DJORGOVSKI: OK. One little piece about energy here. This is how this energy it's made in cores of stars gets out. And there are basically two mechanisms, radiative transfer and convection. Which play different roles in different parts of stars of different mass, which we'll cover a little more next time. But in general there are three ways in which you can conduct heat, radiatively, convectively-- it's boiling --and through conduction. Conduction is unimportant in stars. But the other two make a real difference.

And so which one will happen when depends on the structure of the star and its chemical composition. So, in any case, you have photons diffusing out. They're scattering off electrons and nuclei. And there are many, many scatterings, so they don't fly out of stellar core with the speed of light. It takes them quarter million years for Sun, for the energy that was made in the middle, to diffuse all the way to the surface. In doing that, any one of those initially gamma rays gets its energy divided into many, many lower energy photons. But the net result is that photons diffuse through plasma just like heat diffuses so different gasses come out and mix.

Now that is governed by the opacity of the plasma. And that depends on density, and temperature, and chemical composition. Because different ions will be better at absorbing or scattering photons than others. And that's fairly complex computation that's based on atomic physics, but we know how to do that.

And so what happens if the plasma is too opaque? And it's hard for energy to, kind of, get out? Well this is when boiling occurs. Star boils, essentially, as convection. And this was first quantified by famous astrophysicist, Schwarzchild. And it works roughly like this. So you have an element of volumes, so really hot deep down, and it moves up little by little bit. It doesn't exchange any energy at this point.

So it's now hot blob in slightly cooler medium. Because of that it will expand, but density will not necessarily match. So, nevertheless, it has taken extra heat from lower layers in to the higher layers purely mechanically. Transporting it up. So that

is a more efficient way of moving the energy out. Just automatically sets up.

Now this is why water boils too, except there it's the convection becomes more efficient than conduction. Radiation is not so important. So at first heat conducts, goes through the water, from stove to the surface. But once you have too much of a gradient, then water starts boiling.