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Polaron-like nature of massive Dirac fermions in valleytronic materials and topological insulators

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In this talk I will investigate the interplay of curvature modifications and spin-orbit interaction. As is well known, band curvature modifications can origin from electron-phonon interaction or other distortions, for example, the cubic or even higher in momentum warping term and the quadratic in momentum classical term, both of which modify drastically the transport properties (optical and magneto-optical, for example) of Dirac fermions in a topological insulator. A not so well known fact is that Berry curvature will also be modified by electron-phonon interaction and this may change the topology and dichroism of the system. Strong coupling theory of small polarons will be revisited in the presence of spin-orbit interaction and wave functions obtained there will be useful to construct low energy effective theory from the strong coupling limit. Phonon structures can be identified in many experiments, for example, STM, ARPES, Raman spectra, inelastic neutron scattering and so on. We have provided results from theoretical investigations for the first two experiments. In a recent work we have studied the optical conductivity in the presence of three terms, which are cubic, quadratic and linear in momentum, and find the interband optical conductivity will vanish when a SU(2) symmetry is recovered. This can be verified in both semiconductors and cold atoms, although the energy scale of these two systems differs by at least 1000000 times.

[1] Phys. Rev. B **87**, 155416 (2013).
[2] Phys. Rev. B **88**, 045414 (2013).
[3] Phys. Rev. B **88**, 045417 (2013).
[4] Phys. Rev. B **88**, 195133 (2013).
[5] Scientific Reports **3**, 02828 (2013).