**Subjects for Phase Transitions exam**

year 2022-2023

1. **Mean Field Theory**

Order of phase transitions, notion of universality. Mean field theory, fluctuations, critical exponents, correlations, Ginzburg criterion, phase diagram of few simple models.

2. **Wilsonian Renormalization Group, basics**

Self-similarity, block transformation. Discussion of 1D Ising model: RG flow, kinks and correlation length. Extension to higher dimensions: naive one parameter scaling, complications in 2 dimensions.

3. **Wilson’s general theory (1)**

RG in higher dimensions, fixed points, critical surface, relevant/irrelevant operators, scaling of free energy.

4. **Wilson’s general theory (2)**

Structure of critical theory, correlations. RG & phase diagrams: application to simple models. Finite size scaling.

**5. Field theory approach**

Gauss integrals and Hubbard-Stratonovich transformation, mapping to phi^4 theory. Sketch of RG and epsilon expansion idea, Wilson-Fisher fixed point.

**6. Non-linear sigma models**

Vector spin models and large n limit: The XY model: vortices, and the Kosterlitz-Thouless transition. O(n) models.

**7. Quantum criticality (1)**

One-dimensional transverse field Ising model. Perturbative treatment, Jordan-Wigner transformation, phase diagrams.

**8. Quantum criticality (2)**

The quantum-classical mapping. Single spin in a transverse field, the one-dimensional transverse field Ising model.

**9. Quantum rotors**

The (XY) quantum rotor, and mapping to the 1D XY model. Generalization to higher dimensions and O(n) rotors. Discussion of quantum phase diagrams.

**10. Ground state theorems for quantum systems**

Marshall’s theorem. Lieb-Schultz-Mattis theorem, implications for 1D Heisenberg. Definition of spontaneous symmetry breaking, and Mermin-Wagner theorem.