MARKUS KLUTE: Welcome back to 8.20, Special Relativity. In this section we're going to talk a bit more about collisions. I've already seen collisions in study of momentum conservation in previous sections. So here we can have a collision. Then we can describe them in the center of mass frame, for example, where the total momentum is equal to 0. So in the case of the collision of two particles, the momentum of particle one plus the momentum of particle two is equal to 0.

We can then describe the energy and the momentum of the particles before and after the collision. In the lab frame, the situation is different. Here typically we have one particle with some momentum hitting another particle, which is at rest.

But we can also have different types of collisions. We describe or characterize elastic collisions where the kinetic energy is conserved and so is the mass. So you can think about two billiard balls colliding without any friction, in which case they don't change their appearance, their mass. Everything is unchanged, so you must change the direction. The total kinetic energy in these collisions are typically conserved.

But we can also have inelastic collisions. And there's two different kinds. There's sticky kinds, where the mass after the collision is greater. So you have two particles, for example, maybe they stick together-- they're some, like, Play Dough balls-- and the kinetic energy after the collision is smaller.

Or you can have explosive collisions, where the mass afterwards is smaller. Maybe you start from one heavy, big object and then which explodes into many smaller ones. But the kinetic energy after the collisions is much smaller. Those are also collisions.

So here we want to do an activity and study an inelastic collision. So before we have two particles there, or billiard balls. They're exactly the same and have a velocity u.

And after the collision their mass is capital M, big mass. And you're going to describe this collision once in the center of mass frame and one in the laboratory frame. And so the question now is, are the masses and is energy conserved in those collisions?

And you're going to just described this in both reference forms. So again, stop the video here and try to work this out. I already did this, so I discussed before, in those collision problems it's always important to be really clear. The situation before the collision was A. The situation after the collision was B.

So I'm describing this here. First in the center of mass frame where the x-- and I'm just talking about x component here-- the x momentum is 0, which is equal to the mass times u times gamma minus the mass times u terms gamma. That's the 0.

The energy before is 2 times the mass times gamma times c squared. After the collision, the particle is at rest. The new one particular is at rest and has an energy, large M over-- times c squared.

In the laboratory frame situations, different case. X momentum 0 minus m times u prime-- this is a different velocity-- times gamma of u prime. So here I'm trying to indicate that this gamma is not the same gamma as over here. This is a gamma, but it's the velocity of u prime.

And the energy is the rest mass of the particle addressed plus the mass times gamma times c squared off the second particle. After the collision, the particle has some velocity u. And so the momentum in x direction is minus large M times u times gamma of u again. And the energy is large M times gamma u times c squared.

OK, good. So now we can use momentum conservation and find this equation here. And from which we can then calculate that the large mass is equal to 2 times the smaller mass. So what you find, and this is the relativistic math, you find that at the conclusion that the rest mass is not conserved. The mass of this big ball is not simply the mass of the two rest masses, or 2 times the mass of the rest mass. You have to consider this gamma factor here. It's 2 times the relativistic math, if you want.

But you also find that the total energy is conserved in circulation so that the sum of m0 gamma times c squared is conserved in the collision, irrespectively in how you actually reference it when you discuss the problem.

I want to close this part of collisions with a small discussion of units. And that will become interesting and important later on when we look at particle physics examples. So in particle physics, we often talk about units of electronvolt in collision experiments, or mega electronvolts, or kilo electronvolts, tera electronvolts.

So 1 electronvolt is the kinetic energy of the particle with charge e, which is accelerated in a potential of 1 volts. So that corresponds-- that's a unit of energy and it corresponds to 1.6 times 10 to the minus 19 joules or 1.6 times 10 to the minus 90 kilograms meter squared over 2nd square.

But the mass of an electron is really, really small. And those units here are introduced because the mass is small and you want to have reasonable numbers to work with. So the mass of the electron is 9.11 times 10 to the minus 31 kilogram.

So if you just rewrite an m0 as equal to m0 c squared times 1 over c squared you find that, huh, now we rewrite this and find that the masses 8 times 10 to the minus 14 joules over c squared. Or in units of electronvolts, 5 times 10 to the 5 electronvolts over c squared, which is 0.511 mega electronvolts over c squared or 511 kilo electrons over c squared.

So when we talk about the mass of an electron, we sometimes approach this with natural units, in which c squared is equal to 1. And that just simply says that the mass of an electron is 511 kilo electronvolts. The math of a neuron is mega electronvolts, and so on, and so on.