Topological excitations in 2D charge-density-wave materials

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Topological excitations in two-dimensional materials play a crucial role in understanding various phase transitions and their unique electronic structures in 2D charge density wave (CDW) systems. 1T-TaS_2 is a prototypical 2D correlated CDW system known to exhibit multiple phases depending on temperature and external conditions. Using scanning tunneling microscopy and spectroscopy (STM/S) combined with density functional theory (DFT) calculations, we demonstrate that topological excitations, namely domain walls, are essential in driving the phase transitions in this system. We further elucidate how these domain walls couple with key properties such as correlated electrons, CDW order, and stacking order. In addition, we investigate the unique physical properties of 1D localized states emerging along the domain walls, including negative differential resistivity, kink solitons, 1D spin chains, deformation of domain wall, as well as the formation of 2D networks. Our study provides critical insights into the nature of phase transitions and emergent properties in 2D CDW materials.