

# Abstract

Dr. Laurent Bellaïche proposes a basic research endeavor geared towards understanding and controlling the interactions that drive the emergence of topological phenomena in ferroic materials. Our endeavor will be articulated around three major thrusts. Namely, we will (1) establish the possibilities of tailoring microscopic lattice and spin interactions for on-demand polar and magnetic topologies, (2) derive the interaction mechanisms among topological defects in various systems, reveal their role in formation of topological phases and scrutinize means of controlling such interactions, (3) unravel and analyze the mechanisms of the coupling of topological defects to light, electrons, lattice defects and quasi-particles such as acoustic and optical phonons, magnons and phasons. To address these fundamental questions we will use unique effective Hamiltonian simulation methods and develop novel first-principles as well as first-principles-based schemes that would allow to account for the coupling of polar degrees of freedom with electrons and light at finite temperature. To understand the emergence of topological phases in low-dimensional ferroelectrics and multiferroics, we will also devise original ab initio-based many-body Hamiltonian representations based on fundamentally new types of non-local polar topological excitations. All of the proposed modeling efforts will be supported by fabrication, imaging and characterization experiments performed by world-leading government laboratories and universities collaborating on the proposed program.