Statistical Field Theory: M2/2020-2021

I- Brownian motions and random paths (week 1)

1.0 What we are aiming at describing?
2.1 Random walks and random paths
2.2 Scaling limits
Readings: 2.3 Brownian motion and path integrals

Exercises week 2:
2.1 Random variables and generating functions.
2.2 Random Gaussian vectors.

II- Statistical lattice models (week 2)

3.1 Examples of statistical lattice models
3.2 Transfer matrices
3.3 2D Ising model
Readings: 3.6: The classical/quantum correspondence

Exercises week 3:
3.1 Fermionic representation of the 2D Ising model.

III- From statistical model to field theory (week 3)

4.7 Field theory representation of statistical models
4.3 Critical systems: phenomenology
4.7 Deviation from mean field theory
(4.5 Landau-Ginzburg theory)
Readings: 4.5 Upper and lower critical dimensions

Exercises week 4:
4.1 Mean field theory from a variational ansatz.
4.4 Mean field vector models.

IV- Renormalization group and universality (week 4+5)

8.1 Block spins and RG transformations
8.3 RG fixed points and universality
8.4 Scaling functions and critical exponents
Readings: 9.2 Momentum RG in field theory or 5.4 Finite size scaling

Exercises week 5:
5.1 Real-space renormalization: Ising model on the triangular lattice.

V- Free field theory (week 5+6)

6.1 Euclidean (free) field theory
6.2 Gaussian field theories
6.3 Green functions
(6.4 Products and composite operators)
Readings: 6.5 Wick's rotation

Exercises week 6:
6.1 Translation invariance and the stress-tensor.
6.2 Lattice scalar field and lattice Green function.

VI- Interacting field theory (week 6+7)
7.1 Preliminaries
7.3 Generating functions
7.4 Perturbation theory and Feynman rules
7.5 Diagrammatic
Readings: 7.2 Symmetries and Ward identities

Exercises week7:
7.1 The effective potential and magnetization distribution functions.
7.2 Two-point functions and vertex functions.

Exercises week8:
7.3 Generating functions and effective action for Phi3 in D=0.

VII- Conformal field theory: part 1 (week 8)
8.4 Massless gaussian free field in 2D
Including: action, Green function, u(1) current, stress-tensor, vertex operators.

Exercises week9: (text on webpage)
7.7 The O(n) vector model with N->infinity in D=3

VIII- The O(n) vector model (week 9)
See exercise "The O(n) vector model with N->infinity in D=3":
Dressed propagator, loop expansion, critical theory, bare and renormalized parameters, saddle point approximation.
Readings: Detailed correction of the above exercise

Exercises week10:
8.7 Regularization of vertex operators.
8.6 Transformation of the stress-tensor in 2D CFT.

IX- Conformal field theory: part 2 (week 10)
8.1 The conformal group
8.2 Conformal invariance in field theory
8.3 Operator product expansion

Exercises week11:
8.2 The group of conformal transformation.
5.2 Correction to scaling.

X- Scaling limits and the field theory renormalization group (week 11-12)
9.0 Back to basics: summary of IV
9.1 Field transformations
9.3 The perturbative renormalization group

9.4 The Wilson-Fisher fixed point
(9.5 Scaling limits and renormalized theories)
Readings: 7.6+9.7 Effective potential + Back to effective potential

Exercises week12:
5.3 Covariance of RG equations.
(9.1 Explicit RG flows (if timing is ok).)

XI- Field theory renormalization & Questions and discussions (week 13)
(9.5 Scaling limits and renormalized theories)
Readings: 9.7 Perturbatively renormalized Phi4 theory.
(Readings/Exercises: 9.3 Renormalisation of Phi3 in D=6)
Questions & Discussion.