Bosonic phonon pairing causes a bulk-boundary duality

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Since the publishing of our seminary theory, "*Scale-free ferroelectricity induced by flat phonon bands in HfO_2*" [1], we have delved into the origins of unconventional ferroelectricity in HfO_2 beyond the flat phonon bands. Finally, we discovered that a bound phonon pair is responsible for the undiminished strength of the ferroelectricity even at the sub-nm scales.

While fermionic particles such as electrons are known to pair and induce observable effects such as superconductivity, bosonic entities such as phonons rarely exhibit pairing. However, in this phenomenon, all phonons in HfO_2 are paired, with each phonon is bound with its band-partner. Unlike the single phonons in conventional ferroelectricity that easily scatter at physical boundaries such as domain walls, the paired phonons bond with each other and successfully reach the domain wall's centre without losing their integrity. As a result, the condensed phonons and the structure of the bulk are fully retained at the domain wall, rendering the wall virtually indistinguishable from the bulk.

1 Hyun Jae Lee et al., Science 1343 (2020) 369.