Questions for Week 7

February 26, 2016

1 Lecture 14

(1) (Yan, Jerome, Evan): What happens to heavy fields if we only consider light ones with this procedure? What are they dual to? Similarly: In Eq. (14.2), why does the sum over i run over all *light* fields in the bulk? Do they mean light within the effective field theory? The same way, why is the sum over *low-dimension* operators in the CFT?

(2) (Jerome): Where does Eq. (14.4) come from?

(3) (Yan, Jerome, Evan) He seems to see only from the dimension of the operator if it is conserved so how do we see it? Also how does his result for a conserved current show that gauge symmetries in the bulk are global ones on the boundary? Similarly: Can we clarify the statement "gauge symmetries in the bulk correspond to global symmetries in the CFT"? Again, what are the real symmetries here?

(4) (Yan, Evan) Is there an intuitive way to see that there is a gap only if the theory is strongly coupled?

(5) (Yan) The number of dof is the same in the bulk theory and in the boundary theory right?

2 Lecture 15 and di Francesco

(1) (Yan and Evan) What happens if we consider conformal transformations in another space than Minkowski?

(2) (Yan) What is the difference between how quasi-primaries with spin transform in 2d and higher d and why is there a difference?

(3) (Evan) See below equation (15.9): can we explain the statement "higher correlators can be computed, at least in principle, by sewing together 3-pt functions and sewing over intermediate states".

(4) (Yan) From what I understand I would say that only QFTs that don't have a RG flow are CFTs since they are the same for every scale but why is it the case for a fixed point too?

(5) (Evan) Regarding RG flow: in a CFT there *is no* RG flow, so there should be no ambiguity in defining the fundamental degrees of freedom (as opposed to QFT where the DOF depend on the energy scale, e.g. quarks vs mesons/hadrons in SUSY yang mills). Yet he is always talking about an ambiguity in defining the DOF in CFT.

(6) (Evan) Again regarding RG flow: in a CFT there *is no* RG flow, so there can be no confinement. Yet below eq 14.11 he explicitly says we want CFT's with confinement. The origin of confinement is that QCD is strongly coupled at low energies. In CFT the coupling does not run with energy, so once you fix the coupling at one energy scale you have fixed it at all energy scales. This seems to directly contradict the discussion below eq. 14.11.

(7) (Yan)This must be stupid but why does the fact that $< T^2 >= 0$ imply $< T >= 0$? (see end of section 4.3.3 for details)

(8) (Yan) Why is the spin-statistics theorem bypassed in 2d and is there people who study parafermions?

(9) (Yan) Can someone clarify the procedure that they do to find the reps of the conformal group?

(10) (Yan)Why don't we ask that the fields are irreps of the conformal group instead of the Lorentz group?

(10) (Evan) Quantum vs Classical conformal invariance? My understanding of this is that a thy that is conformally inv. at the classical level may have a scale generated at loop level. An example of this is massless ϕ^4, which gets a loop-induced mass. Is the the argument in Di Francesco at the beginning of section 4.2 valid? (he argues that any regulator breaks conformal invariance so that any non-UV complete QFT must break conformal invariance. The reason to think this is not quite right is because brute force cutoff breaks Lorentz invariance, but this is a spurious effect).

And related to this, the meaning of a *conformal anomaly*: this is a spacetime symmetry in a theory on a fixed spacetime, it is *not*: (1) a gauge group anomaly in a QFT on a fixed background, or (2) a spacetime anomaly in a (super)gravity thy. Both of (1) and (2) would make the theory not well defined, but the 'conformal anomaly' is not really an anomaly at all. Is this correct?

(11) (Evan) What is the manipiulation in equation 4.37 of Di Francesco? In fact, can we also go through 4.39 to 4.45?

(12) (Evan) Regarding the Ward Identities: I don't understand the setup of the calculation for eqautions 4.63 to 4.68. What is the (general) definition of a ward identity that we are using?