Trojan horse as indirect technique in nuclear astrophysics

A. M. Mukhamedzhanov, L. D. Blokhintsev,[1] B. F. Irgaziev,[2] A. S. Kadyrov,[3]
M. La Cognata,[4] C. Spitaleri,[4] and R. E. Tribble
[1]*Skobeltsyn Institute of Nuclear Physics, Moscow State University, Russia*
[2]*GIK Institute of Engineering Sciences and Technology,Topi, District Swabi, N.W.F.P.,Pakistan*
[3]*Curtin University of Technology, GPO Box U1987, Perth, WA 6845, Australia*
[4]*DMFCI, Universit di Catania, Catania, Italy and INFN - Laboratori Nazionali del Sud, Catania, Italy*

A general theory of the Trojan Horse (THM) method as indirect technique in nuclear astrophysics has been developed. The kinematics of the THM, the experimental conditions for measurements via the THM are considered and the explanation why the THM works are given.

In the TH method the cross section for the binary process $x + A \rightarrow b + B$ is determined from the TH reaction $a + A \rightarrow y + b + B$, where $a = (yx)$ is the Trojan Horse particle. Projectile a is accelerated to energies higher than the Coulomb barrier in the initial state allowing a to approach the proximity of the target A. After that the binary reaction $x + A \rightarrow b + B$ occurs, while the spectator y carries away the excess of energy of the projectile.

The binary sub-process can be direct and resonant. We address both cases, because they require different approaches. For direct binary reactions the THM amplitude can be approximated by the zero-range DWBA amplitude describing the transfer of particles x into the continuum times the half-off-energy-shell (HOES) amplitude for the binary sub-process $x + A \rightarrow b + B$. For the resonant binary sub-reaction the multi-level, multi-channel R matrix method has been generalized for the $2 \rightarrow 3$ reactions proceeding through isolated or overlapping resonances.

The practical applications of the THM method for different astrophysical reactions are presented and comparisons with direct measurements are done.