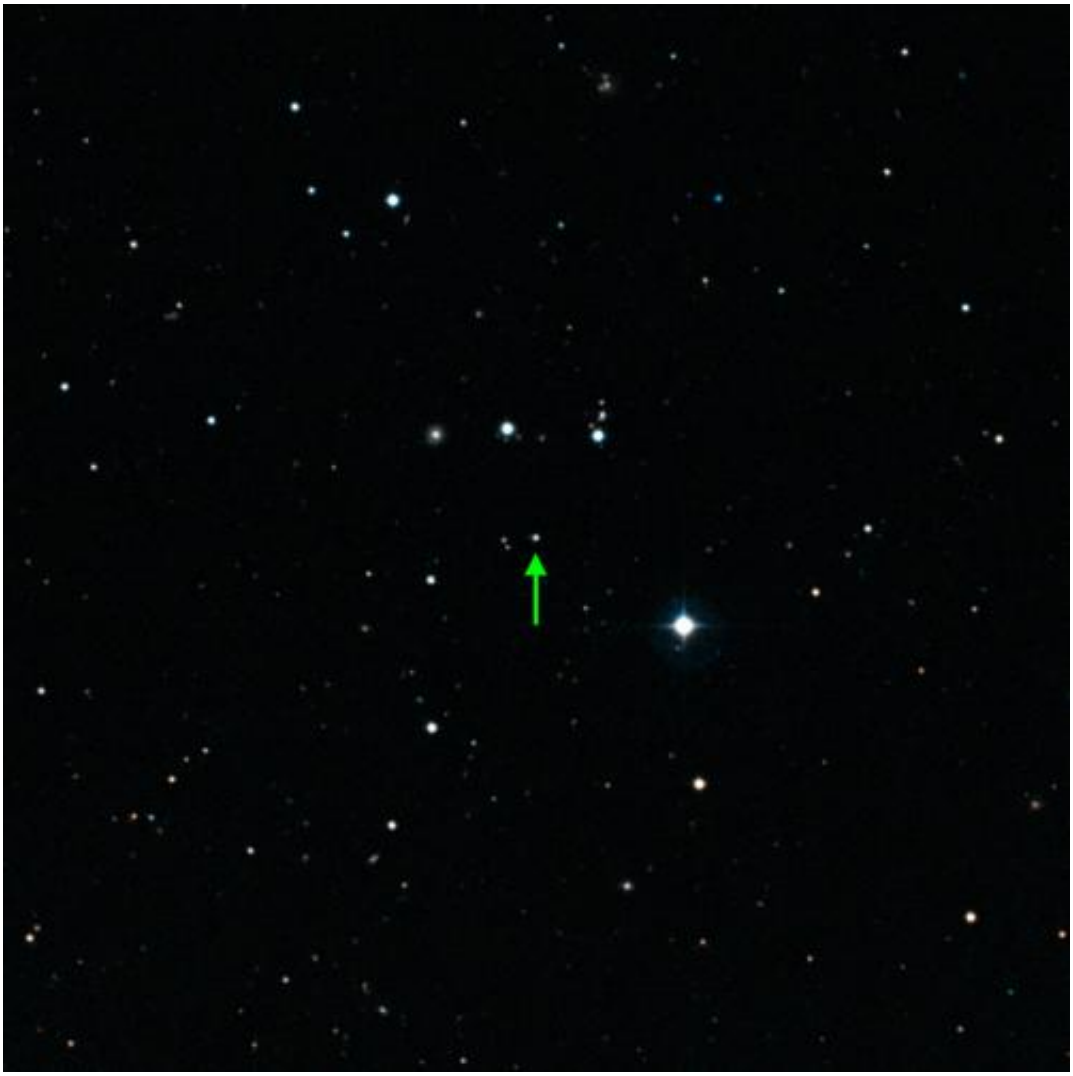
The star that should not exist

August 31 2011



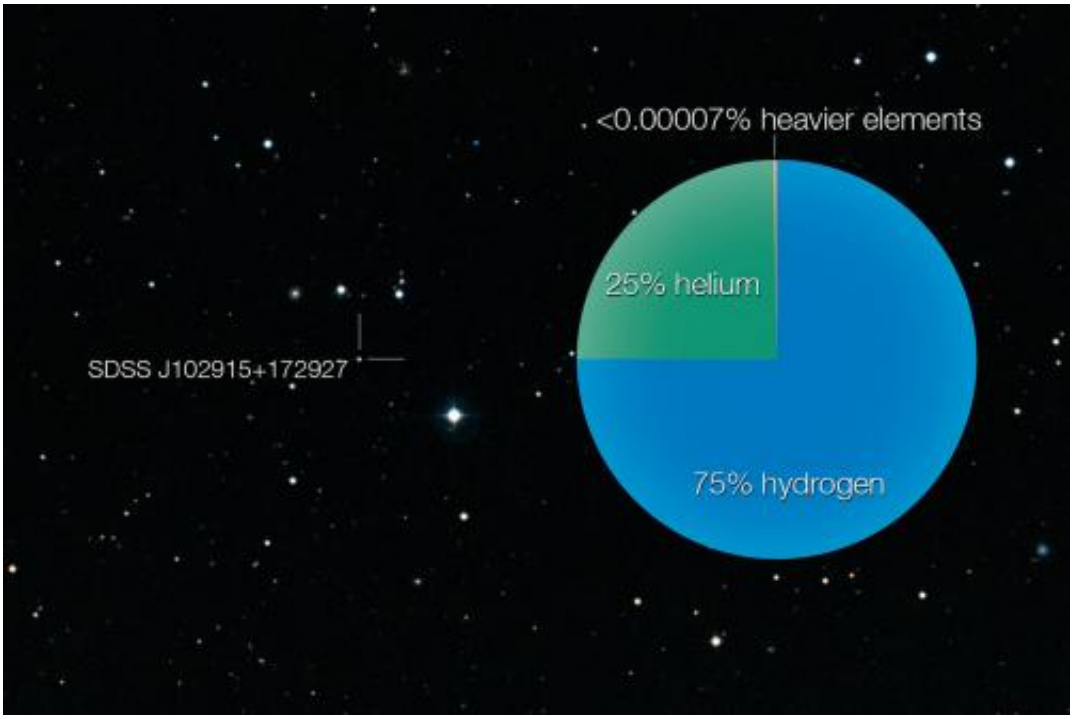
At the centre of this picture is a very unremarkable looking faint star, too faint to be seen through all but the largest amateur telescopes. This ancient star, in the constellation of Leo (The Lion), is called SDSS J102915+172927 and has been found to have the lowest amount of elements heavier than helium of all stars yet studied. It has a mass smaller than that of the Sun and is probably more than 13 billion years old. Credit: ESO/Digitized Sky Survey 2

(PhysOrg.com) -- A team of European astronomers has used ESO's Very Large Telescope (VLT) to track down a star in the Milky Way that many thought was impossible. They discovered that this star is composed almost entirely of hydrogen and helium, with only remarkably small amounts of other chemical elements in it. This intriguing composition places it in the "forbidden zone" of a widely accepted theory of star formation, meaning that it should never have come into existence in the first place. The results will appear in the 1 September 2011 issue of the journal *Nature*.

A faint star in the constellation of Leo (The Lion), called SDSS J102915+172927, has been found to have the lowest amount of elements heavier than helium (what astronomers call "metals") of all stars yet studied. It has a mass smaller than that of the Sun and is probably more than 13 billion years old.

"A widely accepted theory predicts that stars like this, with low mass and extremely low quantities of metals, shouldn't exist because the clouds of material from which they formed could never have condensed," said Elisabetta Caffau (Zentrum fur Astronomie der Universität Heidelberg, Germany and Observatoire de Paris, France), lead author of the paper. "It was surprising to find, for the first time, a star in this 'forbidden zone', and it means we may have to revisit some of the star formation models."

The team analysed the properties of the star using the X-shooter and UVES instruments on the VLT. This allowed them to measure how abundant the various chemical elements were in the star. They found that the proportion of metals in SDSS J102915+172927 is more than 20 000 times smaller than that of the Sun.



