Analog quantum simulators of small-polaron physics

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The small-polaron problem – that of an excess carrier (electron or a hole) whose kinetic energy is heavily suppressed due to a self-induced deformation of the host-crystal lattice – is typically addressed within the framework of the Holstein molecular-crystal model. In this talk, two analog quantum simulators for the one-dimensional version of this model will be discussed, based on arrays of trapped ions and superconducting transmon qubits (circuit-QED setup) as their respective physical platforms [1,2]. We show that in both cases the strong excitation-phonon coupling regime – characterized by small-polaron formation – can be reached using realistic values of the underlying-system parameters. We propose state-preparation schemes, as well as experimental probes for validating the polaronic character of the phonon-dressed excitations in both physical platforms. We perform a comparative analysis of the two realizations of the Holstein model, and conclude by underlining their potential use for studying the dynamics of small-polaron formation and density-driven destabilization of such excitations.

[1] V. M. Stojanovic, T. Shi, C. Bruder, and J. I. Cirac, Phys. Rev. Lett. 109, 250501 (2012).

[2] F. Mei, V. M. Stojanovic, I. Siddiqi, and L. Tian, unpublished.