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Polaron physics with cold atoms

We show that if you apply the Bogoliuobov approximation on the Hamiltonian of an impurity in a Bose-Einstein condensate it is possible to cast the resulting Hamiltonian in the generic form of Frölich's polaron Hamiltonian. As compared to the archetypical polaron the role of the electron is replaced by the impurity and the role of the phonons by the Bogoliubov excitations. With the specific dispersion and interaction amplitude for the system we derive an expression for the polaronic coupling strength as a function of the scattering lengths, the trap size and the number of bosons. This relation identifies several approaches to reach the polaronic strong coupling regime that so far have not been experimentally reachable in other polaron systems. We then make use of Feynman's path-integral approach to calculate the polaronic shift in the free energy and the effective mass for arbitrary coupling strength. This is done in a formalism that allows us to include the temperature dependence. We find some similarities with the acoustic polaron and indications of a transition between a free polaron and a self-trapped state. The current theory is applied to the specific system of a lithium impurity in a sodium condensate.

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