MARKUS KLUTE: Welcome to 8.701. So in this lecture, we'll give you the first introduction to Feynman diagram. This is part 1 out of a few sections on Feynman diagrams. So this is really meant to introduce the topic such that we can use the same language to talk about Feynman diagrams before we then later on are able to use them as a tool to calculate interesting processes.

This brings me right to the essence already. What is a Feynman diagrams and what can it be used for? They arise from pertubative calculations of amplitude for reactions. And that's exactly how we're going to use them later on.

It turns out that the mathematical terms in the perturbation series can be represented as a diagram. And then you can turn this around and use the diagram in order to perform a calculation. So each of the diagrams then indicates a particular factor in the calculation. Again, and then you have a rule which allows you to, after drawing, you can then put the pieces together in order to perform [INAUDIBLE] calculation.

The derivation of those tools or rules is beyond the content of this course. But I will teach you how to actually use diagrams in order to calculate things.

So here's one example of a diagram. Let me just put this down here so you can see this. So this is an electron radiating a photon. You see components like those lines here.

Those represent particles with energy and momentum also what to consider the spin. And they meet at a point. This point here is called a vertex.

And this is where the interaction takes place. And in this example. The vertex is labeled with a q or e, representing the charge, the electric charge, which gives us the strength of the coupling.

We already discussed when we talked about units that we can express the strength of the electromagnetic-- the coupling in QED with the electric charge. And that's shown below again.

The amplitude then turns out to be proportional to the charge or to this coupling. And the diagrams with n vertices for n of those components here get a factor e, the charge, to the nth power in the amplitude, and e to the second. Because if we're going to calculate a probability, you have to square the amplitude. You get a factor of e to 2n. Again, don't get confused-- e is charge.

So for n vertices, there will be a factor alpha to the nth power for the probability. And so since alpha is 1/137, you see that if I want to do a calculation, and diagrams which have n vertices will be suppressed, will not contribute much to our perturbation serious because alpha is much, much smaller than 1.

So this is already an interesting finding. Can restrict yourself to calculating diagrams which have a couple of vertices or n vertices, but you don't have to calculate the entire series. You want to measure your calculation with experimental findings.

Interesting here-- antiparticles. If you have a specific vertex and you calculated it, it can be reused. It can be reused for example by replacing a particle with an antiparticle or by re-labeling.

One thing I haven't explained to you yet, you have to define when you write them which is the direction of time. We'll come to this direction. And so in this case here, you have a particle and an antiparticle unrelating to a photon.

So far, so good so. This is again a good point to stop and just try to read the diagrams. Note that what happens in this discussion when you actually change the direction of time-- forward down. You want either directions.

So now if you want to calculate the reaction, it's not sufficient to just use one word vertex. Why? Because a single vertex will not be able to give us a reaction. You can simply see this when you look at something like an electron plus electron photon.

This is not really possible because of energy and momentum conservation in this diagram. So you need a couple of vertices in order to make a reaction. So this here is, again, we have potentially the time going this direction. There's a scattering between an electron and a muon through the exchange of a photon.

Both particles have electric charge of e. And then you can just calculate what is the probability for a process like this to occur. We'll see how to do this technically later on. But hopefully you have a first impression.

Again, let's label this now very quickly. So you have an incoming particle, a second incoming particle, outgoing particles, and an exchange particle. So this exchange particle is a photon. And there's two vertices in this diagram.