S. GEORGE DJORGOVSKI: And so that is the last subject that we can do very quickly, which is the reionization era, the cosmic renaissance that follows up the Dark Ages. And here is a schematic cartoon what that might look like. Very far away is microwave background, and nothing happens-- Dark Ages.

You start having these first bubbles of ionized gas. Eventually they overlap completely, and the universe is transparent to UV light. This happens roughly when the universe is between a few hundred million years old and 1 billion years old.

Now, the interesting thing about this is the theoretical models tell us that the first stars that form will be more massive than stars that are forming now. Stars that are made out of pure hydrogen and helium tend to come in larger masses than those that are made up of already chemically enriched material, like the Sun.

And because they're very massive, they'll be very luminous, and very hot. And these are the theoretical upper main sequences for regular Population I stars, like these stars here now. And then for the population III stars, those first primordial stars, you can see that they can grow to millions or 10s of millions of solar luminosities at very high temperatures. And so there's plenty of ultraviolet radiation to ionize all of the gas in the universe at the time.

Actually, the idea is that you make one star per protogalaxy that ionizes everything. Then it has to explode before anything else could form. And they do explode quickly. That releases some methyls in the interstellar medium of the protogalaxy, and then the population II normal stars start to form.

So this has now been modeled to great detail, but observations are still pretty scarce. One interesting way is to look for gamma-ray bursts, because very briefly, they're really luminous. And this is the one that's likely at the redshift 8.2. The data were not super-duper convincing on this, in my opinion, but it has a good chance of actually being a stellar explosion, maybe if one of those primordial Pop III stars at the redshift 8.2 the universe was only a few 100 million years old.

The way we have studied this is by looking for complete absorption of ultraviolet light blueward of Lyman-alpha line in quasars. That's called the Gunn-Peterson Effect. And that was seen maybe the year 2002, 2001.

And we know that the ionization era ends at around redshift of 6, when the universe is about a billion years old. It begins earlier, probably around redshift 15 or 20 when it very first starts to form, but it takes some time to actually build up both sources of light, and to actually ionize the gas.

So the next frontier is before there are any stars. How can you do this? You can look for neutral hydrogen that's not yet converted into stars, in 21 centimeter line. And you can compute how much of that you should see.

So people are hoping to see maps of highly, highly redshifted neutral hydrogen during the Dark Ages, before any galaxies even lit up. And so that is something that will hopefully come along over the next 10 years or so.