Generalized Gross-Pitaevskii equation in kinetics of spatially nonuniform Bose condensate

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An approach to kinetics of Bose gas in the presence of condensate developed in paper [1] was simplified and justified by us. We describe state of the system with amplitude $\eta(x,t)$ of wave function of the condensate $\psi(x,t)$ (average value of Bose field operator), velocity of the condensate $v_n(x,t)$ and distribution function of the Bogolyubov quasiparticles $f_p(x,t)$. For these values and for phase $\varphi(x,t)$ ($\psi = \eta e^{i\varphi}$) of the condensate wave function evolution equations were obtained ($v_n = \frac{\hbar}{m}\frac{\partial\varphi}{\partial x_n}$, m is mass of a particle). Small parameter λ of interaction $\Phi(r)$ is chosen in accordance with relations $\Phi(r) \sim \lambda^2, \eta \sim \lambda^{-1}$; gradients of values η, v_n, f_p are considered as small values of the order g. According to our definition a generalized Gross-Pitaevskii equation can be obtained from the derived equations as an equation for ψ or for η and φ in the absence of quasiparticles (i.e. at $f_p = 0$). Let us give here the obtained equations assuming for simplicity that $g \sim \lambda$ and omitting contributions of the order λ^3

$$\dot{\eta} = -v_l\frac{\partial\eta}{\partial x_l} + \{\frac{1}{2\eta}(\frac{\eta}{2}\frac{\partial}{\partial\eta} - 1)n_0(\eta) - \frac{\eta}{2}\}\frac{\partial v_l}{\partial x_l}$$

$$\hbar\dot{\varphi} = -m\mu_0(\eta) - \frac{mv^2}{2} + \frac{\hbar^2\triangle\eta}{2m\eta} - \alpha\frac{\partial}{\partial x_l}(\eta\frac{\partial\eta}{\partial x_l}), \qquad (1)$$

where $n_0(\eta)$, $\mu_0(\eta)$ are equilibrium density of particle number and chemical potential at zero temperature; $\alpha = 4\pi\int drr^4\Phi(r)/3$. Equations (1) was applied by us to studying of wave close to equilibrium and structure of vortexes in the condensate.

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1. Peletminsky S.V., Sokolovsky A.I., Shchelokov V.S. Theor. and Math. Phys., 1977, V.30, P.57-72 (in Russian).