CYCLOTRON INSTITUTE
TEXAS A&M UNIVERSITY

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DON'T TOUCH: How Scientists Study the Reactions Inside Stars

Indirect method lets scientists determine stellar reaction rates, providing detailed information about the universe

THE SCIENCE

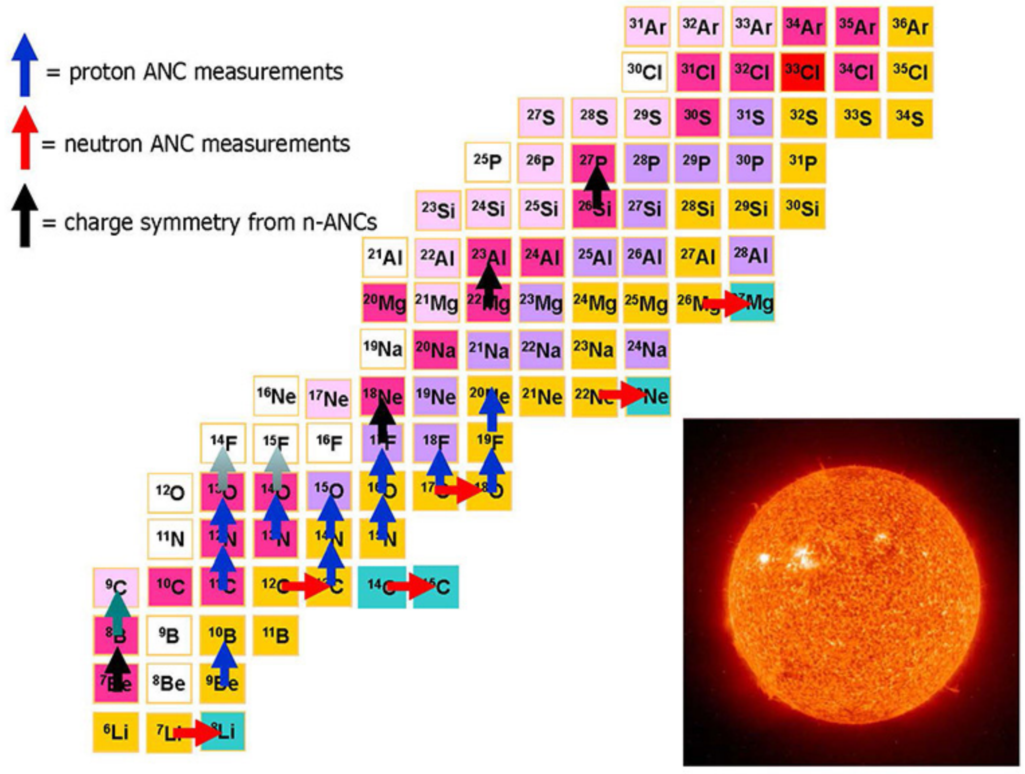
How old is the universe? What causes a star to catastrophically explode? Answering these and other questions about stellar evolutions requires knowing the rates of the reactions involved. Specifically, scientists need to understand low-energy nuclear reactions that involve stable and unstable nuclei, the positively charged core of atoms. With few exceptions, laboratory measurements are limited to stable isotopes and high energy levels and thus must be extrapolated to lower energies. Nuclear scientists at Texas A&M University devised a method, using the asymptotic normalization coefficients (ANC), that allows scientists to determine key reaction rates at stellar energies using conventional nuclear reactions.

THE IMPACT

The measurement of the ANC for the capture of a proton by a specific atom, 14N, caused nuclear scientists to reconsider the age of the universe, which had been based on earlier work. This result is just one of many important rates that have been measured by this technique.

SUMMARY

Measurements of ANCs over the past decade have provided new information about rates of many stellar reactions that involve capturing a proton by light-mass nuclei. Such reactions are important in supernovae and other stellar burning and stellar evolution phenomena. The ANC method involves both stable and unstable nuclei. Results from the ANC research have been published in more than 70 papers in the leading peer reviewed journals. A summary of the work has been published as a review article in *Reports on Progress in Physics*.



Left: Chart of nuclides and important astrophysical reactions.

Right: SOHO-EIT image from 14 September 1997 showing a huge eruptive prominence in the resonance line of singly ionized helium (He II) at 304 Angstroms in the extreme ultraviolet. The material in the eruptive prominence is at temperatures of 60,000-80,000 K, much cooler than the surrounding corona, which is typically at temperatures above 1 million K.

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PUBLICATIONS

R.E. Tribble, C.A. Bertulani, M. La Cognata, A. M. Mukhamedzhanov, and C. Spitaleri, "Indirect Techniques in Nuclear Astrophysics: A Review." Reports on Progress in Physics 77, 106901 (2014).

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ABOUT THE CYCLOTRON INSTITUTE: *Dedicated in 1967, the Cyclotron Institute serves as the core of Texas A&M University's accelerator-based nuclear science and technology program. Affiliated faculty members from the Department of Chemistry and Department of Physics and Astronomy conduct nuclear physics- and chemistry-based research and radiation testing within a broad-based, globally recognized interdisciplinary platform supported by the United States Department of Energy (DOE) in conjunction with the State of Texas and the Welch Foundation. The facility is one of five DOE-designated Centers of Excellence and is home to one of only five K500 or larger superconducting cyclotrons worldwide.*