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New advances in the Trojan Horse Method as an indirect approach to nuclear astrophysics

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According to our knowledge, the source of energy that sustains burning stars for millions to billions of years is represented by nuclear reactions which are responsible also for the continual conversion of one element to another inside them. Over the past fourty years nuclear physicists have been trying to measure the rates of the most relevant reactions, but there is still considerable uncertainty about their values. Although the stellar temperatures are high, on the order of hundred million degrees, they correspond to sub-Coulomb energies. As a consequence, the
Coulomb barrier causes a strong suppression of the cross-section, which drops exponentially with decreasing energy. Thus, the corresponding reaction rates are extremely small , making it difficult for them to be measured directly in the laboratory. In addition, the electron screening effect due to the electrons surrounding the interacting ions prevents one to measure the bare
nucleus cross-section. Typically, the standard way to get the ultra-low energy bare nucleus cross-section consists in a simple extrapolation of available higher energy data. This is done by means of the denition of the astrophysical S(E) factor which represents essentially the cross-section free of Coulomb suppression. However, the extrapolation may introduce additional uncertainties
due for instance to the presence of unexpected resonances or to high energy tails of subthreshold resonances. A valid alternative approach is represented by the Trojan Horse Method (THM) [1, 2] that provides at present the only way to measure the bare nucleus S(E) factor down to the relevant ultra-low energies, overcoming the main problems of direct measurements. The THM selects the quasi-free (QF) contribution of an appropriate three-body reaction A + a c + C + s performed at energies well above the Coulomb barrier to extract the cross section of a charged particle two-body process A + x c + C in the Gamow energy window. This is done with the help of direct theory assuming that the nucleus a is described in terms of the x+s cluster structure. The THM has been successfully applied to several reactions connected with fundamental astrophysical problems [3, 4, 5]. I will recall the basic ideas of the THM and show some recent results.

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[3] A. Tumino et al., Phys. Rev. 67, 065803 (2003).
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Author: Prof. TUMINO, Aurora (Laboratori Nazionali del Sud - INFN, Catania, Italy and \Universit\'a degli Studi di Enna "Kore", Enna Italy)

Orateur: Prof. TUMINO, Aurora (Laboratori Nazionali del Sud - INFN, Catania, Italy and \Universit\'a degli Studi di Enna "Kore", Enna Italy)