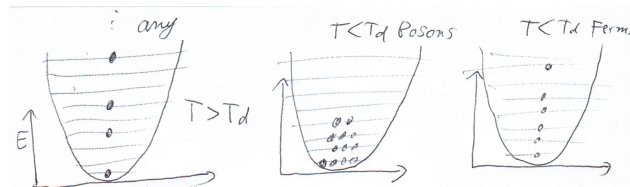


Phys635, MBQM II-Semester 2022/23, Tutorial 3, Wed 8.2.

Please sit in your assignment teams, two or three teams to a table (behave like Bosons, not like Fermions). Do the “Stages” in the order below. When all teams finished a stage, elect a student to present and explain on the board.

Stage 1 Consider the attached two diagrams for Bosons or Fermions in a harmonic trap. The temperature where it becomes important whether two particles can enter the same state or not, is called “degeneracy temperature” T_d .



- (i) Why would the Bose/Fermi character not be important for temperatures $T \gg T_d$?
- (ii) Make a rough estimate of the degeneracy temperature. Discuss on the table, write on the board.
- (iii) Suppose we are slowly reducing the temperature of the system. Discuss what might happen in the context of section 2.2.2 of the lecture.

Stage 2 Use a math plotting tool (such as mathematica) to explore Eq. (3.12). If you copy paste the following lines into mathematica, you can start comparing BE distributions for two different sets of parameters.

```

kbT1 := 2;
kbT2 := 1;
mu1 := -2;
mu2 := -2;
Plot[{1/(Exp[(Eb -mu1)/kbT1] - 1), 1/(Exp[(Eb -mu2)/kbT2] - 1)}, {Eb, 0, 5}]

```

- (i) Let us assume a constant density of states $g(E)$ for simplicity. Confirm that when you reduce the temperature, the total number of particles $N = \int_0^\infty dE g(E) m(E_b)$ does down.
- (ii) Suppose you want to keep the total number constant what do you do?
- (iii) We cannot have $\mu > 0$. Can you find a way to keep the total number constant once $\mu = 0$ and you further reduce the temperature?

Stage 3 Mean-field theory (MFT), discuss:

- (i) What is “mean-field” about mean-field theory?
- (ii) What are the most important assumptions about the atomic gas for MFT to be valid?
- (iii) What is the interpretation of the condensate wavefunction ϕ ?
- (iv) If you want to theoretically study a certain Bose-Einstein condensate experiment (after condensation has happened), which equations can you use? What do they tell you? What input information do you need?