Moiré polar topologies and interlayer interactions in twisted oxide membranes

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The recent realization of freestanding membranes of perovskite oxides, has enabled their deterministic mechanical assembly into twisted homo bilayers. Twisted oxide membranes surpass the limitations of epitaxial growth, which lock the direction of the crystalline axes of the growing layer to the substrate. Twisted interfaces gives rise to completely novel strain patterns though the strong long range ionic bonding in the non coherent atomic registry. Twisted ferroelectric membranes unlock a "chirality" degree of freedom opening an unprecedented opportunity to tailor topological polar landscapes in a way determined by the lateral strain modulation driven by twisting [1].

To examine the strength of interlayer interaction we have examined how strain and polar lanscapes are modified when graphene layers inserted in between of the twisted layers. We will show that, as in remote epitaxy, graphene layers partially screen the atomic potential and interlayer interaction, reducing the footprints of induced strains below the detection limit, yet ferroelectric vortices are detected for graphene thickness in the range of 3 nm suggesting the possibility of remote moiré interaction between the twisted layers. This finding opens exciting opportunities to manipulate the remote moiré interaction between the layers allowing for the exploration of novel physical effects and functionalities.

Since flexoelectricity has been demonstrated to induce polar features in a wide set of materials, a second question tackled in this presentation is whether polar topologies can be induced in twisted bilayers of non-ferroelectric materials. In this communication we explore the effect of non-homogeneous moiré strains in twisted bilayers made of $SrTiO_3$, a quantum paraelectric developing polar response at very low temperatures. We have found that twisted $SrTiO_3$ bilayers also display an array of polarization vortices. DFT simulations show polar vortex arrays in close agreement with experimental results and confirm the stability of the polar vortex state, indicating that the origin of the polar topology is a flexoelectrically induced polar state driven by a highly anomalous negative flexoelectric coefficient.

References:

[1] G. Sanchez-Santolino et al. Nature 626, 529 (2024)