Bose polaron in ideal Bose gas at finite temperature

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When the impurity atom interacts with the Bose environment it forms quasiparticle called Bose polaron. Important progress in investigation of single Bose polarons experimental possibility control by parameters of the Bose bath and directly observe by behavior of the impurity atom [M. G. Hu, Phys. Rev. Lett. **117**, 055301 (2016); N. B. Jorgensen, Phys. Rev. Lett. **117**, 055302 (2016)]. The approximate theoretical methods and Monte Carlo simulations give us a complete picture for the explanation of properties of Bose polarons at low temperatures.

The behavior of the Bose polaron at finite temperatures is interesting, but almost not studied, because of features arising in the region of critical point, where the Bose system undergoes superfluid transition. Particularly, in [N. E. Guenther, Phys. Rev. Lett. **120**, 050405 (2018)] two branches of spectrum of the attractive Bose polaron in the case strong of boson-impurity interaction were discovered. The infrared behavior of Green's function of Bose polaron weakly coupled to the dilute D-dimensional gas in close vicinity of the Bose-Einstein condensation transition temperature was studied in [V. Pastukhov, J. Phys. A: Math. Theor. **51** 195003 (2018)]. In the work [J. Levinsen, Phys. Rev. A. **96**, 063622 (2017)] the authors show, by means of the second order perturbation theory in terms of the boson-impurity coupling parameter applied to a mobile impurity immersed in Bose gas, that the self energy of the Bose polaron in the region of critical temperature is divergent. In order to explain the physical nature of the above mentioned features of the Bose polaron spectrum we considered a simplified model of an impurity immersed in the ideal gas of bosons at temperatures close to the Bose-Einstein condensation transition point. By using of the non-self-consistent t-matrix approach we found out that the binding energy and life-time of the impurity loaded in Bose gas remain finite even in the critical region.