Advanced Statistical Physics

Exam - rattrapage

January 2025

Surname :

Name :

Master :

Write your surname & name clearly and in CAPITAL LETTERS in this page and in all pages you use for your answers.

You can write in English or French, as you prefer.

No books, notes, calculator nor mobile phone allowed.

Not only the results but also the clarity and relevance of the explanations will be evaluated.

Focus on the questions asked and answer them (and not some other issue).

If doubt exists as to the interpretation of any question, the candidate is urged to consult the examiners in the room and to submit with the answer paper a clear statement of any assumptions made.

At the end of the exam, we will staple these pages to the ones where you write yours answers.

1. How does the free energy behave near a critical point?
2. Explain the concept of a thermodynamic limit and its role in the occurrence of phase transitions.
3. Define the critical exponents α, β, γ, and δ. What physical quantities do they describe?
4. What is universality in the context of critical phenomena? How does it depend on the system's dimensionality and symmetry?
5. Explain the concept of scaling laws and how they relate critical exponents.
6. What are the key assumptions of mean-field theory, and under which conditions does it fail?
7. How does the Landau theory describe the free energy near the critical point of a system with a scalar order parameter and a second order phase transition?
8. What is the correlation length, and how does it behave near a phase transition?
9. How does the Ginzburg criterion determine the validity of mean-field theory?
10. What are topological phase transitions, and how do they differ from conventional phase transitions?
11. What is the basic idea behind the renormalization group approach to phase transitions?
12. Describe the concept of a fixed point in the renormalization group framework and its significance.
13. What distinguishes a quantum phase transition from a classical one? How does temperature play a role in this distinction?
14. Describe the behavior of correlation functions near a quantum critical point. How does this differ from classical criticality?
15. Explain the quantum Ising model and its phase diagram. How does it differ from the classical Ising model?