Stellar archaeology traces Milky Way's history

ScienceDaily (May 30, 2012) — Unfortunately, stars don't have birth certificates. So, astronomers have a tough time figuring out their ages. Knowing a star's age is critical for understanding how our Milky Way galaxy built itself up over billions of years from smaller galaxies.

Kalirai’s study reinforces the emerging view that our galaxy's halo is composed of components, some of which could be 13.5 billion years old. The measurements suggest the inner-halo stars are younger than the outer-halo population, some of which could be 13.5 billion years old. (Credit: NASA, ESA, and A. Field (STScI))

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Jason Kalirai of the Space Telescope Science Institute and The Johns Hopkins University's Center for Astrophysical Sciences, both in Baltimore, Md., has found the next best thing to a star's birth certificate. Using a new technique, Kalirai probed the burned-out relics of Sun-like stars, called white dwarfs, in the inner region of our Milky Way galaxy's halo. The halo is a spherical cloud of stars surrounding our galaxy's disk.

One of the biggest questions in astronomy is, when did the Milky Way form?" Kalirai said. "Sun-like stars live for billions of years and are bright, so they are excellent tracers, offering clues to how our galaxy evolved over time. However, the biggest hindrance we have in inferring galactic formation processes in the Milky Way is our inability to measure accurate ages of Sun-like stars. In this study, I chose a different path: I studied stars at the end of their lives to determine their masses and then connected those masses to the ages of their progenitors. Given the nature of these dead stars, their masses are easier to measure than Sun-like stars."

Kalirai targeted white dwarfs in the galaxy's halo because those stars are believed to be among the galaxy's first homesteaders. Some of them are almost as old as the universe itself. These ancient stars provide a fossil record of our Milky Way's infancy, possessing information about our galaxy's birth and growth. "The Milky Way's halo represents the premier hunting ground in which to unravel the archaeology of when and how the galaxy's assembly processes occurred," Kalirai explained.

His results were published online May 30 in a letter to the journal Nature. White dwarfs divulge their properties so freely because they have a distinct spectral signature. Kalirai analyzed their signatures using archival spectroscopic data from the European Southern Observatory's Very Large Telescope at the Paranal Observatory in Chile. The spectroscopic data are part of the SN Ia Progenitor Survey (SPY), a census of white dwarf stars in the Milky Way. Spectroscopy divides light into its constituent colors, yielding information about a star's characteristics, including its mass and temperature. In his study, Kalirai first analyzed the spectra of several newly minted white dwarfs divulge their properties so freely because they have a distinct spectral signature. Kalirai analyzed their signatures using archival spectroscopic data from the European Southern Observatory's Very Large Telescope at the Paranal Observatory in Chile. The spectroscopic data are part of the SN Ia Progenitor Survey (SPY), a census of white dwarf stars in the Milky Way. Spectroscopy divides light into its constituent colors, yielding information about a star's characteristics, including its mass and temperature. In his study, Kalirai first analyzed the spectra of several newly minted white dwarfs in the Milky Way's halo because those stars are believed to be among the galaxy's first homesteaders. Some of them are almost as old as the universe itself. These ancient stars provide a fossil record of our Milky Way's infancy, possessing information about our galaxy's birth and growth. "The Milky Way's halo represents the premier hunting ground in which to unravel the archaeology of when and how the galaxy's assembly processes occurred," Kalirai explained.

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white dwarfs in the galaxy's inner halo to measure their masses. "The hottest white dwarfs are the descendants of Sun-like stars that have just extinguished their hydrogen fuel," he explained. "The masses of these white dwarfs are proportional to the masses of their progenitors, and we can use that mass to establish the age of the parent stars."

To measure the halo's age, Kalirai compared the masses of the halo stars with those of six newly formed white dwarfs in the ancient globular star cluster M4. Fortunately, the cluster is one of Hubble's favorite targets, and astronomers have a reliable age for when it formed, 12.5 billion years ago. Kalirai found these dead cluster stars in archival visible-light images of nearly 2,000 white dwarfs taken by the Advanced Camera for Surveys aboard NASA's Hubble Space Telescope.

He applied the same techniques that he used on the halo white dwarfs to these cluster white dwarfs. The spectroscopic observations for these stellar remnants came from the W.M. Keck Observatory in Hawaii. His measurements revealed that the halo white dwarfs are heavier than those in M4, indicating the progenitor stars that are evolving into white dwarfs today are also heavier. Therefore, these stars are younger than the M4 stars. More massive stars consume their hydrogen fuel at a faster rate and therefore end their lives more quickly than lighter-weight stars.

Although Kalirai's result is based on a small sample of stars, it does support recent work proposing that the halo is composed of two different populations of stars.

According to the research, the Milky Way's construction schedule began with the oldest globular star clusters and dwarf galaxies, which formed a few hundred million years after the big bang, settling into what is now the galaxy's halo. These populations merged over billions of years to form the structure of our Milky Way. Stars in the inner halo were among the second generation of stars to form after the Big Bang. Located in the dwarf galaxy Sculptor some ... > read more

Kalirai hopes to apply his new technique on more halo white dwarfs in the galaxy's outer halo to discover that they are still making new stars. The results provide insights into how galaxies evolve with ... > read more

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