

Advanced Statistical Mechanics 171.703

Homework Assignment 6

Due date Friday, March 12

Reading. Chapters 7.1–7.4 in Pathria.

1. Bose condensation in 2 dimensions Show that Bose condensation of the ideal nonrelativistic Bose gas in 2 spatial dimensions occurs at zero temperature.

2. Bose condensation in a trap. An ultracold gas of $N \gg 1$ bosonic atoms is kept in a trap with a harmonic potential

$$U(x, y, z) = \frac{m\omega_x^2 x^2}{2} + \frac{m\omega_y^2 y^2}{2} + \frac{m\omega_z^2 z^2}{2}.$$

Determine the temperature of Bose condensation for sodium atoms in an optical trap used by the Ketterle group [1]:

$$\omega_x/2\pi = 235 \text{ Hz}, \quad \omega_y/2\pi = 410 \text{ Hz}, \quad \omega_z/2\pi = 745 \text{ Hz}, \quad N = 1.2 \times 10^6.$$

3. The ideal Bose gas is not a superfluid. Show that the mass of the “normal component” [2] of an ideal Bose gas equals the total mass even below the condensation temperature. Thus there is no superfluid part, even though there is a condensate.

References

- [1] K.B. Davis *et al.*, [Phys. Rev. Lett. **75**, 3969 \(1995\)](#).
- [2] L. Landau, *J. Physics* **5**, 71 (1941).