Titolo Tesi: Low-Dimensional Quantum Gases in Curved and Flat Geometries

Abstract:

Low-dimensional quantum gases, produced by confining and cooling atoms in two- or in one-dimensional configurations, display a rich variety of equilibrium and nonequilibrium properties. The emerging experimental techniques for controlling both their geometry and their topology, by trapping these systems, for instance, in rings or in hollow shells, offer a promising route for the investigation of quantum many-body physics in curved spatial domains. In this thesis, we discuss the quantum statistical properties of spherically-symmetric bosonic shells, analyzing the phenomena of Bose-Einstein condensation and of superfluidity in the finite-size two-dimensional regime. Adopting the functional integral formulation of quantum field theory, we obtain the finite-temperature equation of state of these shell-shaped systems, and, with similar techniques, also of two-dimensional flat superfluids, both bosonic and fermionic. Moreover, we quantitatively analyze the hydrodynamic excitations at finite temperature, which consist of the first and second sound in flat superfluids, and which are the main probe of the Berezinskii-Kosterlitz-Thouless superfluid transition. We conclude our analysis by studying bright solitons in one-dimensional Bose-Bose mixtures, and discussing the quench dynamics of tunneling quasicondensate tubes.