[MUSIC PLAYING]

ANNA FREBEL: Have you ever wondered how all the chemical elements are made? Then, join me as we are lifting all the data secrets to understand the cosmic origin of the chemical elements. We're now going to look at the first chemical enrichment events, and how the universe recycles matter.

[MUSIC PLAYING]

Imagine that this is the primordial gas left over from after the Big Bang. And as we already said, the first stars formed from this gas. So here is a first star.

And stars are not static objects. They actually evolve with time, which is an interesting thing, and we're going to look into more detail at that later. But for now, we're just going to say that they evolve, for example, into something that's called a red giant. Actually it's going to get much bigger. So a red giant here.

And what happens, is already during this evolutionary phase here, stars have strong stellar winds so they can lose mass from their surface. Whatever is in that gas that's being lost, gets put back into the reservoir here. If this is a massive star, which is a given in the case of the first star, this star is going to keep evolving until it explodes as a giant supernova, so as an explosion of the star.

The star gets completely disrupted. And naturally, everything from the outer portions as well as the inner portions of the star gets spilled around and put back into the reservoir again. And so, here we now have all these new elements from the core of the star that are being put into the reservoir.

And so, some time later after the death of these four stars, this gas cloud is chemically enriched. And then, the next generation of stars forms from this enriched material. They'll evolve.

The massive ones contribute new elements, make new elements and contribute them. Low mass stars, they don't explode in supernova. They just keep sitting there happily ever after, pretty much. So they do not contribute to this chemical evolution cycle, but all the massive stars with every new generation contribute to a successive build up of all the elements with time.

Now an interesting consequence of that, is that old stars have a lower overall abundance of these heavy elements because they're simply formed at a time when the cycle here had only gone around a few times. So all stars contain little of the heavy elements heavier than hydrogen and helium. And consequently, younger stars, starting with the Sun, and even younger than that, they contain a relatively larger amount. So they are more enriched.

And we already had it, the Sun, has 1.4% of all these heavy elements. And a star that would be born today would have 2%. These old stars here however, compared to the sun, contain only a millionth of what the sun contains.

So a millionth of 1%. That's a really, really small number. So that really makes old stars stand out.

The issue for us is that we need to figure out a way how to measure the element composition of our stars so that we can figure out are there older or younger, which really means have they formed early on in this cycle here or much later. We equate that to old age or younger age, but we do so without an actual age measurement. So it's an inferred quantity for now, but various independent tests have shown that this is a pretty good assumption, and that stars with very little of all the elements really are old and formed as some stars in these very early generations.

Now in terms of the nomenclature, we have to introduce one important term, namely old stars. Well, as I just said, we don't really have an age measurement. We just infer that it formed soon after the Big Bang. And so, what astronomers use is the term metal poor, because that actually describes what the star's composition is.

It is poor in heavy elements, metals as astronomers say, and it is poor compared to the Sun. The Sun is our reference star. The Sun has 1.4% of metals.

And our old stars from the early universe contain only a tiny, tiny fraction of this here. And so, we call them metal poor. And when you look for the older stars, or want to look for the older stars, what you actually have to do, is you have to search for the most metal poor stars.

[MUSIC PLAYING]