Abstract Submitted
for the MAR17 Meeting of
The American Physical Society

Dual critical thickness for lattice and electronic instabilities in the $LaAlO_3/SrTiO_3$ interface. G. HERRANZ, J. GAZQUEZ, M. STENGEL, M. SCIGAJ, F. SANCHEZ, J. FONTCUBERTA, Institute for Materials Science of Barcelona ICMAB-CSIC, R. MISHRA, Washington University in St. Louis, USA, M. ROLDAN, M. VARELA, Universidad Complutense de Madrid — When matter is strongly downscaled, entirely new properties can emerge that are not present in the parent bulk crystals. A paradigmatic example is the quantum well formed at the interface between $SrTiO_3$ (STO) and $LaAlO_3$ (LAO). Their charge mismatch leads to a built-in electric field inside the LAO film, which eventually induces the formation of a two-dimensional electron system at the boundary. In addition to this electronic reconstruction, here we show that the LAO/STO system also undergoes a "phononic reconstruction" strongly coupled to the inbuilt electric fields. More specifically, we have discovered an unexpected mechanism whereby nonpolar antiferrodistortive rotations of AlO_6 octahedra couple to the internal electrostatic fields. Two basic facts can explain such an unanticipated observation: (i) the extreme confinement of LAO vibration modes, which leads to a "phonon reconstruction" that has been so far overlooked; (ii) the emergence and subsequent decline of internal electric fields, resulting from the polar/nonpolar character of this interface. Such internal fields modulate the intensity of the antiferrodistortive modes, providing a new pathway to tailor functional properties that can be extrapolated to other oxide interfaces, beyond the case studied here.

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Date submitted: 10 Nov 2016 Electronic form version 1.4