Neutron capture and beta-decay rates under stellar conditions: theoretical approaches and perspectives for their experimental determination

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Under stellar conditions, nuclear reaction rates are different from those measured in laboratory. A notable example of this situation is the stellar rate for neutron capture, when nuclear excited states are thermally populated. Capture can then proceed not only for nuclei in their ground states, but also from nuclear excited states. While, the composite nucleus of a capture process is the same, different excited compound states can be populated from different target nuclear states with different spin and parity. In addition, inelastic scattering channels can be open for these states, in which the neutron is scattered out with kinetic energy higher than kinetic energy of the entrance channel (the so-called super-elastic scattering).

An additional example of the modification of stellar rates with respect to laboratory rates is provided by the beta decay. Here, the different degree of ionization of the nuclei involved imply a modification of the phase-space factor in the decay probability. In addition, here again, excited parent decaying states can be populated in a stellar plasma and additional transitions, with different degrees of forbidness, become possible. A dramatic change in the beta-decay rates under stellar conditions have been predicted and observed in a number of cases.

A review of these two rates evaluations, from the theoretical point of view as well as from the perspectives of their experimental determination will be presented with some relevant examples for both, neutron capture and beta-decay processes.