I.V. Sankar
Euyheon Hwang
SKKU Advanced Institute of Nanotechnology and Department of Physics, Sungkyunkwan University, Suwon 16419, South Korea

ivshankar27@gmail.com

Correlated Polaronic Effects in the Kane-Mele Model

We study the possible existence of different quantum phases and the quantum phase transitions in Kane-Mele model (with Rashba spin-orbit coupling) [1] on honeycomb lattice in the presence of both electron-electron and electron-phonon interactions. The electron-electron and electron-phonon interactions are modeled as a Holstein-Hubbard model. The Kane-Mele model together with the Holstein-Hubbard model exhibits several quantum phases such as topological insulating, quantum spin Hall, Mott insulating, Peierls insulating, and metallic states makes the model very interesting to investigate. The conducting edge states are spin polarized. The existence of these spin-polarized currents and pure spin currents are crucial for spintronic devices and the electrical control and interaction effects play an important role in constructing spintronic devices. Here, we present the interaction effects on these spin-polarized currents exhibited by the edge states. The combined model allows us to study simultaneously the electron-electron and electron-phonon interaction, and Rashba spin-orbit coupling effects and their competitions. We present the results of the model in the infinite/bulk honeycomb lattice and honeycomb ribbon to explore the *correlated polaronic* effects in topological insulator states. The model cannot be solved exactly owing to the presence of electron-phonon coupling which we treat approximately using the variational approach. In the variational approach, we eliminate phonon by choosing a suitable variational phonon state [2,3] and obtain the effective or correlated-polaronic Kane-Mele model which can be solved exactly to obtain the ground state energy, band structure, and spectral function for the bulk system. We also calculate the correlated-polaronic effects on the edge states for the zigzag ribbon and quantum spin Hall conductance.

References

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[3] P.J. Monisha, I.V. Sankar, S. Sil, and A. Chatterjee, Scientific Reports 6 (2016) 20056.

Figures

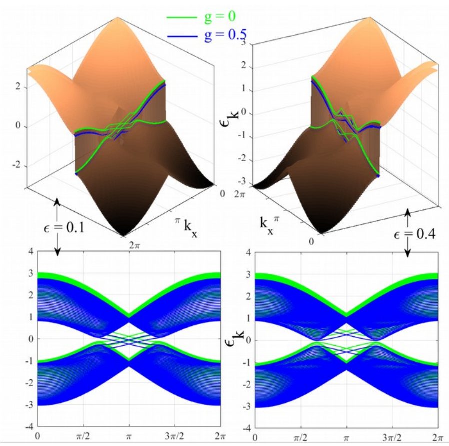

Figure 1: The zigzag edge states with (g=0.5) and without (g=0) electron-phonon interaction strength in the absence of electron-electron interaction.