ID de Contribution: **16** Type: **Non spécifié**

Polaron interactions and bipolarons in one-dimensional Bose gases in the strong coupling regime (ONLINE presentation)

mardi 24 août 2021 14:00 (1 heure)

Bose polarons, quasi-particles composed of mobile impurities surrounded by cold Bose gas, can experience strong interactions mediated by the many-body environment and form bipolaron bound states. Here we present a detailed study of heavy polarons in a one-dimensional Bose gas by formulating a non-perturbative theory and complementing it with exact numerical simulations. We develop an analytic approach for weak boson-boson interactions and arbitrarily strong impurity-boson couplings. Our approach is based on a mean-field theory that accounts for deformations of the superfluid by the impurities and in this way minimizes quantum fluctuations. The mean-field equations are solved exactly in Born-Oppenheimer (BO) approximation leading to an analytic expression for the interaction potential of heavy polarons which is found to be in excellent agreement with quantum Monte-Carlo (QMC) results. In the strong-coupling limit the potential substantially deviates from the exponential form valid for weak coupling and has a linear shape at short distances. Taking into account lowest-order BO corrections we calculate bipolaron binding energies and find excellent agreement with QMC results for impurity-boson mass ratios as low as 3.

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