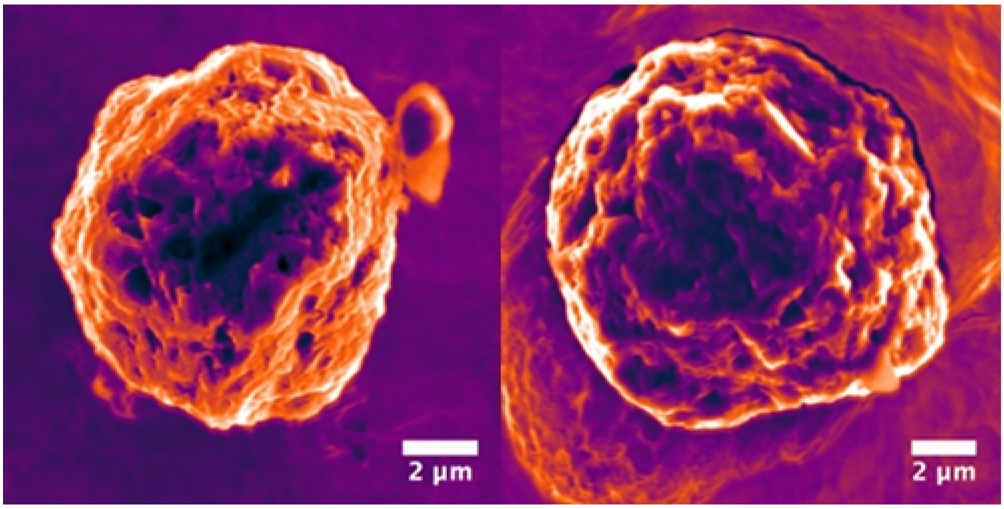
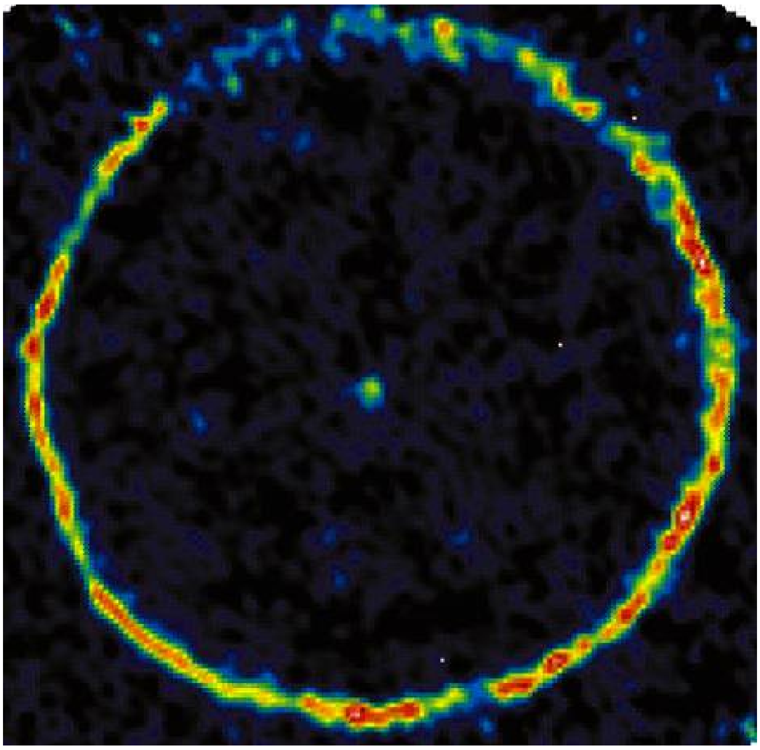
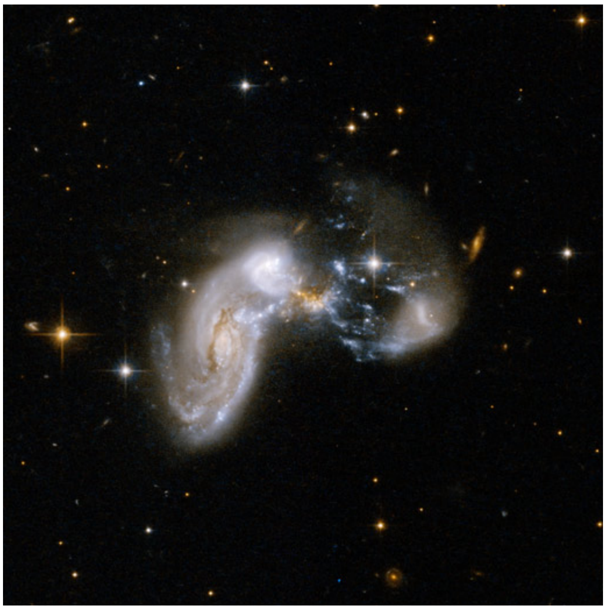


Scanning electron microscope images (false color) of silicon carbide grains from this study.
Credit: *P. Heck*

A fragment from the Murchison meteorite.
Credit: *NASA*



This false-color image shows an AGB, or carbon, star (called TT Cygni) surrounded by a carbon-rich shell that was blown out by a stellar wind. This ejected material eventually winds up seeding other star systems. Credit: *H. Olofsson (Stockholm Observatory) et al.*



This object, called Zw II 96, is a galactic merger of two galaxies, 500 million light years from Earth. The blue spots are regions of intense star formation. Credit: *NASA, ESA, the Hubble Heritage Team (STScI/AURA)-ESA/Hubble Collaboration and A. Evans (University of Virginia, Charlottesville/NRAO/Stony Brook University)*

Where do we come from? The answer varies depending on how far back you want to look. Researchers are studying the oldest meteorite grains to figure out the origin of our solar system. Some of the planet-making material may have resulted from another galaxy smacking into ours.

