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Mott-insulators vs. bipolaronic insulators in a deformable lattice and their transitions to metallic ground states by tuning the deformation potential

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Insulator-to-metal transitions (IMTs) still remain a central theme in condensed-matter physics despite many zealous experimental and theoretical efforts. The persistence of this question for decades can be attributed to the complexities that arise due to strong correlation-effects and many degrees of freedom that exist in real systems. The seminal work of Mott introduced insulating character originating from strong on-site Coulomb repulsion energy U. The ratio of U and Hubbard bandwidth W (U/W) is a critical parameter that tips the balance of insulating and metallic states. However, in real systems, correlation effects are not limited to these two parameters, and effects from intra-atomic exchange energy, orbital degeneracy, crystal-field splitting, etc., come into the equation. For electrons in a deformable lattice, electron-phonon interaction energy S and the induced deformations become crucial parameters that govern the evolution of the transfer integral t. Aluminosilicate zeolites ($M_aAl_aSi_bO_{2(a+b)}$) provide an ideal, but non-trivial playground for exploring such interactions. The negative charge of $Al_aSi_bO_{2(a+b)}$ framework is balanced by the cations M_a and present a deformable lattice. Guest electrons can be introduced into this deformable lattice through encapsulation of guest atoms. Experimental investigations show that even with same/comparable effective U, subtle changes in the deformable lattice (in turn change in the deformation potential), and tuning of S by changing M can give rise to different ground states. The competition between U, t and S together with the electron density governs the balance between insulating vs. metallic states and magnetic vs. nonmagnetic states directing the discussions of IMTs towards a relatively old but less discussed branch, the "Polaron Physics".

Biography

Gayan Prasad Hettiarachchi completed his PhD in Physics at Osaka University in 2015. He is currently working as a specially-appointed Assistant Professor at the Institute for NanoScience Design at Osaka University. He is interested in experimentally investigating strongly-correlated electron systems in order to elucidate vital correlation effects and the underlying mechanisms that ultimately lead to interesting physical properties and phase transitions.

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