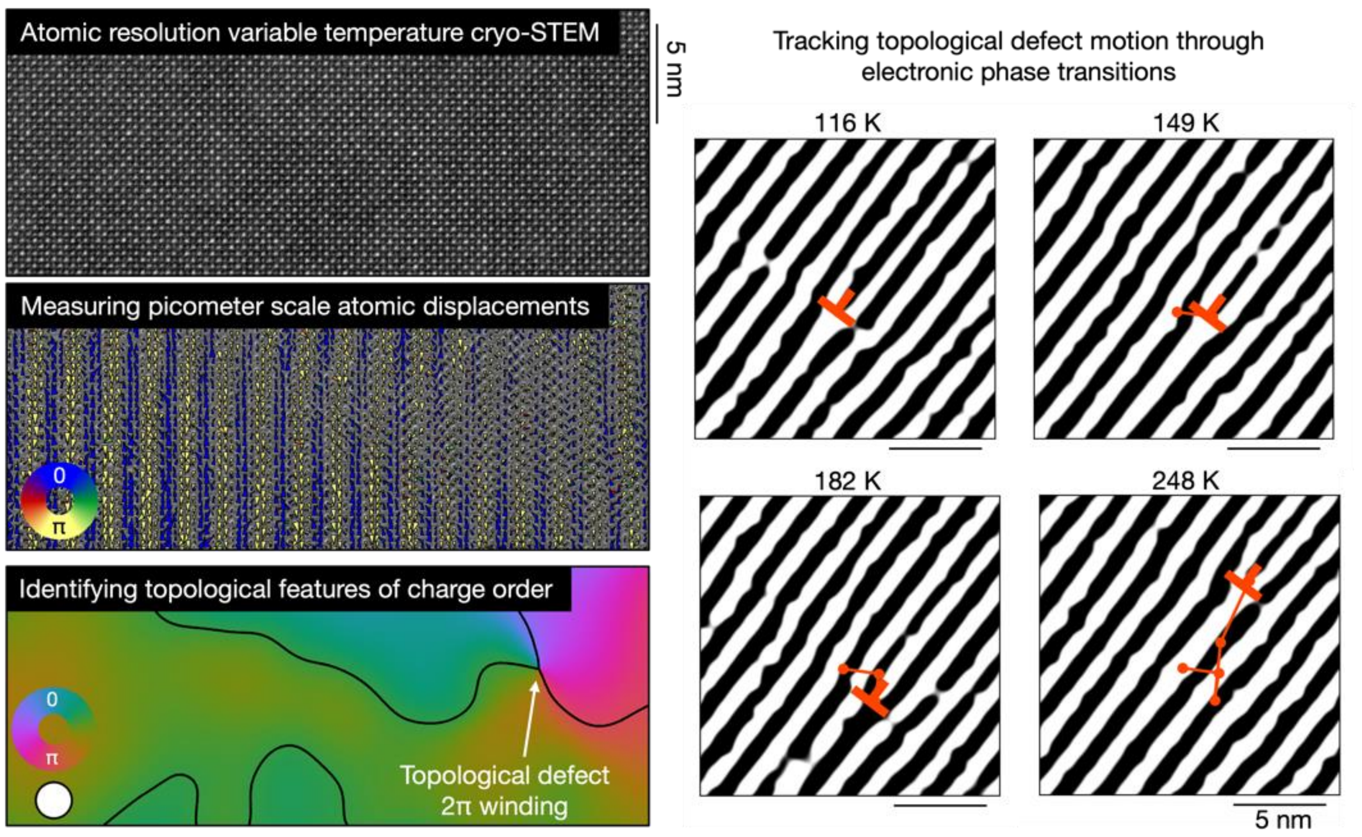

Figure: (**Left**) Atomic-resolution imaging and atomic displacement, arrows showing direction & amplitude, and orientation map of the displacement stripes at 198 K. (**Right**) Charge order defects and motion at low temperatures as indicated, while tracking the position of a topological defect (red T marker) and its trajectory through the material (thin red line).