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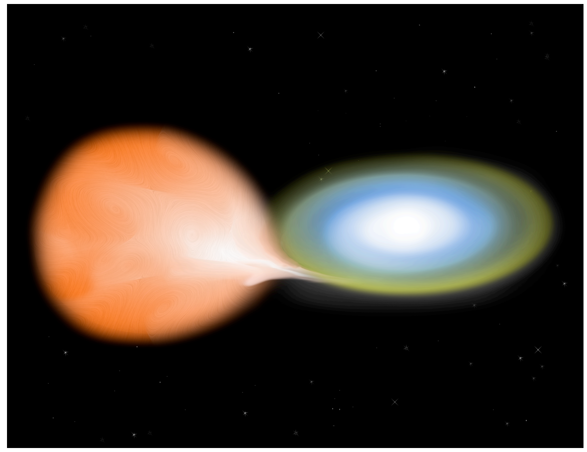
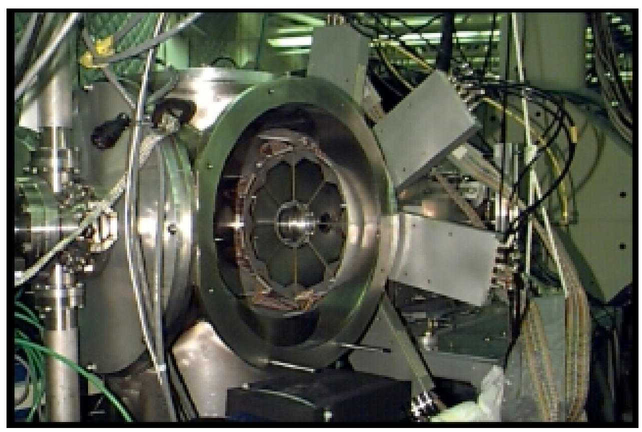
LABORATORY ASTROPHYSICS SHATTERS PREVIOUS NOTIONS OF COSMIC ORIGINS OF OXYGEN



CXC/M.Weiss
The artist's illustration depicts a classical nova binary system just before an explosion on the surface of the white dwarf star. Classical novas occur in a system where a white dwarf closely orbits a normal, companion star. In this illustration, gas is flowing from the large red, companion star into a disk and then onto the white dwarf that is hidden inside the white area.



Detector system used to measure nuclear interaction of radioactive Fluorine-17 and Hydrogen at Oak Ridge National Laboratory's Holifield Radioactive Ion Beam Facility.

Scientists are reporting today that new computer simulations utilizing a recent result from a terrestrial atom smasher show that the amount of heavy oxygen cooked up in the innermost regions of nova explosions was underestimated by a factor of 10,000, causing scientists to reexamine the cosmic origins of this important, life-giving element. These results dramatically demonstrate the importance of establishing firm experimental foundations for simulations of astrophysical explosions.

Nearly all of the elements in the cosmos were created deep within stars and then dispersed during cataclysmic stellar explosions. To study the cosmic origins of the elements, scientists smash atomic nuclei together to recreate, one nucleus at a time, the processes that cause stars to explode. One such measurement in a unique terrestrial laboratory has now been shown to change estimates of the amount of heavy oxygen and other nuclei produced in violent nova explosions by up to a factor of 10,000 compared to older studies. This suggests that the origins of plentiful elements like oxygen are not well understood. The new computer simulations show that further study is needed to determine the mechanisms by which atomic nuclei are synthesized in stellar conflagrations. Suzanne Parete-Koon (University of Tennessee) and colleagues will present the findings today at the American Astronomical Society meeting in Seattle, Washington.

Parete-Koon, a graduate student, and collaborators used the results of a novel measurement of the interaction of hydrogen and radioactive Fluorine nuclei to determine how fast they fuse together in the extremely high temperatures and densities that occur when stars explode. Such fusion reactions are believed to be the power source of novae, runaway thermonuclear outbursts in stars that create elements and eject them into space. The researchers, led by Senior Scientist Michael Smith of Oak Ridge National Laboratory (ORNL), incorporated the new fusion rate into a computer program written by Research Assistant Professor W. Raphael Hix of the University of Tennessee. The code numerically traces the evolution of a nova from the first spark through the violent peak to the last fizzle. Detailed calculations previously made by collaborator Professor Sumner Starrfield at Arizona State University indicated how the temperature of the explosion rapidly changes from tens of millions to a few hundred million degrees in only a few hundred seconds. This temperature history was input into Hix's computer code, along with the new fusion rate, and results were compared to calculations using older fusion rates.

The team found that the new fusion reaction rate changed the amount of heavy Oxygen, primarily Oxygen-17, synthesized in the innermost regions of an energetic nova explosion on the surface of a white dwarf star by more than a factor of 10,000 compared to some previous estimates. A method to account for the different temperatures of regions within the nova explosion was devised and used to demonstrate a factor of 3 change in the Oxygen-17 production from the entire nova event. In these simulations, the underlying white dwarf was 1.35 times more massive than the sun, but only one-hundredth of the diameter, and was composed primarily of Oxygen, Neon, and Magnesium. Simulations were also made of a nova outburst on a 1.25-solar mass white dwarf star with lower peak temperatures, and here the changes in Oxygen-17 production were less but still pronounced.

While only 0.04 % of all Oxygen in your body is Oxygen-17, this is thought to be almost entirely synthesized in novae. In contrast, the dominant isotope Oxygen-16 is synthesized inside massive stars and dispersed via supernovae. Since the ratio of oxygen isotopes in our bodies and on earth is well known, the new results may cause scientists to reexamine theories of the cosmic origins of oxygen.

The measurement motivating these new simulations was led by ORNL Research Staff Member Daniel Bardayan and performed at ORNL's Holifield Radioactive Ion Beam Facility (HRIBF) in Oak Ridge, Tennessee. This national user facility, managed by UT-Battelle, LLC, for the U.S. Department of Energy, is the only facility in the U.S. dedicated to the production of reaccelerated beams of radioactive ions for basic research in nuclear astrophysics and other areas.

HRIBF, along with a handful of other facilities, is providing some of the experimental foundation required for simulations of exploding stars. However, a bold, next-generation facility is required to study the thousands of radioactive nuclei occurring in supernova explosions: the Rare Isotope Accelerator (RIA). This nearly billion-dollar proposed facility is the highest priority for new construction in the nuclear physics community, and will be a flagship Department of Energy facility. It will be hosted either by Argonne National Laboratory, outside Chicago, Illinois, or Michigan State University in East Lansing, Michigan.

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Images: http://chandra.harvard.edu/photo/cycle1/v1494aql/index.html, http://www.phy.ornl.gov/astrophysics/nuc/rib/sidar/sidar.html