The exact probability in the charged particle interaction is derived by using the WKB method and compared with the primitive (standard) probability for three nuclear reactions; \(^3\text{He}({^3\text{He},2p})^4\text{He}, {^3\text{He}}(^{4}\text{He,γ})^7\text{Be} \) and \(^7\text{Be}(p,γ)^8\text{B}\). The Gamow peak produces a nonlinear formula that is solved iteratively to obtain the most effective energy for a reaction. We redefine the astrophysical S-factor for each reaction when the exact probability replaces the primitive probability. We then apply the exact probability and the new S-factor in the reaction rate formula. In all cases, the exact probability increases with the energy until it reaches unity at the top of Coulomb barrier, \(V_c\). The reaction rate per pair using the exact probability for these three nuclear reaction rate are found to be lower by 11%, 5% and 9% respectively compared to the reaction rate from NACRE [3] for the temperatures in the center of the sun.

References