BOSE-EINSTEIN CONDENSATE A WITH A DEFOCUSING NONLINEARITY IN THE POTENTIAL $X^2 + MX^3$

X.N.Ismatullaev

NUUz

Abstract. Eigenfrequencies are found for oscillations of the width and center of mass of the Bose Einstein condensate in an anharmonic potential

The dynamics of a one-component Bose condensate in a parabolic trap has a simplified character due to the fact that the fluctuations in the width and coordinates of the center of mass of the condensate are independent of each other [1]. In [2], the case of an anharmonic trap $V(x) = x^2 + mx^4$, with a small parameter m was considered , and it was shown that, in an anharmonic trap, the fluctuations in the width and coordinates of the center of mass of the condensate are mutually related. It was shown that fluctuations in the position of the external potential lead to fluctuations in the width of the condensate. In this paper, we study the dynamics of a condensate with a focusing nonlinearity in an external potential of the form $V(x) = x^2 + mx^3$, with a small parameter *m.* The asymmetric form of the potential is chosen so that the fluctuations in the width lead to fluctuations in the center of mass of the potential, which is impossible in a condensate in symmetric potentials. The dynamics of the Bose condensate is described by the Gross- Pitaevskii equation ,

$$iu_t = -\frac{1}{2}u_{xx} + F(t)V(x)u - g|u|^2 u, \quad (1)$$

where the subscripts t and x mean differentiations with respect to time and coordinate, respectively, $V(x) = x^2 + mx^3$ - external field, g *is* the coefficient of two-particle interaction, which we consider to be negative, $F(t)=1+0.1\,Sin(wt)$ *is* the external potential coefficient, the changes of which describe the changes in the strength of the external potential. Periodic oscillations of the strength of the external potential in asymmetric potentials lead to oscillations of the center of mass of the condensate. For the condensate wave function $u(x,t)$ we use the following ansatz :

$$u = A(t)\exp\left(\frac{(x-x_0(t))^2}{2w^2(t)} + ik(t)(x-x_0(t)) + \frac{ib(t)(x-x_0(t))^2}{2}\right), \quad (2)$$

where the parameters A , w, b , x_0 k are amplitude, width, chirp , center of mass and velocity and linear phase, respectively. Using ansatz (2), we have obtained a system of variational equations for the parameters of the condensate. The results of variational equations showed that a periodic change in the strength of the external potential leads to oscillations of the center of mass of the condensate and small oscillations of the system have the following natural frequencies:

$$\nu_\omega^2 = 2F + \frac{3}{\omega^4} + \frac{\sqrt{2}gN}{\sqrt{\pi}\omega^3}$$

$$\nu_x^2 = 2F$$

The explicit form of the frequencies is necessary to analyze the possibility of simultaneous resonance in the oscillations of the width and center of mass of the condensate.

Literature

1. F.Kh. _ Abdullaev , J. Garnier, Phys. Rev. A **70** , 053604 (2004)
2. F. Kh . Abdullayev , R. _ M. Galimzyanov , Kh.N. _ Ismatullaev , J. Phys. B **41 ,** 015301 (2008)