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Microscopic theory of BEC phase transition in a critical region VITALY KOCHAROVSKY, Texas A&M University, VLADIMIR KOCHAROVSKY, Inst. of Applied Physics of the Russian Academy of Science and Univ. of Nizhny Novgorod, Russia — A microscopic theory, which should connect the asymptotics of the ordered and disordered phases across a critical region, has not been found so far even for anyone of the numerous phase transitions. Here we present such microscopic theory for a phase transition in an interacting Bose gas [Phys. Lett. A 378, n. 49 (2014)]. It allows one to describe formation of a condensate phase from a disordered phase across an entire critical region continuously. We find an exact Hamiltonian for Bose-Einstein condensation (BEC) in a mesoscopic system and derive the exact fundamental equations for the condensate wave function and Green's functions, which are valid both inside and outside critical region. They are reduced to the usual Gross-Pitaevskii and Beliaev-Popov equations in a low-temperature limit outside critical region. The theory is readily extendable to other phase transitions. All these advances come from a correct account, first, of the Noether's symmetry constraints in a many-body Hilbert space and, second, of the related properties of true excitations in a mesoscopic system. In a limit of vanishing interaction, the theory is reduced to a recently found analytical theory of universal critical fluctuations in BEC of an ideal gas [Phys. Rev. A 81, 033615 (2010); 90, 033605 (2014)].

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