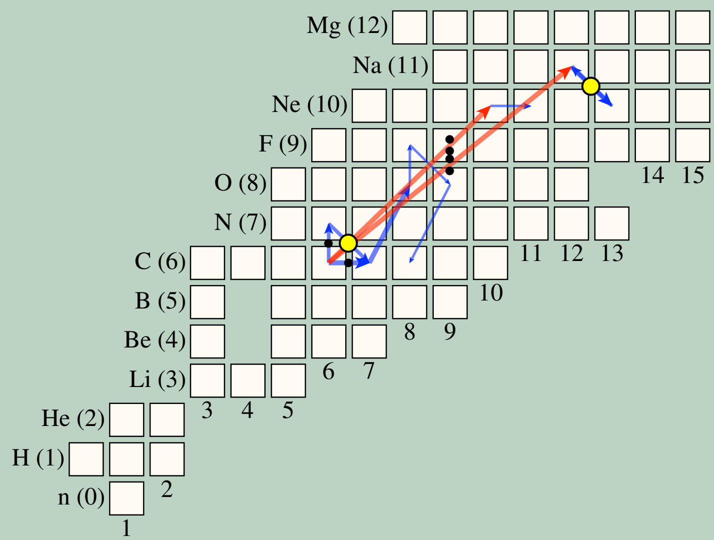
The Joint Institute for Nuclear Astrophysics

JINA

Simmering white dwarfs consume electrons



Schematic of reaction pathways during the pre-explosive "simmering" of a white dwarf. Every black dot indicates a ^{12}C nucleus consumed, and each yellow dot indicates the capture of an electron. During this simmering, there are 2 electrons captured for every 6 ^{12}C nuclei consumed.

Prior to its explosion as a type Ia supernova, a white dwarf “simmers”: over a 1000 year period, ^{12}C fusion in its core gradually raises its internal temperature to roughly 800 million K. Now JINA researchers have discovered how the white dwarf consumes some of its electrons during this period. In one of two independent efforts to study this phase, MSU graduate student David Chamulak has computed the rate at which the core of the white dwarf becomes neutron-enhanced prior to the explosion. The JINA team found, in agreement with Piro & Bildsten of the Kavli Institute for Theoretical Physics, that the reduction in electron abundance depends how much ^{12}C is consumed, which depends on factors such as the temperature of the white dwarf prior to ignition. This electron abundance plays an important role in the supernovae: it controls the amount of radioactive ^{56}Ni synthesized in the explosion, and hence controls the peak brightness of the supernovae. Astronomers have been aware for some time that type Ia supernovae in elliptical galaxies are slightly dimmer, on average, than their cousins in spiral galaxies, but the reason for this correlation is unclear. It may be that part of the difference depends on the internal structure of the white dwarf prior to its explosion. The JINA team has computed new effective heating and neutronization rates for this simmering phase. These rates include a new evaluation of the ^{13}N electron capture rate computed by MSU researcher Remco Zegers and will be useful for future hydrodynamical simulations of the pre-explosion white dwarf.

Investigators
David A. Chamulak[1]
Edward F. Brown[1]
Francis X. Timmes[2,3]
Kimberly Dupczak[1]
[1]Michigan State University
[2]Los Alamos National Laboratory
[3]Arizona State University

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Contact
Edward Brown
ebrown@pa.msu.edu
517/355-9200 x2420