# Bose-Einstein condensation in the Bose-Fermi lattice gas with strong correlations

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Observations of BE-condensation of the ultracold Bose-atoms in optical lattices (Greiner et al., 2002, $^{87}Rb$) stimulates a considerable increase of interest to quantum effects in systems of such a type. Bose-Hubbard model is used as a basis for theoretical description of this effect that is determined by interplay of transfer of particles ($t$) and their on-site repulsion ($U$). The effect exists also in atomic B-F mixture on a lattice (Gunter et al., 2006, $^{87}Rb -^{40} K$). Investigations of the Fermi-atoms influence on BE-condensation, that continue for a long time, are performed in the framework of Bose-Fermi-Hubbard model with allowance for the on-site Bose-Fermi interaction ($U_{BF}$).

Description, performed in the regime of given values of chemical potentials $\mu_B$ and $\mu_F$, reveals a possibility of change of order of the phase transition (from 2nd to the 1st one) to the SF phase with BE-condensate (Stasyuk, Krasnov, 2015). The phase diagrams $(\mu_B, \mu_F)$ and $(|t_0|, \mu_B)$ give an evidence of this feature of BF mixture. At the temperature change, the re-entrant phase behavior can take place (with SF phase as intermediate one).

We show that the BF interaction influence is asymmetric with respect to the sign of $U_{BF}$ parameter. The phase sequences are different in the cases $U_{BF} > 0$ and $U_{BF} < 0$. We consider also the boson one-particle spectrum found in RPA. The reconstruction of the respective spectral density at the change of $\mu_B$ and $\mu_F$ in different phases is analyzed.

Our study is performed in the limit of strong boson correlations (in the cases: 1) $U \to \infty$, $n_i^B \leq 1$ (hard-core bosons); 2) $U^{(3)} \to \infty$, $n_i^B \leq 2$) and in the heavy fermion approximation. The approach is used, whereby the $U_{BF}$ interaction is taken into account exactly.