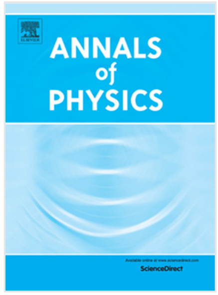

High-density limit of quasi-two-dimensional dipolar Bose gas

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High-density limit of quasi-two-dimensional dipolar Bose gas

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Abstract

We consider a simple model of the quasi-two-dimensional dipolar Bose gas confined in the one-dimensional square well potential. All dipoles are assumed to be oriented along the confining axis. By means of hydrodynamic approach it is shown that the general structure of the low-lying excitations can be analyzed exactly. We demonstrate that the problem significantly simplifies in the high-density limit for which the density profile in the confined direction as well as the leading-order contribution to the ground-state energy and spectrum of elementary excitations are calculated. The low-temperature result for the damping rate of the phonon mode is also presented.

1 Introduction

For more than decade the dipolar condensates of atoms with large magnetic moments can be realized experimentally [1, 2, 3, 4]. Such experimental progress stimulated extensive theoretical studies (see, for instance, reviews [5, 6, 7]). On the other hand, it is well-known that three-dimensional Bose gas with only dipole-dipole interaction is unstable, but presence of any trapping potential that strongly confines system in the direction of the external magnetic (electric) field stabilizes the system [8, 9, 10]. The reason underlying this property can be easily understood even on the mean-field level. In this approximation, which accurately describes only dilute systems, the stability condition is fully controlled by the sign of zero-momentum Fourier transform of the effective two-body interaction between particles. Although this potential functionally depends on the one-dimensional density profile in the confining direction, but at least weakly-interacting quasi-two-dimensional dipolar Bose systems are always stable. Another interesting feature of such objects is the existence of maxon-roton behavior of the excitation spectrum [11] even in the simplest Bogoliubov's approximation. As the result the Beliaev damping of these quasi-particles disappear in

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