QFT3.

The Standard Model and Electroweak Theory.

Lecture 1.

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Motivation for QFT3:

Quantum field theory courses teach the basics of perturbation theory and Lagrangian physics, but the second semester of QFT culminates usually with a brief mention of the Standard Model and the electroweak theory, leaving the rest for self-exploration

This is at odds with the current state of the art in particle physics, where the Standard Model is the most successful model of Nature to date. Notwithstanding the familiar shortcomings like dark matter, quantum gravity, dark energy, baryogenesis, nature of neutrinos, strong CP, etc., the breadth of successful predictions and measurements of the Standard Model cannot be overstated.

Knowing the suite of experimental verifications of the SM is not simply an exercise in celebrating the success of the SM, but rather it is the essential way we can make progress in finding the next model of Nature.

This can be seen in two ways.

1.) Making more & more precise measurements (in whatever realm is possible) may reveal a discrepancy between the experimental result and the theoretical prediction. In this scenario, diagnosing the discrepancy can lead to model building/

revealing what is responsible for the new physics.

2.) Making a precise measurement at the limit of our experimental capability is near-impossible to use sensibly unless we have an understanding of experimental uncertainty and background (SM) prediction.

In the first sense, SM provides a set of phenomena and itself defines the measurements that could invalidate it.

In the second case, we are instead motivated by trying to define the SM by its complement: measuring everything where the SM gives a "zero" prediction and getting a positive result is another way to invalidate the SM.

Thus, it's critically important to know what the SM <u>predicts</u> as well as what it <u>does not predict</u>.

Another strong motivation to study SM phenomenology: QFT is hard!

In contrast to classical physics, where it was relatively to set up mechanics or E+M systems then measure the results, it's very difficult to set up an experiment to "test" QFT. Aside from isolated condensed matter systems, essentially all ways we have to determine properties of QFTs relies on SM interactions + particles. Thus, being able to measure the SM is a nontrivial check that we get the right answer.

Although these lectures are about the SM, I will try to talk about "a SM" most of the time instead of "the SM." In fact, you can learn a lot of the structure of the SM by calculating without inputting any experimental measurements of masses or couplings.