Mass Dependence of Different Surface Effects in Heavy-ion Fusion Reactions*

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The Skyrme Energy Density Formalism (SEDF) is well known for its potentialities to explain the various ground states properties like; binding energy, charge radii, surface as well as deformation properties [1]. Along with these properties, it is also good enough to explain the fusion and fission barriers of large number of nuclei across the periodic table [2]. Large number of studies have been undertaken in the recent time to incorporate the role of effective mass, particle number projection and new emerging degree of freedom like isospin [1-2].

Generally, SEDF consists of Hamiltonian that depends on the nucleonic density, kinetic energy density as well as spin density. Among all these, the form and strength of the kinetic energy density has been always calculated in the literature [2-4]. In the literature, a correction in the gradient term has been suggested [4]. Though all studies agree on this term, its strength has not been resolved and a wide range of its coefficient (denoted as λ having values between 1/36 and 9/36) is available in the literature. We plan to explore the role of this coefficient in heavy-ion collisions in terms of fusion dynamics and want to understand whether one can narrow down the choice based on the study of fusion dynamics.

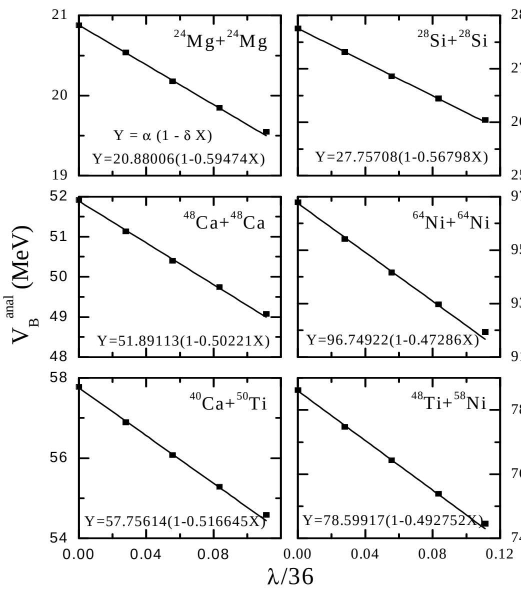

Fig 1. The analytical barrier heights V_B^{anal} as a λ/36 for different reactions.

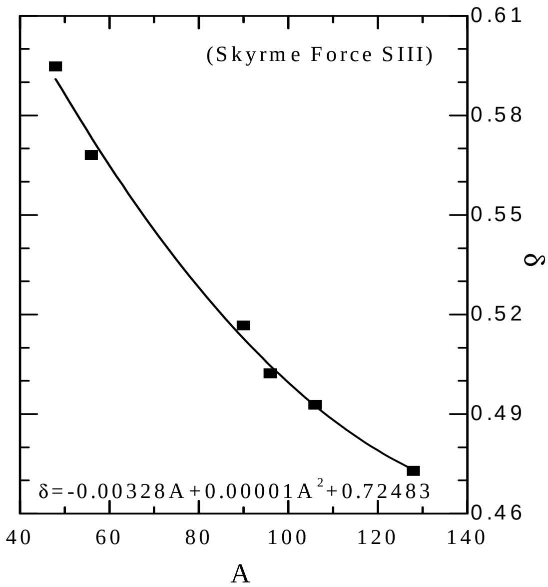

Fig 2. The decrement coefficient δ as a function of function of mass of the system A.

Within the SEDF, we calculated and then parametrized the fusion barriers of 200 reactions in terms of simple quantities like charges and masses of the colliding nuclei for different values of surface correction λ (λ =1/36 - 4/36). In Fig. 1, we display the parametrized fusion barrier heights V_B^{anal} as a function of different values of λ/36. Very interestingly, we see that the barrier height reduces systematically in a linear fashion as one move from λ = 0.0 to λ = 4/36. We further note that the decrement coefficient δ is 0.59474 for ^{24}Mg+^{24}Mg and 0.47286 for ^{64}Ni+^{64}Ni. In Fig. 2, we plotted δ as a function of total mass of the system. It is clear from this figure that λ plays a strong role in lighter nuclei as compared to heavier one. We further pointed out that λ = 1/36 is a better choice for this coefficient and is in good agreement with some recent studies [2-4].

[1] D. Davesne et al., Phys. Rev. C **80**, 024314 (2009); Q. Shen et al., Phys. Rev. C **80**, 024604 (2009); S. Goriely et al., Phys. Rev. C **68**, 054325 (2003).
[2] N. Wang et al., J. Phys. G: Nucl. Part. Phys. **34,** 1935 (2007). A. Dobrowolski et al., Nucl. Phys. A **729**, 713 (2003); R. K. Puri et al., Phys. Rev. C **45**, 1837 (1992).
[3] N. K. Dhiman and R. K. Puri, Acta Phys. Pol. B **38**, 2133 (2007) and earlier references therein.
[4] I. Dutt and R. K. Puri, Phys. Rev. C **81**, 047601 (2010); **81**, 044615 (2010); **81**,064608 (2010), **81**, 064609 (2010).

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