Finite-momentum impurity in one-dimensional Bose gas

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Talking about impurities in condensed matter systems we mainly keep in mind the situation when a very small number of atoms is immersed in the majority of bath particles. In a linear approximation in density of these extraneous particles both effects of the impurity statistics and the impurity-impurity interaction can be freely neglected and one faces the problem of a single particle loaded in the many-body environment. When this medium is formed by cold Bose-condensed atoms the problem is usually called the Bose polaron one.

Recent experimental realization of single mobile impurities in Bose-Einstein condensates of alkalies stimulated theoretical efforts for studying the dynamic and spectral properties of Bose polarons which, however, are mostly directed on the investigation of low-energy parameters of the impurity spectrum and a question of the finite-momentum Bose polaron behavior is typically left opened.

In this talk we discuss the full momentum dependence of spectrum of a point-like impurity immersed in a dilute one-dimensional Bose gas. Particular we elaborate, the path-integral approach whose semi-classical approximation leads to the conventional mean-field treatment of the problem while quantum corrections can be easily accounted by standard loop expansion techniques. The extracted low-energy parameters of impurity spectrum, namely, the binding energy and the effective mass of particle, are shown to be in qualitative agreement with the results of quantum Monte Carlo simulations.