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Bose-Einstein condensates and the thin-shell limit in bubble traps

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Bose-Einstein condensation (BEC) is a quantum phenomenon which is nowadays intensively explored both theoretically and experimentally. Such a phase is defined when there is a macroscopic number of particles sharing the same 1-particle quantum state, so that they can be described by one equal quantum wave function. BEC has many interesting properties, but one which stands out is the appearance of a pseudo-potential due to a geometric deformation on the trapping manifold (1) in the thin-shell limit. The true theoretical aspects of this pseudo-potential are somehow related to the curved nature of the manifolds in which the trapping stands in real space. In BEC, the pseudo-potential nature is far from being investigated. With the growing use of cold atoms to design BEC different models and experimental setups have appeared in the literature, in particular, the bubble trap shaped potential has been of great interest (2), due to its fairly easy experimental manipulation. The behavior of pseudo-potentials in relation to physical parameters still presents challenges in regard to the theoretical description, in special to the case of the BEC on the bubble trap in the thin-shell limit. The reason RF-dressed potentials are of so much interest for experimentalists is that they are very adjustable and smooth. The high level of control in these experiments allows for the building of many complex trap geometries. The bubble can be produced using a radiofrequency field in an adiabatic potential based on a quadrupole magnetic trap. Here, we used both numerical and direct integration methods for the theoretical investigation of the system. Basically, the direct integration studies consist on the energy minimization in relation to the variation parameters, investigations on expansions of the geometrical quantities and interpretations of the Hamiltonian and its solutions; while the numerical ones are based on the direct result of the time-independent Gross-Pitaevskii equation (GPE) in conjunction with real-time three-dimensional long-scale simulations. (3) In this ongoing work, we have found so far, the Hamiltonian of the system in the thin-shell limit approximation and considered some particular cases such as the perfect sphere geometry for the bubble trap and the Thomas-Fermi approximation. In the current status of this research, we continue questioning the nature of the normal modes' oscillations and its physical properties, which, at this point, we know are geometry-related.

Palavras-chave: Bose-Einstein condensates. Thin-shell limit. Bubble trap.

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