Pycnonuclear Reactions

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Fusion reactions inside compact astrophysical objects can be divided into thermonuclear fusion and pycnonuclear processes. While thermonuclear fusion takes place in relatively hot and dilute plasmas inside stars with only the high-energetic components of the velocity distribution being important, pycnonuclear fusion happens at rather high densities where mostly low-energetic nuclei contribute to the fusion process. Pycno-nuclear reactions in neutron stars are considered as a possible energy source for γ-ray bursts. Neutron-rich nuclei are arranged on a lattice, the spacing of which is shrinking under the gravitational pressure of accreting material. At a critical distance nuclear fusion of lattice nuclei sets in. The detailed knowledge of the nuclear matter distribution is crucial for the determination of the pyconuclear fusion rates and their dependence on the densities inside the neutron star's crust. The Relativistic Hartree-Bogoliubov approach is used for calculating the density profiles for protons and neutrons in the nuclei involved in pycno-nuclear reactions. They are necessary nuclear structure inputs for estimating this critical lattice constant and the rates of these reactions. The rates are calculated within the optical model where the Pauli nonlocality of nuclear interaction is taken into account [1]. The figure illustrates the accuracy of the description of the S-factors obtained within such hybrid approach by comparing with reactions that are accessible in the laboratory. The agreement promises reliable predictions for the reactions in the neutron star. The work is progress and the final results will be reported later. [2].

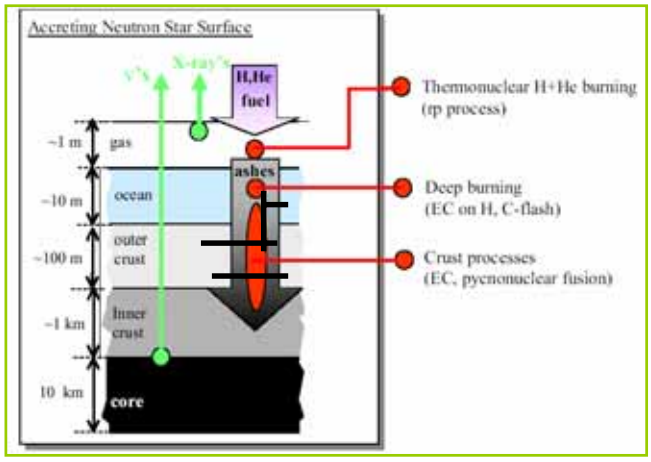

Fig. 1 *Schematic illustration of pycno nuclear reactions is the crust of neutron stars*

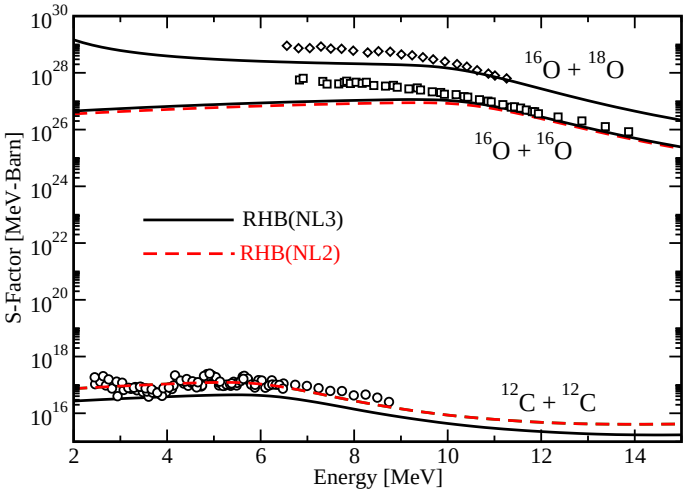

Fig. 2
Calculated and experimental S-factors of indicated reactions. The calculations are based on the RHB densities obtained with the NL3 and NL2 parametrizations of the RMF Lagrangian.

[1] L. C. Chamon, B. V. Carlson, L. R. Gasques, D. Pereira, C. De Conti, M. A. Alvarez, M. S. Hussein, M. A. Candino Ribeiro, E. S. Rossi, Jr, and C. P. Silva, Phys. Rev. C 66 (2002) 014610

[2] L. R. Gasques et al., in preparation

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