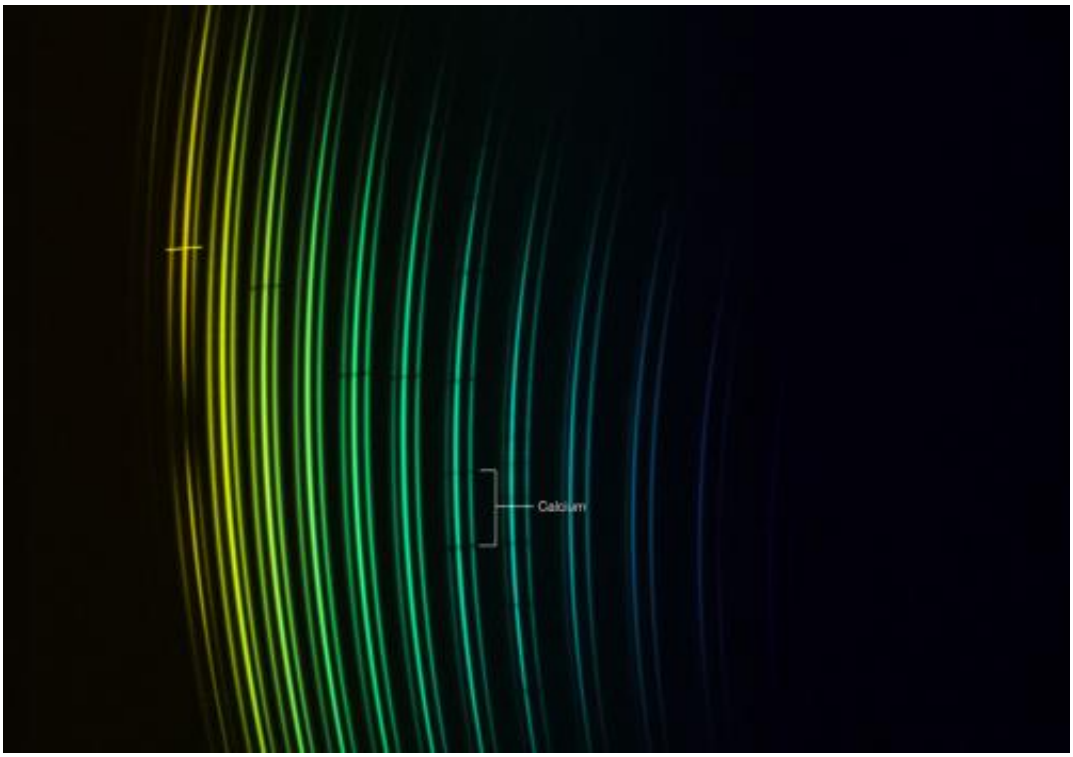
An ancient star in the constellation of Leo (The Lion), called SDSS J102915+172927, has been found to have the lowest amount of elements heavier than helium of all stars yet studied. The pie-chart shows the star's composition: it is almost entirely made from hydrogen and helium with only a tiny trace of heavier elements. Credit: ESO/Digitized Sky Survey 2

"The star is faint, and so metal-poor that we could only detect the signature of one element heavier than helium — calcium — in our first observations," said Piercarlo Bonifacio (Observatoire de Paris, France), who supervised the project. "We had to ask for additional telescope time from ESO's Director General to study the star's light in even more detail, and with a long exposure time, to try to find other metals."

Cosmologists believe that the lightest chemical elements — hydrogen and helium — were created shortly after the Big Bang, together with some lithium, while almost all other elements were formed later in stars.

Supernova explosions spread the stellar material into the interstellar medium, making it richer in metals. New stars form from this enriched medium so they have higher amounts of metals in their composition than the older stars. Therefore, the proportion of metals in a star tells us how old it is.

“The star we have studied is extremely metal-poor, meaning it is very primitive. It could be one of the oldest stars ever found,” adds Lorenzo Monaco (ESO, Chile), also involved in the study.



This picture shows the distribution of the light of different colours coming from the remarkable star SDSS J102915+172927 after it has been split up by the X-Shooter instrument on the ESO VLT. Different colours fall in different places in this strange picture and astronomers can use this data to find the chemical signals from different elements within the star, which show up as dark interruptions of the curved lines. The spectrum of the star appears to be triple at each wavelengths as it was split up using an integral field unit to collect as much light

as possible. This ancient star has been found to have the lowest amount of elements heavier than helium of all stars yet studied. The only evidence of elements heavier than helium is two dark lines from the element calcium. Credit: ESO/E. Caffau

Also very surprising was the lack of lithium in SDSS J102915+172927. Such an old star should have a composition similar to that of the Universe shortly after the Big Bang, with a few more metals in it. But the team found that the proportion of lithium in the star was at least fifty times less than expected in the material produced by the Big Bang.

“It is a mystery how the lithium that formed just after the beginning of the Universe was destroyed in this star.” Bonifacio added.

The researchers also point out that this freakish star is probably not unique. “We have identified several more candidate stars that might have metal levels similar to, or even lower than, those in SDSS J102915+172927. We are now planning to observe them with the VLT to see if this is the case,” concludes Caffau.

Provided by ESO

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