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New complex states in the system of one-level localized quasi-particles interacting with polarization phonons at T≠0K

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The confined sizes of nanoobjects (quantum layers, wires and dots) bring to the size quantization of quasi-particles spectra. Thus, the problem of inter-level or inter-band interaction between the quasi-particles and quantized fields (phonons, photons) becomes more and more actual. The mathematical aspects of the theory of renormalized spectra of interacting quasi-particles are very complicated, especially at finite temperature due to the essential role of multi-phonon processes.

In the present paper, using the Feynman-Pines diagrams technique, the consistent theory of renormalized spectrum of one-level system of localized quasi-particles interacting with nondispersive polarization phonons at $T \neq 0K$ is developed. At its time, the same problem was solved within the simplified model where it was assumed that the operators of creation and annihilation of quasi-particles states satisfy the condition $\left(B_n\, B_n^+\right)^N = B_n\, B_n^+$. At such additional condition the spectrum was obtained exactly. It consisted of the ground state, shifted into the low-energy region and infinite number of bound quasi-particle-phonon states in the high-energy region. The latter are equidistant with the difference between energy levels of one phonon energy and does not depend on temperature.

The detailed analysis of the mathematical structure of mass operator diagrams of high order over the coupling constant gave us opportunity to develop the new approach of partial summing of the infinite ranges of main resonance diagrams and to reveal the spectrum of the system with all complex states at $T \neq 0K$ in the vicinity of one-phonon repeats in both energy regions. Herein, it is shown that besides the earlier known bound states, the two new high-energy satellites and one low-energy satellite exist. Their energies depend on temperature.