Phys635, MBQM I-Semester 2019/20, Tutorial 2, Wed 18.9.

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 Let's try to sort out some questions about the material so far.

(i) List the main points of the material covered since the last tutorial [i.e. week 3 and following] try to agree on your table on what the essentials are.

(ii) Among those, each list three items you think you understood best, and three that you understood least.

(iii) Pair up, such that each of you explains to another student on the table one of those concepts, then swap. Ask us if unsure.

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 $N = \int_0^\infty dEg(E)m(E_b)$ 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 Quantum Fields: Discuss the following in your team, then on your table. Use the board as well.

(i) Suppose you want to solve Eq. (2.33) for the quantum field operator in some brute force manner. How could you try this in principle? When does it work? When does it not work?

(ii) What is a quantum field?

(iii) Which disciplines use quantum fields? How are they used there.