Old star, new trick

April 30 2012

The Big Bang produced lots of hydrogen and helium and a smidgen of lithium. All heavier elements found on the periodic table have been produced by stars over the last 13.7 billion years. Astronomers analyze starlight to determine the chemical makeup of stars, the origin of the elements, the ages of stars, and the evolution of galaxies and the universe.

Now for the first time, astronomers have detected the presence of arsenic and selenium, neighboring elements near the middle of the periodic table, in an ancient star in the faint stellar halo that surrounds the Milky Way. Arsenic and selenium are elements at the transition from light to heavy element production, and have not been found in old stars until now.

Lead author of the Astrophysical Journal paper, Fellow Ian Roederer of the Carnegie Observatories explained: "Stars like our Sun can make elements up to oxygen on the periodic table. Other more massive stars can synthesize heavier elements, those with more protons in their nuclei, up to iron by nuclear fusion—the process in which atomic nuclei fuse and release lots of energy. Most of the elements heavier than iron are made by a process called neutron-capture nucleosynthesis.

"Although neutrons have no charge, they can decay into protons after they're in the nucleus, producing elements with larger atomic numbers. One of the ways that this method can work is by exposure to a burst of neutrons during the violent supernova death of a star. We call this process the rapid process (r-process). It can produce elements at the

middle and bottom of the periodic table—from zinc to uranium—in the blink of an eye."

Roederer, with co-author James Lawler, looked at an ultraviolet spectrum from the Hubble Space Telescope public archives to find arsenic and selenium in a 12 billion year-old halo star dubbed HD 160617. These elements were forged in an even older star, which has long since disappeared, and then—like genes passed on from parent to infant—they were born into the star we see today, HD 160617."

The team also examined data for this star from the public archives of several ground-based telescopes and were able to detect 45 elements. In addition to arsenic and selenium, they found rarely seen cadmium, tellurium, and platinum, all of which were produced by the r-process. This is the first time these elements have been detected together outside the Solar System. Astronomers cannot replicate the r-process in any laboratory since the conditions are so extreme. The key to modeling the r-process relies on astronomical observations.

"What I find exciting is that arsenic and selenium can be found in other stars, even ones like HD 160617 that we've been studying for decades," remarked Roederer. "Now that we know where to look, we can go back and study these elements in other stars. Understanding the r-process helps us know why we find certain elements like barium on Earth, or understand why uranium is so rare."

Provided by Carnegie Institution for Science