Trojan Horse Method: Recent Experiments

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Nuclear reactions in stellar environments take generally place at energies much lower than the Coulomb barrier, $E_{\text{CB}}$, existing between the colliding nuclei. Nuclear fusion reactions proceed then via tunnel effect with an exponential decrease of the cross section: $\sigma(E) \approx \exp(-2\pi\eta)$, where $\eta$ is the Sommerfeld parameter. This implies that the cross sections values are generally very small, of the order of micro- and even nanobarns. This results in serious difficulties if one wants to make a measurement in the Gamow window region. Measurements were then performed at higher energies and extrapolated to the Gamow ones.

In performing this extrapolation, owing to the strong exponential suppression of the cross section mentioned above, the astrophysical factor $S(E) = E \sigma(E) \exp(2\pi\eta)$ is introduced, the inverse of the Gamow factor removing the dominant energy dependence in $\sigma(E)$.

The extrapolation is then easier but it is not completely safe and often errors occurred in the evaluation of $S(E)$ at $E_G$ energies, e.g. because of the presence of unknown resonances in the energy range of interest.

Even recent experiments, performed directly in the Gamow energy regions, couldn't avoid an extrapolation procedure as the values of the bare nucleus cross section, $\sigma^{\text{bare}}(E)$, needed by astrophysicists are obtained from measured data after removing the electron screening effects using an extrapolation of higher energy data. These effects are not negligible as they were thought to be before these measurements were done.

In order to overcome some of the difficulties outlined above, a number of indirect methods were introduced. Among them, the Trojan Horse Method (THM) allows for the measurement of thermonuclear reaction cross sections. The Trojan Horse Method allows for the measurements of cross sections in nuclear reactions between charged particles at astrophysical energies. It is based on the quasi-free break-up mechanism. A suitable three-body reaction is selected as a mean to investigate the two-body reaction of astrophysical interest. In this process it is assumed that the interaction between a projectile and the Trojan Horse particle, which may be described in terms of two clusters, involves only one cluster leaving the other as a spectator.

The THM can be applied to determine the energy dependence of the bare nucleus astrophysical $S(E)$-factor, without Coulomb suppression as well as electron screening effect.

The basic features of the method are discussed and recent applications are presented.