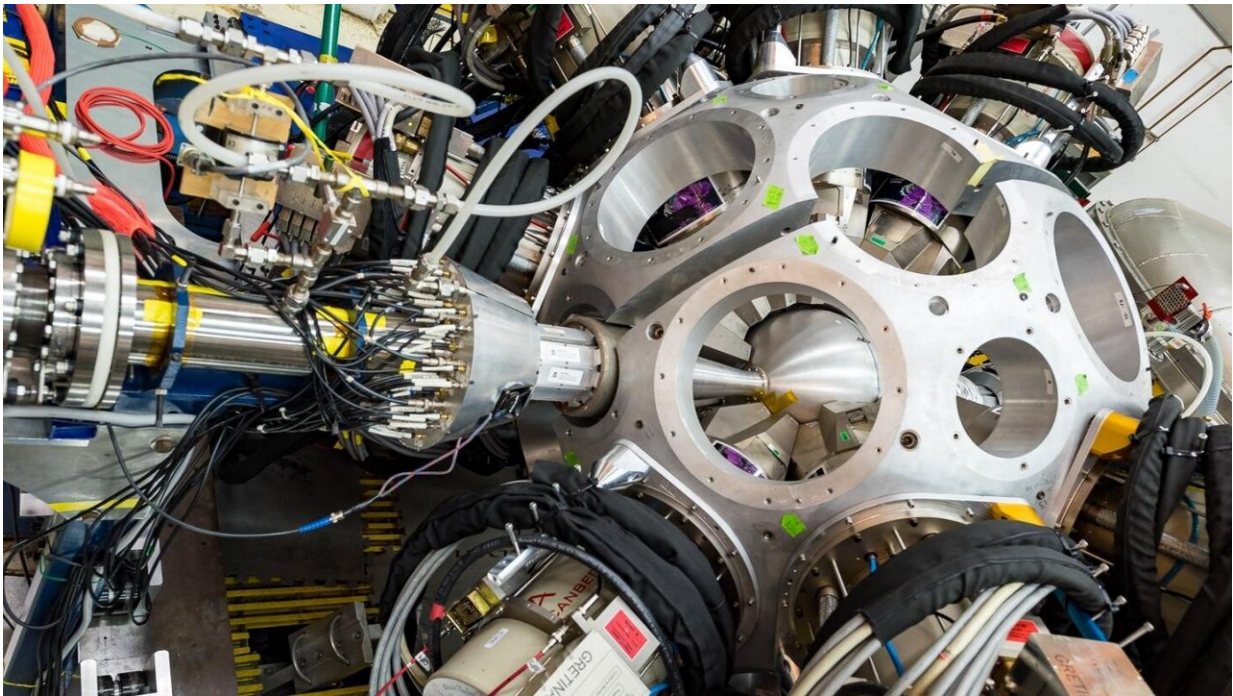


International team develops new method to determine origin of stardust in meteorites

August 10 2020, by Joseph E. Harmon



Photograph of GREY in ATLAS at Argonne. Credit: Argonne National Laboratory

Analysis of meteorite content has been crucial in advancing our knowledge of the origin and evolution of our solar system. Some meteorites also contain grains of stardust. These grains predate the formation of our solar system and are now providing important insights into how the elements in the universe formed.

Working in collaboration with an international team, [nuclear physicists](#) at the U.S. Department of Energy's (DOE's) Argonne National Laboratory have made a key discovery related to the analysis of "presolar grains" found in some meteorites. This discovery has shed light on the nature of [stellar explosions](#) and the origin of chemical elements. It has also provided a new method for [astronomical research](#).

"Tiny presolar grains, about one micron in size, are the residue from stellar explosions in the distant past, long before our solar system existed," said Dariusz Seweryniak, experimental nuclear physicist in Argonne's Physics division. The stellar debris from the explosions eventually became wedged into meteorites that crashed into the Earth.

The major stellar explosions are of two types. One called a "nova" involves a binary star system, where a main star is orbiting a white dwarf star, an extremely dense star that can be the size of Earth but have the mass of our sun. Matter from the main star is continually being pulled away by the white dwarf because of its intense gravitational field. This deposited material initiates a thermonuclear [explosion](#) every 1,000 to 100,000 years, and the white dwarf ejects the equivalent of the mass of more than thirty Earths into interstellar space. In a "supernova," a single collapsing star explodes and ejects most of its mass.

Nova and supernova are the sources of the most frequent and violent stellar eruptions in our Galaxy, and for that reason, they have been the subject of intense astronomical investigations for decades. Much has been learned from them, for example, about the origin of the heavier elements.

"A new way of studying these phenomena is analyzing the chemical and isotopic composition of the presolar [grains](#) in meteorites," explained Seweryniak. "Of particular importance to our research is a specific nuclear reaction that occurs in nova and supernova—proton capture on

an isotope of chlorine—which we can only indirectly study in the lab."

In conducting their research, the team pioneered a new approach for astrophysics research. It entails use of the Gamma-Ray Energy Tracking In-beam Array (GRETINA) coupled to the Fragment Mass Analyzer at the Argonne Tandem Linac Accelerator System (ATLAS), a DOE Office of Science User Facility for nuclear physics. GRETINA is a state-of-the-art detection system able to trace the path of gamma rays emitted from nuclear reactions. It is one of only two such systems in the world.

Using GRETINA, the team completed the first detailed gamma-ray spectroscopy study of an astronomically important nucleus of an isotope, argon-34. From the data, they calculated the nuclear reaction rate involving proton capture on a chlorine isotope (chlorine-33).

"In turn, we were able to calculate the ratios of various sulfur isotopes produced in stellar explosions, which will allow astrophysicists to determine whether a particular presolar grain is of nova or supernova origin," said Seweryniak. The team also applied their acquired data to gain deeper understanding of the synthesis of elements in stellar explosions.

The team is planning to continue their research with GRETINA as part of a worldwide effort to reach a comprehensive understanding of nucleosynthesis of the elements in stellar explosions.

More information: A. R. L. Kennington et al, Search for Nova Presolar Grains: γ -Ray Spectroscopy of Ar34 and its Relevance for the Astrophysical Cl33(p, γ) Reaction, *Physical Review Letters* (2020). [DOI: 10.1103/PhysRevLett.124.252702](https://doi.org/10.1103/PhysRevLett.124.252702)

Provided by Argonne National Laboratory

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