Statistical Physics

Fall 2020, Examiner: Gianni Blatter

1. **Summary:**
Started with Bosons and Fermions
Prof: What can you tell me about bosons and fermions?
B: Best to describe them in the grand canonical ensemble
I wrote down formulas for the grand partition function, pressure, number, occupancy
Blatter wanted to plot the occupancy as a function of energy, T=0, T>0
Then he wanted a formula for the fermi energy (eq 6.18)
Then he wanted the formula for chemical potential for fermions
Then he wanted the behaviour of chemical potential for bosons, how it it diverges and how the plot looks like
Then on to massive Bosons
G: What can you tell me about massive?
B: Well what do you want to know?
G: You have to know something about massive bosons
B: Well okay, let‘s start with Ideal Bose gas
Wrote again the pressure, and density
Talked about how if n*lambdaˆ3 is bigger than 2.612 then we get a macroscopic value for the ground state occupancy
G: show me the phase diagram!
B: Draw the p-t diagram and talked about how we can condense, the forbidden region and how the behaviour is
On to Magnetic Systems
G: What does a phase diagram look for a magnetic system
B: Draw a h-T diagram showing the first and second order phase transitions
G: how does the order parameter behave as a function of temperature?
B: wrote down the formula and talked about the value for Beta at Critical and tricritical
G: How does the first order jump behave when close to T_C
B: paused for a few seconds, now knowing what he was referring to.
G: Draws some lines on the diagram
B: Ahh, as a function of h 1/delta where in MFT delta=3
On to scaling relations
G: How are the scaling exponents related
B: They are related through these four scaling relations, wrote down all the relations (chap 13.1)
G: Widom had an ansatz about the behaviour around the critical point (data collapse). What is this ansatz?
B: wrote down the formula explaining each term
G. how is the gap exponent related to our old exponents?
B. Gave formula for both that (13.31) and relation to lambda exponents
Very briefly about RG
G: Aa good remark. How do we get these remaining exponents?
B: RG, wrote down the RG eqs. And talked about the linearization and the eigenvalue problem to get the remaining exponents
G: Very well, time’s up!

2. **Summary:**
Start:
   - Explain the 3 laws Of TD
   - Ideal gas equation of state
   - How to calculate entropy of the ideal gas

   Calculate the free energy Of the ideal gas (hamiltonian -4 partition function (canonical) —i free energy

-)
- What will happen when the gas parameter is very large?

Go to the Quantum case
- partition function for fermions and bosons
- Specific heat for both cases (to check that the 3rd law is fulfilled; for bosons he wants TA(d/n))
- Draw the Cv as a function of T for BEC;

Go to BEC
- How to calculate T_BE?

Order parameter?
- Similar transition in magnetic system? (Heisenberg; BEC cannot happen below 30, he also asked why)

GO to magnetic PT
- Hamiltonian for XY model
- What is the interesting transition in 2D and describe it (BKT transition);

What is QLRO; Write down the formula for it (Algebraical decay correlator, here he really wanted me to get the full formula, i.e. (8.75))
- What's the anomolous exponent for BKT transition? (Neta-1/4)

Go to exponents and scaling law
Write down the scaling laws and the exponents for the simplest model (MFT)
Do MFT exponents fulfill these laws? (yes except the Josephson)
When do they fulfill Josephson?
What about tricritical point?

3. **Summary:**
These were the topics of my exam:
Bosons, Fermions
- Partition function, eq. of state, gas parameter
- Dilute case: eq. for p for Fermion gas and Boson gas, statistical interaction
- Dense case for Fermions: eq. for p, U, Cv

BEC
- Phase diagrams, ways to cool down in the graph
- Equivalent Phase diagram for Van der Waals gas
- How to determine T_BE
- What is the order parameter + Graph

MFT
draw full m-h-t diagram
- What happens at Tc?
- critical exponents, derived form landau functional

Scaling
- Widom scaling: data collapse, Ansatz, Widom law