Around 4.6 billion years ago, our yellow star and its planet-filled disk arose out of a dense molecular cloud. Most of the details about this pre-solar environment were lost to heating of the primordial gas and dust, but some rocky grains escaped alteration and therefore preserve clues of our solar system's distant past.

"Presolar grains are the oldest materials in the solar system," says Philipp Heck of the University of Chicago. "The ages of the grains clearly indicate that they are older than the solar system."

But just how old?

Heck and his colleagues isolated 22 grains from the Murchison meteorite, which is well-known for the organic material it contains, and measured how long the grains spent in interstellar space before winding up in our nascent solar system. The implied grain ages, reported in a recent paper of the Astrophysical Journal, appear to support a hypothesis that our solar system formed after a smaller satellite galaxy crashed into the Milky Way around 6 billion years ago.

Pre-solar graininess

Scientists have known since the 1960s that meteorites contain rare isotopes (an isotope is a more or less massive version of an element). In 1987, some of these isotopes were found to be localized in micron-sized grains that presumably formed outside of our solar system and somehow survived the planet-formation process.

For example, some small diamond crystals in meteorites have high levels of heavy xenon isotopes that imply that they originated from a supernova explosion.

"Isotopic abundances tell us what type of star a pre-solar grain came from or which planet or parent body a meteorite comes from," Heck says.

Heck and his colleagues looked in particular at silicon carbide grains from the Murchison meteorite. These grains stand out by having more heavy silicon isotopes than anything else in the solar system. In particular, the levels of silicon-29 and silicon-30 (relative to the more common silicon-28) are as much 100 times that found in normal silicon crystals.

Because of these anomalous abundances, scientists believe that pre-solar silicon carbide grains formed in the winds blowing off of asymptotic giant branch (AGB) stars, which are often called "carbon" stars because of the high levels of carbon detected in their atmospheres.

Interstellar travel times

The silicon carbide grains also contain other isotopes that speak of the long interstellar voyage the grains made from their carbon star sources to the molecular cloud that eventually became our solar system.

The interstellar medium is full of cosmic rays, which are highly energetic protons and other small nuclei. When a cosmic ray smashes into a space-faring grain, it can break up one of the resident atoms into several pieces. Some of these pieces are isotopes that are not expected to form in stars, Heck explains.

The so-called "cosmogenic" isotopes are like a clock – the more of them that a grain contains, the

longer it spent in interstellar space being bombarded by cosmic rays. (Once the grain becomes incorporated into the larger space rocks of a burgeoning solar system, it is no longer exposed to as many cosmic rays, and therefore the clock stops.)

Other researchers have tried to measure this interstellar travel time, but their results have been plagued by uncertainties over what exactly happens to atoms that are struck by cosmic rays.

Heck and his colleagues use an improved model for cosmic ray interactions, and they focus on chemically inert gases, which provide a cleaner record of the past. Using a specially-built noble gas mass spectrometer, the researchers recorded the amount of helium-3 and neon-21 in their samples. Both of these rare isotopes are created largely by cosmic ray collisions.

From the isotope abundances, the researchers estimate that the majority of grains spent between 3 and 200 million years in interstellar space before falling into our molecular cloud some 4.6 billion years ago.

Galactic smashup

The grain ages are shorter than expected. Previous studies had estimated that silicon carbide grains could last in interstellar space for 500 million years before being destroyed, most likely by a supernova shock wave.

The fact that almost none of the grains in Heck's study had pre-solar ages more than 200 million years seems to imply that something dramatic happened in the galaxy's history right before our solar system formed.

This dramatic event could have been a merger between our Milky Way galaxy and a metal-poor satellite galaxy. Such a collision, proposed by Donald Clayton of Clemson University, would have unleashed a burst of star formation.

"The merger-induced starburst about 2 billion years prior to the sun's birth would indeed seem to explain this data," says Clayton, who was not one of the authors.

The timing of the merger would explain the lack of "old" silicon carbide grains. It takes about a billion and a half years for an intermediate-mass star to mature into an AGB star, so there would be a relative lull in silicon carbide grain production following the burst in star formation. Then about 200 million years before the solar system formed, the merger-induced AGB stars started pumping out grains.

The grains didn't stay in one place, but spread out across the galaxy. In fact, there is evidence that all the matter that made up our solar system was widely dispersed, says outside researcher Anthony Jones from the Institut d'Astrophysique Spatiale at the University of Paris.

"We weren't born anywhere special," Jones says.

However, we may have been born in a special time. Prior to the merger, our galaxy may not have had enough of star-processed materials to produce our type of solar system.

"Such a starburst would have been important, in particular, to deliver carbon and other elements to our solar system," Heck says.