Exercises in Statistical Mechanics

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This exercises pool is intended for a graduate course in "statistical mechanics". Some of the problems are original, while other were assembled from various undocumented sources. In particular some problems originate from exams that were written by B. Horovitz (BGU), S. Fishman (Technion), and D. Cohen (BGU).

======= [Exercise 6010]

Effusion from a box with Bose gas and magnetic field

Bosons that have mass m and spin 1 with gyromagnetic ratio γ are placed in a box. The temperature T is below the condensation temperature. A strong magnetic field B is applied in the z direction. A hole that has small area δA is drilled in the box so the particles can flow out. The flux is separated into 3 beams using a Stern-Gerlach aparatus. Each beam is directed into a different container.

(a) Write the single particle Hamiltonian.

(b) Find the velocity distribution $F_{S_z}(v)$ for $S_z = -1, 0, 1$.

(c) Define what does it mean a strong magnetic field, and explain why and how it helps for the solution of the next item.

(d) Find how many particles are accumulated in each container after time t.

(e) Find what would be the velocity distribution for horizontal filtering $S_x = -1, 0, 1$ of the beam.

Express your answer using $\mathsf{m}, \gamma, B, \delta A, T, t$. In the last item assume that $F_{S_z}(v)$ is known, irrespective of whether the second item has been solved.

$$\int_0^\infty x^3 e^{-x^2} dx = \frac{1}{2}, \int_0^\infty \frac{x^3}{e^{x^2}-1} dx = \frac{\pi^2}{12}$$