

Towards efficient numerical description of hybrid quantum systems: a study of extended Hubbard-Holstein model

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Systems with intermediate and strong coupling still pose important questions in the field of condensed matter. In these regimes, conventional analytical methods become ineffective, and numerical computations become computationally expensive due to the exponential scaling of the problem. Regardless, lots of different numerical methods (DMRG, QMC, ED) were developed to minimize scaling and examine the systems and its variants in the best possible way. The natural progression was to introduce hybrid systems, where bosons and fermions interacted with themselves, as well as with phonons or photons. Unfortunately, due to the infinite nature of this additional Hilbert space, these new types of systems require a novel approach. The method of non-Gaussian variational ansatz [1] allows us to map the problem onto an effective model that encapsulates a higher-order correlation effect. We use this method to study a hybrid system of electrons interacting with phonons, i.e. Hubbard-Holstein model.

[1] Shi, Tao, Eugene Demler, and J. Ignacio Cirac. "Variational study of fermionic and bosonic systems with non-Gaussian states: Theory and applications." *Annals of Physics* 390 (2018): 245-302.