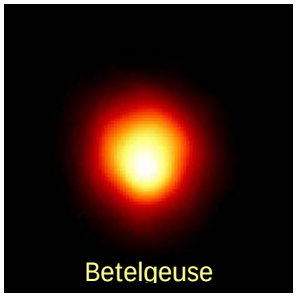
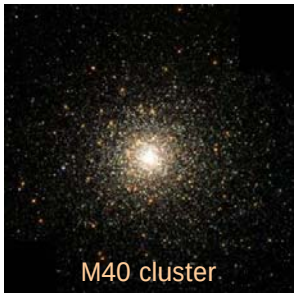
Modeling of nuclear reactions at stellar energies





Just how long a star lives is determined by the energy production from nuclear reactions in the stellar core. The temperature of stellar burning is relatively low which reduces the overall probability for nuclear fusion processes and such guarantees long stellar lifetimes. It is critical to know the reaction probability at these temperatures so that we may determine with certainty just how long stars like our sun or neighboring objects like Sirius or Betelgeuse will live.

Only twice have physicists been able to measure the nuclear reactions at stellar energies in the laboratory. Experiments involving other stellar reactions would take years to complete. Modeling the life course of stars and stellar evolution therefore depends on simulating the associated nuclear reaction processes. The Joint Institute for Nuclear Astrophysics (JINA) has developed a new "multi-channel R-matrix" model AZURE to perform these calculations. Based on existing data from reaction and elastic scattering channels, we have successfully recalculated reactions such as $^{14}N(p,\gamma)^{15}O$, $^{15}N(p,\gamma)^{16}O$, and $^{15}N(p,\alpha)^{12}C$ in the CNO cycles. The cross sections are extrapolated into the stellar energy range.

The reaction rates of these processes allow us to determine the lifetime of massive globular cluster stars. This information has determined the age of old globular clusters such as M40 leading to an independent determination of the age of our universe. Based on the AZURE analysis, the age of globular clusters changes by approximately one billion years compared to previous estimates.

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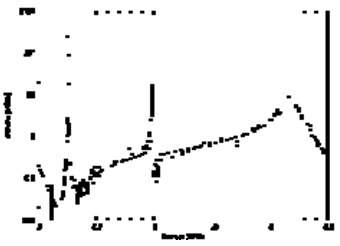
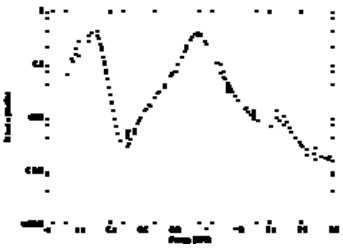
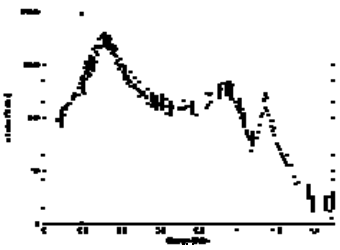


R-matrix analysis of $^{14}N(p,\gamma)^{15}O$



R-matrix analysis of $^{15}N(p,\gamma)^{16}O$



R-matrix analysis of $^{15}N(p,\alpha)^{12}C$

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