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Collective oscillations of a quasi-one-dimensional Bose condensate under damping

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Abstract

Affect of the damping on collective oscillations of a quasi-one-dimensional trapped repulsive Bose gas has been studied. Based on the phenomenological damping approach [L.P. Pitaevskii, Zh. Eksp. Teor. Fiz. 35 (1958) 408, Sov. Phys. JETP 35 (1958) 282] developed by Pitaevskii variational equations for the parameters of the condensate wave function have been derived. Analytical expressions for the condensate parameters in the steady-state have been obtained. Combined effect of the *resonant periodical variation of the trap strength* and the *damping* has been shown to change drastically asymptotical behavior of the driven norm oscillations. Bistability in nonlinear oscillations of the condensate under periodic variations of the trap potential is predicted.

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1. Introduction

The dynamics of a one-dimensional trapped ultra-cold Bose gas has attracted a great attention for last years [2,3]. Recently 1D regime has been realized experimentally in [4]. Measurements of the collective oscillations of such a system should give a lot of information about the BEC dynamics. In particular this is important in the analysis of the condensate dynamics in a magnetic waveguide, being a fundamental atom optical element [5].

A trapped 1D repulsive Bose gas is known [4] to be characterized by a single parameter $\zeta = mg_{1D}/(\hbar^2 n_{1D})$ which is the ratio between interaction energy and the kinetic energy of the ground state, m , g_{1D} and n_{1D} being atomic mass, the strength of interaction and 1D density correspondingly. Different regimes in one-dimensional geometry are possible depending on the

density of gas. In the high density regime ($\zeta \ll 1$) the dynamics at low temperatures is described by a one-dimensional Gross–Pitaevskii equation with cubic mean field nonlinearity. The low density regime ($\zeta \gg 1$, Tonks–Girardeau (TG) regime) is characterized by the strong quantum correlations and a fermionic behavior of the system [6–8]. Modern experiments cover both of these limiting cases. Computations of the collective excitations frequencies of a trapped 1D repulsive Bose gas for different 1D configurations varying from the mean field regime to the TG regime were performed in [9]. In the present work we will concentrate our attention on the description of the quasi-one-dimensional dynamics of a repulsive BEC in the mean field regime.

Performed by now theoretical descriptions have mainly dealt with conservative systems (e.g., see [5,10]), where collective oscillations of a quasi-1D Bose–Einstein condensate (BEC) in the low and high density regimes were investigated. However the dissipation inheres in real systems. So it is of interest to investigate theoretically effect of damping on collective oscillations of a one-dimensional trapped repulsive Bose gas. The

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