Two-dimensional electric vortices in soft ferroelectric cylindrical nano-particles

BYOUNGHAK LEE, Department of Physics, Texas State University, San Marcos, TX 78748 USA, SERGE NAKHMANSON, Department of Materials Science & Engineering, and Institute of Materials Science, University of Connecticut, Storrs, CT 06269, USA, OLLE HEINONEN, Materials Science Division, Argonne National Laboratory, Lemont, IL 60439, USA, FERROELECTRIC VORTEX COLLABORATION — We present a theory of electric vortices in cylindrical nano-particles. Recently it was predicted that Goldstone-like states (collective, close to zero frequency excitations, requiring practically no consumption of energy) can be induced in a layered perovksite PbSr$_2$Ti$_2$O$_7$ material, manifesting themselves as “easy” rotations of the in-plane polarization vector [1]. Utilizing the results of the first-principles simulations, we fit a Landau-Ginzburg-type energy expression for this compound that couples the ferroelectric order parameter with elastic strains. We then use this expression to demonstrate that competition among bulk anisotropy, ferroelectric exchange, and surface Coulomb energies can lead to an emergence of a variety of polarization vortex arrangements in cylinder-shaped nano-particles. We also discuss the possibility of in-situ mechanical control of such vortex structures.