

Syllabus for Physics 230

Advanced Condensed Matter Physics

Spring 2016-2017, Physics Department, UCSD

INSTRUCTOR: Congjun Wu (5430 MH)

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Time/Place:

Instructor Office hour:

Text Books:

1. R. Shankar, *Quantum Field Theory and Condensed Matter: An Introduction*, Cambridge University Press; 1st edition (August 31, 2017).
2. T. K. Ng, *Introduction to Classical and Quantum Field Theory*, Wiley-VCH, 1st edition (April 27, 2009).
3. E. Fradkin, *Field Theories of Condensed Matter Physics*, Cambridge University Press; 2nd edition (April 30, 2010).

Class Schedule

1. One dimensional systems

Lecture 1: Antiferromagnetic spin chain: non-linear σ -model, Berry phase, Haldane's conjecture

Lecture 2: Bethe ansatz (I): Spin-1/2 chain

Lecture 3: Bethe ansatz (II): ground state energy, and spinon excitations

Lecture 4: Quantum Ising chain as free-Majorana fermion system, duality

Lecture 5: Abelian Bosonization, Sine-Gordon theory

Lecture 6: The Luttinger liquid (I): spin-charge separation

Lecture 7: The Luttinger liquid (II): spectroscopic properties

2. Topological defects

Lecture 8: Soliton and instanton

Lecture 9: Winding number, Poisson summation

Lecture 10: Vortices, Coulomb gas, KT transition

Lecture 11: Burges vector, dislocation

Lecture 12: Skyrmion, Hopf invariant

3. Lattice gauge theory

Lecture 13: The Ising gauge theory, Z_2 confinement/deconfinement

Lecture 14: Matter field, Fradkin-Shenker theorem

Lecture 15: 2D Compact QED

Lecture 16: Quantum dimer model

4. Renormalization group

Lecture 17: RG for fermions – revisit Fermi liquid

Lecture 18: Hertz-Millis theory for itinerant ferromagnetic criticality

Lecture 19: Non-linear σ -model for disordered electrons

5. Exact theorems

Lecture 20: Perron-Frobenius theorem, Nagaoka theorem, Lieb-Mattis theorem, Marshall sign rule

Lecture 21: Spin reflection positivity

Lecture 22: Mermin-Wegner theorem, Coleman theorem

Lecture 23: Mathematical principles of quantum Monte Carlo sign problem

Lecture 24: Hidden symmetries in spin-3/2 systems, unifications