Trojan horse method as an indirect approach to study resonant reactions in nuclear astrophysics

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The primary goal of the Trojan horse method (THM) is to analyze resonant rearrangement reactions when the density of the resonance levels is low and statistical models cannot be applied. The main difficulty of the analysis is related with the facts that in the final state the THM reaction involves three particles and that the intermediate particle, which is transferred from the Trojan horse particle to the target nucleus to form a resonance state, is virtual. Another difficulty is associated with the Coulomb interaction between the particles, especially, taking into account that the goal of the THM is to study resonant rearrangement reactions at very low energies important for nuclear astrophysics. The exact theory of such reactions with three charged particles is very complicated and is not available. This is why different approximations are used to analyze THM reactions. In this review paper we describe a new approach based on a few-body formalism that provides a solid basis for deriving the THM reaction amplitude taking into account rescattering of the particles in the initial, intermediate and final states of the THM reaction. Since the THM uses a two-step reaction in which the first step is the transfer reaction populating a resonance state, we address the theory of the transfer reactions. The theory is based on the surface-integral approach and R-matrix formalism. We also discuss application of the THM to resonant reactions populating both resonances located on the second energy sheet and subthreshold resonances, which are subthreshold bound states located at negative energies close to thresholds. We consider the application of the THM to determine the astrophysical factors of resonant radiative capture reactions at energies so low that direct measurements can hardly be performed due to the negligibly small penetrability factor in the entry channel of the reaction. We elucidated the main ideas of the THM and outline necessary conditions to perform the THM experiments.

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