Scaling theory for the collapse of a trapped Bose gas in an artificial magnetic field: a critical study at the condensation point

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Although Bose-Einstein condensate (BEC) had been predicted in 1924 by Albert Einstein and Satyendra Nath Bose, the atomic BEC in ultracold gases has been a subject of intense investigation since their proposal by Eric Cornell and Carl Wieman in 1995. In this work, we have analytically explored both zero and finite temperature scaling theory for the collapse of an attractively interacting 3D harmonically trapped Bose gas in an artificial magnetic field. We have considered short-range (contact) attractive inter-particle interactions and the Hartree-Fock approximation for the same. We studied the collapse of the condensate and the thermal cloud below and above the condensation point, respectively. We have obtained anisotropy, artificial magnetic field, and temperature-dependent critical number of particles for the collapse of the condensate. We have found a dramatic change in the critical exponent (from $\alpha = 1$ to 0) of the specific heat ($C_v \propto |T - T_c|^\alpha$) when the thermal cloud is about to collapse with the critical number of particles ($N = N_c$) just below and above the condensation point. Our findings shed light on the intricate interplay between the critical number of particles, critical exponent of specific heat, and artificial magnetic field within the finite temperature scaling theory, offering new avenues for theoretical exploration and experimental verification set-up for the ultracold systems in the magneto-optical traps.

Keywords: Bose-Einstein Condensation, Artificial Magnetic Field, Hartree-Fock Approximation, Critical Exponent of Specific Heat.

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