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Effects of Topological Insulation on Phonon properties

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Nearing a decade of rapid progress, research on Dirac materials and topological insulators remains exceptionally active and broad, with ongoing work ranging from exotic field theory to applied physics. At the interface between theory and experiment, there is an intense interest to understand the effect of non-electronic environments on the band topology of Dirac materials.

Recent research [1, 2] has shown that, in a Dirac insulator, long-wavelength phonons can induce and stabilize topological insulation as a function of temperature. In other words, a narrow-gap semiconductor with an intrinsically trivial band topology may turn into a topological insulator in presence of electron-phonon coupling.

In this project, we study the converse effect, namely the influence of band topology on phonon properties. Using a model Hamiltonian, we calculate how electron-phonon interactions change the phonon dispersion and find that a topological insulator is more prone to lattice instabilities than a trivial insulator. This phenomenon is due to the change in the momentum-space texture of the band eigenstates across a topological phase transition. We evaluate the critical temperature for the lattice instability as a function of the bandgap, carrier concentration and transport electric fields.

[1] I. Garate, Phys. Rev. Lett. 110, 046402 (2013).

[2] K. Saha and I. Garate, arXiv (2014).

Authors: Prof. GARATE, Ion (Université de Sherbrooke); Ms LÉGARÉ, Katherine (Université de Sherbrooke)

Presenter: Ms LÉGARÉ, Katherine (Université de Sherbrooke)

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