[P4] Two-dimensional Bose-Einstein condensate under pressure

Wonyoung Cho, Sogang University

Evading the Mermin-Wagner-Hohenberg no-go theorem and revisiting with rigor the ideal Bose gas confined in a square box, we explore a discrete phase transition in two spatial dimensions. Through both analytic and numerical methods, we verify that thermodynamic instability emerges if the number of particles is sufficiently yet finitely large: specifically, $N \geq 35131$. The instability implies that the isobar of the gas zigzags on the temperature-volume plane, featuring supercooling and superheating phenomena. The Bose-Einstein condensation can then persist from absolute zero to the superheating temperature. Without necessarily taking the large N limit, under a constant pressure condition, the condensation takes place discretely both in the momentum and in the position spaces. Our result is applicable to a harmonic trap. We assert that experimentally observed Bose-Einstein condensations of harmonically trapped atomic gases are a first-order phase transition that involves a discrete change of the density at the center of the trap.