REACTION RATE CALCULATIONS IN DENSE STELLAR MATTER

Abstract

by

Mary Beard

An interesting question on nuclear astrophysics is the fate of X-ray burst ashes as they descend under gravity to the deep layers of an accreting neutron star crust. As the ashes sink, they are subject to a range of nuclear reactions which transmute the nuclei. The primary of these reaction mechanisms are electron capture reactions, which are activated for different isotopes depending on the electron Fermi energy. At sufficiently high mass densities ($\rho = 2.1 \times 10^9$ g cm^{-3} for $^{12}C + ^{12}C$ and $\rho = 3.2 \times 10^{12}$ g cm^{-3} for $^{40}Mg + ^{40}Mg$), density induced fusion reactions, known as pycnonuclear reactions, begin to occur.

By combining existing electron capture formalism and a phenomenological expression for pycnonuclear reactions (specifically developed for a multi component plasma environment) with a network solver, the fate of the X-ray burst ashes has been addressed. In this context it has been found that with increasing mass density, the rigid Coulomb lattice of the neutron star crust dissolves into the isotopes ^{40}Mg and ^{46}Si, with an integrates energy release of between ~ 1.8 MeV/u and ~ 2.4 MeV/u, depending on lattice models. This result is fairly insensitive to the initial abundance distribution. The production of ^{46}Si is determined to be the result of a cyclical pycnonuclear fusion, electron capture process.