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A new formalism for the study of the surface tension coefficient of α-nuclei systems using the density-dependent nucleon-nucleon interactions

R Gharaei and S Mohammadi

Department of Physics, Sciences Faculty, Hakim Sabzevari University, Khorasan Razavi, Sabzevar, Iran

E-mail: r.gharaei@hsu.ac.ir

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Abstract

This study investigates the nuclear surface tension coefficient, γ, of the proximity formalism by using the microscopic double-folding (DF) model with the realistic density-dependent (DD) nucleon-nucleon interaction of the effective M3Y forces type (including DDM3Y1, CDM3Y4 and BDM3Y1) for the ground-state to ground-state α transition of 230 parent nuclei with Z = 61-99. In fact, the present work can be considered as an expansion of the previous study which has been performed by Gharaei and Mohammadi using CDM3Y6 version in 2019. Within the propsed approach, we have tried to present a new approach for the calculation of the surface energy coefficient, γ, in alpha-decay by integrating the proximity and DF potential models. In addition, we present a new dependency of the surface energy coefficient, γ, on the asymmetry parameter, A_s , of the considered α-nuclei systems by fitting all of the calculated values. The obtained results suggest a new formalism for the coefficient γ that is dependent directly on the selection of the interaction type. We also test the validity of the suggested formula. To this aim, by using the the obtained formula of the coefficient γ in the original version of the proximity potentials, we calculate the theoretical values of the alpha-decay half-lives for different nuclei in the framework of the WKB approximation. The calculated results are compared with the corresponding experimental data and those obtained from the original proximity potential 1977. It is shown that the modified forms of the proximity potential model, labeled as Prox. New (DDM3Y1), Prox. New (CDM3Y4) and Prox. New (BDM3Y1), provide better descriptions of the experimental α-decay half-lives than the proximity potential 1977 (Prox. 77). Further, the best results are obtained using the Prox. New (CDM3Y4) potential model for our selected mass range. Using the modified forms of the proximity potential, we examined the closed-shell effects in nuclei and the validity of the Geiger-Nuttall law. Additionally, the results of the Prox. New (CDM3Y4) potential model are compared with the various empirical formulas for alpha decay half-lives. Ultimately, the prediction of alpha decay half lives is made for superheavy nuclei with Z=117-120.

Keywords: alpha decay, nuclear surface tension coefficient, proximity potential, double-folding model

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