Ancient stars

Astronomers have identified a geriatric star whose parents belonged to the first generation of stars to exist in the Universe. **Jasmin Fox-Skelly** discovers what this aged star can teach us about the early days of the Universe.

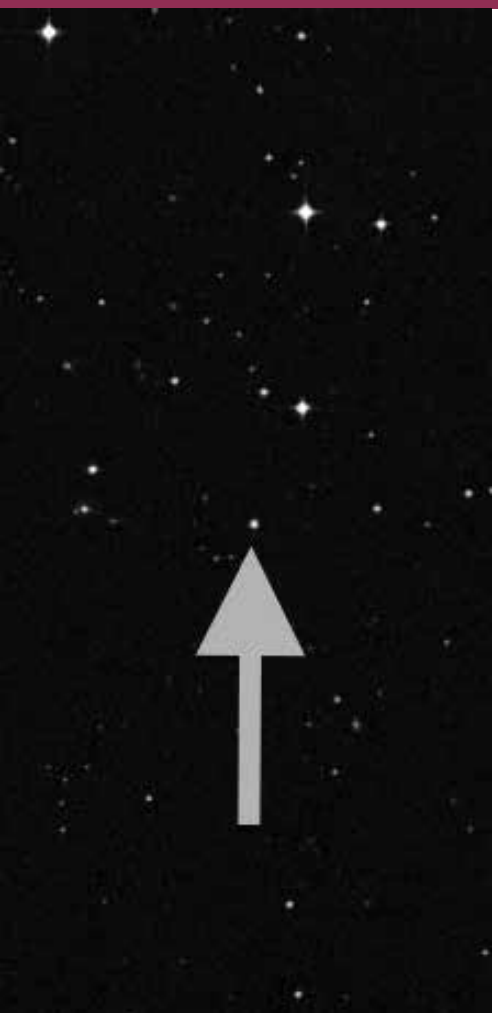
Astronomers have discovered the oldest known star in the Universe, which formed shortly after the big bang 13.81 billion years ago. Only 6,000 light years from Earth, it is one of a small number of second generation stars, formed from the dying embers of a giant primordial star thought to have had a mass 60 times that of our own Sun.

The huge mass of these first stars meant that they died out a long time ago, as the energy they needed to produce in order to fight their intense gravitational pull inwards would have quickly exhausted their fuel supply. The small size of this star is key to why it is still alive and burning strong.

"The star we have found is only 80 percent the mass of the Sun, so it has a significantly longer lifetime," explains Dr Stefan Keller of the Australian National University, who led the astronomers who discovered the star. "The Sun has a lifetime of around 9 billion years, whilst this oldest star that we have found has a lifetime more like 15 billion years. So even though it has been in existence for 13.6–13.4 billion years, it still has a couple of billion years to go. It is starting to show its age slightly though, as it is more puffed up and cooler than we would expect for a young star of this mass."

The researchers found the star in the galactic halo in the outer reaches of our Galaxy, where the majority of the oldest stars have been hiding. The star, catalogued as SMSS 0313-6708, would have formed in a gas clump before the creation of our galaxy. Over time a series of such clumps would have merged together under the pull

■ An artist's impression of the first generations of stars. Image: David A Aguilar/CfA.



of gravity to form the grand spiral we now see as the Milky Way.

By analysing the light from the star, the team could see that it contained ten million times less iron than the Sun. This low metal fingerprint was what first alerted them to the star's colossal age.

Ageing stars

By splitting the light from stars up into a rainbow, researchers can see that there are tell-tale colours missing from the spectrum. These colours correspond to specific elements that are found in the outer atmosphere of stars and which absorb the starlight, causing a dark absorption line in the spectrum. The elements a star contains tell us a lot about how it was formed and how old it is.

After the big bang, the Universe was made almost entirely of hydrogen and helium, the two lightest elements. Clouds of hydrogen and helium collapsed to form the first stars. All the other heavier elements that exist were created in stars and supernova explosions. There have been many thousands of generations over the 13.8 billion years of our Universe. To make the Sun, for example, takes of the order of a thousand supernovae. However, it takes time to make all these elements, so the oldest stars do not contain as much.

Astronomers hunting for primordial stars look for a low iron fingerprint, a tell-tale sign of a second generation star. Over the last twelve years, a number of these stars have been discovered, shedding light on what the Universe was like in its infancy.

So how many of these second generation stars are left? According to Keller they really are one in a million, or one in 60 million to be precise.

Keller's team have been using a 1.35-metre wide-field survey telescope called SkyMapper, at the Australian National University, to produce the first digital map of the southern sky. So far they have examined 60 million stars, which is just 10 percent of the total number of stars the SkyMapper can observe. They believe that there might be up to forty more of these ancient stars yet to be discovered.

"The stars we are searching for are extremely rare," says Keller. "The rule of thumb is that, for stars below a thousandth the iron of the Sun, the abundance of such stars drops by a factor of ten for each factor of ten drop in the iron content."

Where will the astronomers look next? As well as the halo, another region where the most primitive stars might be hidden is deep in the heart of the Milky Way, in what is termed the bulge.

"As the bulge is located deep in the gravitational potential well of our Galaxy, this might be where some of the first stars can be found. The problem is the vast numbers of stars to search though," says Keller, but it is a challenge he expects to overcome soon. "Nonetheless, we are searching the bulge in upcoming observations for these ancient stars."

We will never find the first stars in the Universe – they are long gone – but this second generation will be able to tell us a great deal about the lives of the early stars and, perhaps, the long lost lives of their ancient parents.

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DISCOVERING THE OLDEST STARS

2002 – HE0107-5240
(~13 billion years old)
The first virtually iron free star was discovered in the direction of the southern constellation Phoenix, 36,000 light years away in the galactic halo. The star has just 1/200,000th of the heavy element content of our Sun.

2005 – HE 1327-2326
(~13.6 billion years old)
This star contains only a 1/400,000th of the abundance of heavy elements compared to the Sun and is 4,000 light years away in Hydra.

2007 – HE 1523-0901
(13.2 billion years old)
A red giant star approximately 7,500 light years from Earth, its age was determined by observing the radioactive decay of uranium and thorium in its spectrum, and was discovered in the constellation Libra by the Very Large Telescope at the European Southern Observatory.

2010 – HD 140283
(13.2 billion years old)
The 'Methuselah star' has actually been known about for more than a century because of its fast motion across the sky. It was probably born in a primeval dwarf galaxy that was eventually shredded and engulfed by the emerging Milky Way over 12 billion years ago. The star retains its elongated orbit from that event and is just passing through our Galaxy at a speed of 1.29 million kilometres per hour, at a distance of just 190 light years. The star, which is at the very first stages of expanding into a red giant, can be seen in the constellation Libra.

2014 – SMSS 0313-6708
(13.6 billion years old)
The newly discovered star contains an abundance of lighter elements such as carbon and magnesium. It was previously believed that the first giant stars died out in extremely violent explosions which threw out large quantities of iron into space. However, when the researchers looked at the chemical fingerprint of the newly discovered star, they found little iron at all. This indicates that the primordial star's supernova explosion was actually of surprisingly low energy. Instead of being used by new stars, the iron released by the primordial star was probably consumed by a black hole that formed at the heart of the explosion.

■ HD 140283, image by the Anglo–Australian Observatory and the UK Schmidt telescope. Image: DSS/STScI/AURA/Palomar/Caltech/UKSTU/AAO.