'Ageless' silicon throughout Milky Way may indicate a well-mixed galaxy

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As galaxies age, some of their basic chemical elements can also show signs of aging. This aging process can be seen as certain atoms "put on a little weight," meaning they change into heavier isotopes—atoms with additional neutrons in their nuclei.

Surprisingly, new surveys of the Milky Way with the National Science

Foundation's (NSF) Green Bank Telescope (GBT) in West Virginia, found no such aging trend for the element silicon, a fundamental building block of rocks throughout our solar system. This "ageless" appearance may mean that the Milky Way is more efficient at mixing its contents than previously thought, thereby masking the telltale signs of chemical aging.

When massive first-generation stars in young galaxies end their lives as violent supernovas, they fill the cosmos with so-called primary isotopes—elements like oxygen, carbon, and silicon with a balance of neutrons and protons in their nuclei.

"Massive stars are the cauldrons in which heavy elements like silicon are fabricated," said Ed Young, a scientist at the University of California at Los Angeles and author on a study appearing in the *Astrophysical Journal*. "First-generation stars make silicon 28—an isotope with 14 protons and 14 neutrons in its nucleus. Over billions of years, later generations of stars are able to create the heavier silicon 29 and 30 isotopes. When these later-generation stars explode as supernovas, the heavier isotopes are blasted into the interstellar medium, subtly altering the chemical profile of the galaxy."

Astronomers cannot directly measure these long-term chemical changes. They can, however, do the next best thing: measuring the apparent maturing of isotopes from the outskirts of our galaxy toward its center.

Since there is a greater concentration of stars the closer you get to the center of the Milky Way, including massive stars that end of their lives as supernovas, astronomers expect to find a greater percentage of heavier isotopes among the elements there.

Past radio telescope studies of carbon and oxygen atoms in the Milky

Way provided some indication that there is in fact a steady progression from light to heavy isotopes the closer you move toward the galactic center.

Intervening interstellar clouds, however, made these observations difficult and the results were inconclusive.

"There were some tantalizing hints in past studies that carbon and oxygen isotope ratios shifted as expected. But it was difficult to account for the material in the interstellar medium, so we were uncertain how reliable these data were," said Young. "Silicon, as detected in molecules of silicon monoxide, has a spectral signature that makes it much easier to account for the dust and gas in our galaxy. We therefore had to make fewer assumptions than were necessary for the surveys done for oxygen and carbon."

Using the 100-meter GBT, the astronomers surveyed vast swaths of the Milky Way, starting from the region near our sun and then moving all the way toward the galactic center. In each region, they probed the radio spectra naturally emitted by silicon monoxide molecules. Differences in the silicon isotopes would be seen as subtle changes in the radio spectra.

Counter to their expectations, the researchers found none of the expected gradient in the isotope ratios.

"There was no evidence of a gradient," said Nathaniel Monson, a member of the research team and a graduate student at UCLA. "That was a bit surprising. We may have to reassess what we think we know about our galaxy."

These data may mean that the Milky Way is remarkably efficient at mixing its material, circulating molecules and atoms from the galactic center out into the galaxy's spiral arms and back. It is also possible that type 1a supernovas—which are formed in binary systems when a white dwarf star steals too much material from its companion and detonates—produce an overabundance of Si 28 later in the lifespan of a galaxy.

If subsequent surveys of carbon and oxygen are better able to account for past uncertainties and show the same lack of gradient, it would point to mixing as being the most likely scenario.

"There's a lot about the galaxy we don't understand yet," concluded Young. "It's possible that further studies with the GBT will teach us a bit more about the Milky Way."

More information: Nathaniel N. Monson et al. Uniform Silicon Isotope Ratios Across the Milky Way Galaxy, *The Astrophysical Journal* (2017). DOI: 10.3847/1538-4357/aa67e6

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