University of California at San Diego – Department of Physics – Prof. John McGreevy

Spring 2014
Physics 239a: Where do QFTs come from?
VERY TENTATIVE COURSE OUTLINE

Disclaimers: The ordering and content indicated below is very approximate and certainly too ambitious. The actual content of the course will be adjusted to reflect the interests of the class and the caprices of my attention. Sub-headings are not at all in one-to-one correspondence with lectures.

1. **Introductory diatribe**

    1.1 Phonons reminder

2. **Lattice spin systems**

    2.1 Xs and Zs

    2.2 transfer matrix, passage between lagrangian and hamiltonian descriptions

    2.3 solution of spin-$\frac{1}{2}$ chain in terms of fermions (Jordan-Wigner)

    2.4 continuum limit

3. **Bosons**

    3.1 Coherent state path integral for (conserved) bosons

    3.2 Superfluidity

    3.3 Sound waves

    3.4 Vortices

    3.5 Effects of interactions

    3.6 Mott transition

    3.7 Particle-vortex duality (XY and abelian Higgs) ($D = 2 + 1$)

4. **CFT in** $d = 1 + 1$

    4.1 Free bosons

    4.2 Free fermions

    4.3 Virasoro algebra

    4.4 Current algebra

    4.5 Bosonization

5. **Other amazing things to be found in lattice spin systems**
    - 5.1 emergent gauge theory
    - 5.2 emergent photons
    - 5.3 emergent fermions in $d > 1 + 1$
6. **Quantum Hall states**
    - 6.1 CFT at the edge
    - 6.2 CFT for the groundstate wavefunction
7. **Fermi liquids and non-Fermi liquids**
    - 7.1 Adiabatic continuity
    - 7.2 Luttinger theorem
    - 7.3 Green's functions and their observation
    - 7.4 Death of quasiparticles
8. **Spin liquids**
9. **CFTs from gravity in AdS**