Fayoum University

Effect of Non-Eikonal Corrections on the Reaction Cross-Section for Spherical Deformed Nuclear Pair

By

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Abstract

The present thesis concerns with the effect of non-eikonal correction on the reaction cross-section, σ_R, of deformed target nuclei. In the first chapter, the effect of deformation of a target nucleus on the different physical processes (like fusion, fission and reaction cross-section) was discussed. We studied the shape of the nuclear surface when quadrupole and hexadecapole deformations exist. We presented the expression for calculating the reaction cross-section for deformed-spherical pair of interacting nuclei. This expression was derived recently in the frame work of optical limit to Glauber theory. Since the existence of deformation complicates the numerical calculation of the heavy ion (HI) reaction cross-section, we assumed Gaussian form for the density distribution of the deformed nucleus instead of the Fermi type shape. The Gaussian shape reduces the problem of calculating the HI reaction cross-section to numerical calculation of one dimensional integral. This simplification is very important since it permits calculations and studies of different cases in a short time. The parameters of the Gaussian density were determined from the parameters of the realistic deformed Fermi shape density distribution. We suggested four methods to get the Gaussian parameters from the corresponding parameters of Fermi distribution. For each method, we calculated the reaction cross-section using both Fermi density and the corresponding Gaussian approximation then we determined the error present in $\sigma_R$due to using Gaussian shape. This had been done at seven values of incident energy per projectile nucleon (in the range from 100 MeV/N to 1000 MeV/N) and using both free and in medium nucleon-nucleon reaction cross-section. We considered small and large mass number deformed target nuclei ($N^{17}$and U^{238}). The best method of approximating the realistic Fermi type density by the Gaussian density

distribution at different orientations and different values of energy was found to produce percentage error less than 6% and 2% for $N^{17}$and U^{238}respectively. This method of fitting Gaussian and Fermi shapes is used in the study made in the second chapter.

In the second chapter of the presentthesis we studied the effect of non-eikonalcorrection on the reaction cross-section for spherical-spherical and spherical deformed pairs of interacting nuclei at energy per projectile nucleon in the range 10 - 300 MeV/N. We assumed Gaussian shapes for densities of both the spherical and deformed nuclei and we used the same method presented in the first chapter of this thesis to determine the Gaussian parameters of the deformed density from the corresponding parameters of Fermi density distribution. Wederived the eikonal phase shift and its first order correction from the real and imaginary parts of the optical model potential. Thelater was represented as folding integral over the density overlap of the interacting nuclei. We considered spherical-spherical pairs of interacting nuclei with different volumes and studied the effect of non-eikonal correction on the reaction cross-section for each pair at different values of incident energy in the range 10-300 MeV/N.We found that the percentage increase in $\sigma_R$when the non-eikonal correction is considered increases as the volumes of the interacting nuclei decrease and when the energy becomes low.The same behaviour of the percentage increase in σ_R was found when the spherical target nucleus is replaced by deformed one. Moreover, for deformed target, the percentage error in $\sigma_R$due to neglecting non-eikonal correction is strongly orientation dependent.It has maximum value of 8.4% for the reaction L^6 - N^{17}at the symmetry axis orientation $(\theta, \varphi) = (90^o, 0^o)$ and is reduced to 1.7% at the orientation$(90^o, 90^o)$. For the same reaction and as the incident energy per projectile nucleon increases from 10MeV/N to 300 MeV/N, the values of error become 1.6% and 0.7% for orientations (90°, 0°) and(90°, 90°)respectively. The above mentionedvalues are reduced when the projectile nucleus $Li^{6}$is replaced byC^{12} and become more smaller when the target nucleusN^{17} is replaced by the heavier one U^{238}.