So here we're talking about-- you use the [? Meikle ?] model to model a hot, transparent-- and before yesterday, I said I wasn't sure if it was opaque or not, but in this case, you do need it to be not opaque. And few people had asked about that yesterday in their written reflections. So it's a hot, transparent, diffuse-- which means a low-density-- gas or plasma with emission lines. So the [? Meikle ?] model is used to predict what kind of a spectrum we would get. So this is a spectrum from a hot, transparent, diffuse gas or plasma with emission lines.

Emission lines are these extra peaks that we get above the background which astronomers call the continuum. The continuum-- and what I didn't tell you yesterday is, where does the continuum come from? Because you're right, if we just had silicon and we heated it up, we would just have-- it would be 0, 0, 0, and then there would be a peak here-- 0, 0, 0. And I think there's another silicon line somewhere else, and it peak up, and it would be 0, 0, 0, 0, if we just had pure silicon.

But where does all the rest of this background shape come from? Well, it actually comes from if you have these atoms that have bound electrons that are going a little orbits around them, those electrons can be excited by bumping into each other. They can be excited by adding energy to the system. And they jump up to higher energy levels, and then the electrons naturally relax back down to a lower energy level and emit a photon. But if you have two atoms that bump together too hard-- remember, we talked about ionization a couple of days ago. What is ionization? Anybody remember? Bianca?

AUDIENCE: When atoms are separated from each other. So the electron breaks off or the protons and neutrons are broken from each other.

PROFESSOR: OK. In this case, it's when atoms are broken up. If you hit two atoms together hard enough, instead of just exciting an electron to a higher energy level, somebody actually asked in the reflection, well, what's the highest energy level that you can be excited to? If you have a really big bump, you won't just excite the electron to a higher orbit, you'll actually kick the electron out.

AUDIENCE: Whoops.

PROFESSOR: Yeah. Imagine that, you get kicked out of your nice, electron orbital home. So if you have collisions that are too hard-- and remember, we said in a thermal gas, or in a gas where there's thermal motion, some of the bounces are hard and some of the bounces are soft. So sometimes, you just bump those electrons up to high energy levels and then they fall back down. Sometimes, if you bump hard enough, you'll knock the electron out. And then what you have is an ion, which may still have some extra electrons around it. Because each atom doesn't just have one electron, it has many electrons. But then you'll have ions and you have free electrons.

And Peter-- oh, before we go on, Juan, you have a question.

AUDIENCE: Yeah. What happens to the electron that got kicked out?

PROFESSOR: What happens to it?

AUDIENCE: Yeah.

PROFESSOR: That's exactly what we're going to take a look at now. So the electron gets kicked out. So now, let's replay the simulation. So can you stop and then start from beginning. OK.

So in this case, this is a little simulation. The purple spheres represent these ions. You should just be able to hit play at the bottom again. There you go.

So the purple spheres represent ions. And then this little yellow sphere represents the free electrons. And you'll see that they still accelerate around each other. They still bounce around. And every time one of them bounces around, just like in the black body model, we get a photon that's produced.

So now, instead of just jumping up and down between specific levels, they're all just kind of bouncing around again, And remember, if we said we had lots of bouncing, we get lots of different energies of photons. If we turn the temperature up, we get the bouncing harder, just like we had with the black body model. Except now the difference is, in the black model we had an opaque object, so all those photons had to bounce around inside of an object, and then they got to the surface.

Whereas in this case, since it's a diffuse gas, we're actually just getting those photons, and now those are photons of a bunch of different energies-- a continuous range of energies. All of those photons come out and they make that background shape that you see. In fact, this process is called thermal bremsstrahlung. Bremsstrahlung is a German word that means braking radiation. Braking, like when you break in your car.

So in each case here, you've got these electrons that are braked, or slowed down, or sped up as they go around another ion. And when they do that, they emit a photon. And the photons are of all different energies, because some of those collisions are fast and hard, some those collisions are slow. Steve?

AUDIENCE: Are they going through the orbit and then jumping out?

PROFESSOR: That's a good question. Are they going through the orbit-- like through a particular energy orbit, and then kind of jumping out? And the answer is, no. With electrons and nuclei, you would have to have the electrons actually get bound to the object, and it would have to go into a closed orbit. In this case, it's just getting close enough that the electromagnetic field from the ion is causing the electron to move in a different direction.

So what we're having is a mixture of stuff. We're having both this, which is just all of these things are kind of moving around randomly so they have a bunch of different energies, but then from inside of these atoms-- this guy-- well, I guess they don't collide in this simulation. But from the atoms themselves, you get extra photons. And Peter, can we go back to the-- this.

So the thermal bremsstrahlung part of the [? Meikle ?] model produces just a nice smooth curve like this. That's because you've got a bunch of random collisions between free electrons and ions, but at certain energies there's extra. There's extra photons here, because there are those extra atoms of silicon-- or I'm sorry, this is calcium, there's extra atoms of calcium-- that are being bounced around, and those electrons are jumping up and down. And they're giving you just a little bit more than what you would expect from that nice smooth curve.

So what I want you to do-- and let's take like two or three minutes-- I want you to write down, what did you learn from us doing this little review this morning. So you guys made this prediction, you looked at what the intensities were here, and we learned a little bit more about the [? Meikle ?] model. What did you learn about the Meikle model? What do we remember about what we just talked about?