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Four types of phase transitions in interacting meson (boson) matter at high temperatures

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Within the framework of the mean field model, the thermodynamics of the relativistic scalar system of interacting particles and antiparticles in the presence of a Bose-Einstein condensate is investigated. It is assumed that the total isospin (charge) density is conserved. It is shown that the particle-antiparticle boson system reveals four types of phase transitions into the condensate phase. Three types belong to the phase transition of the second order and one to the first order. Along with the standard second-order phase transition with the formation of a Bose condensate only in the temperature range $0 \leq T \leq T_c$, three new ones have appeared: the formation of multiple condensate states, a second-order meta-phase transition without the formation of condensate, and the formation of condensate at finite temperatures through a first-order phase transition.

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