Dynamics of the condensed Bose gas at the nonzero temperatures

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Bose-Einstein condensation (BEC) - one of the most interesting phenomena foreseen by quantum statistical mechanics. It is unique, because to be the exclusively quantum-statistical phase transmission and may occur without interaction between atoms. In the 1995 was got BEC "in a clean kind" in the trapped dilute ultracold clouds of alkaline metals.

Creation of the microscopic theory that described dynamics condensed Bose gas is very important problem. The foundation of theoretical description such quantum degenerate systems with spontaneous broken symmetry were laid by Bogolyubov in the paper about weakly-nonideal Bose gas. A central place in his theory occupies idea about separation of the condensate. To difference from Bogolyubov's model of weakly-nonideal Bose gas, the atomic Bose condensate is spatial inhomogeneous. At the temperatures close to zero (0 — $0.2\,T_{BEC}$), when almost all atoms being in condensate, the dynamics of atomic Bose condensate is describing by nonlinear equation for condensate wave function — Gross-Pitaevskii (GP) equation. In this temperature region GP equation very precise describe the experimental date with condensate (condensate oscillation, interferences of condensates etc). At higher temperatures, when an appreciable fraction of atoms is excited out of the condensate, the dynamics of the trapped gas becomes much more complicated since it now involves the coupled motion of the condensate and the non-condensate degrees of freedom. Thus description of the atomic Bose condensate at the nonzero temperatures in terms of GP equation is inadequate.

In this paper, from the first principles, we obtain generalized GP equation, which include the non-condensate degrees of freedom. This equation isn't closed, because dynamics of the non-condensate atoms is indefinite. For description of the non-condensate atoms, using Zubarev's method of nonequilibrium statistical operator, we derived Boltzmann quantum kinetic equation. Therefore we obtain complete dynamics of the condensed Bose gas at the nonzero temperatures.