Theory of the sun's role in formation of the solar system questioned

September 4 2008

Pale specks on the surface of this meteorite are among the oldest minerals in the solar system. An odd mix of oxygen atoms within these minerals has puzzled scientists for decades. Credit: Susan Brown

A strange mix of oxygen found in a stony meteorite that exploded over Pueblito de Allende, Mexico nearly 40 years ago has puzzled scientists ever since. Small flecks of minerals lodged in the stone and thought to date from the beginning of the solar system have a pattern of oxygen types, or isotopes, that differs from those found in all known planetary rocks, including those from Earth, its Moon and meteorites from Mars.

Now scientists from UC San Diego and Lawrence Berkeley National Laboratory have eliminated one model proposed to explain the anomaly:

the idea that light from the early Sun could have shifted the balance of oxygen isotopes in molecules that formed after it turned on. When they beamed light through carbon monoxide gas to form carbon dioxide, the balance of oxygen isotopes in the new molecules failed to shift in ways predicted by the model they report in the September 5 issue of *Science*.

"It's solar system forensics. We're understanding a little about how it got made," said Mark Thiemens, Dean of the Division of Physical Sciences and a professor of chemistry and biochemistry at UC San Diego, who directed the project. The results pare down the potential explanations for how gas and dust coalesced to form the planets and will help this team and others interpret samples of the solar wind returned by NASA's Genesis spacecraft.

Atomic Shield

This is how gases became dust and then larger minerals that collided and continued to build to form the planets. Oxygen, the most abundant element in the solar system, is a player in almost all of these reactions.

Each oxygen isotope responds to a unique set of light wavelengths. An abundance of a particular oxygen isotope within in a cloud of gas molecules will quench the light at its preferred wavelengths, shielding gas molecules farther along the light's path. Other wavelengths, including those that dislodge different oxygen isotopes, will continue unimpeded, favoring the inclusion of these rarer isotopes in new molecules.

The balance of oxygen isotopes found in the Allende meteorite is tipped toward the most abundant one, 16O. Planetary rocks have relatively more rarer heavier oxygen isotopes, as though rare isotopes were preferred as the planets formed.

Photo Effect

"We decided to directly test this idea that photoshielding could change the isotope ratios," said Subrata Chakraborty, a postdoctoral fellow at UC San Diego and first author of the paper.

The team focused an intense beam of far-ultraviolet light generated by the Lawrence Berkeley National Laboratory's Advanced Light Source into a tube filled with carbon monoxide gas. The light knocked some of the oxygen atoms free, allowing them to recombine with other carbon monoxide molecules to form carbon dioxide. Chakraborty then collected and analyzed the carbon dioxide to determine the balance of oxygen isotopes in the new molecules.

By precisely controlling the wavelength of the light, the scientists were able to set up conditions that should have resulted in oxygen isotope mixes that matched either those found on Earth or in the Allende meteorite.

Wavelengths known to be absorbed by 16O should result in carbon dioxide molecules enriched with the heavier forms of oxygen. They tested two of these wavelengths: one enriched the mix; the other did not.

Wavelengths not absorbed by 16O should result in a mix that matched that found in the Allende meteorite. Again, of the two the team tested, one did and one did not. "Some process is altering the mix, but it can't be photoshielding," Chakraborty said.

Original Mix

Several other models have been proposed to explain the anomaly--including the idea that an exploding star could have blasted in an extra dose of 16O--only to have been discarded when experimental evidence showed them to be unlikely.

The only one left standing, according to Thiemens, is an idea called molecular symmetry that says an atom flanked by two oxygen isotopes is more likely to become a stable molecule if the two isotopes are mismatched. This quieter process would also favor the formation of molecules that included rarer oxygen isotopes.

"There's no violence," Thiemens said. "It doesn't require a star blowing up or turning on to cast a nebula-wide shadow. It's symmetry."

Source: University of California - San Diego

Citation: Theory of the sun's role in formation of the solar system questioned (2008, September 4) retrieved 10 April 2024 from
https://phys.org/news/2008-09-theory-sun-role-formation-solar.html