Projectile break-up effects on fusion in $^{12}$C,$^{16}$O+$^{159}$Tb

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Recently a renewed interest has emerged, in heavy-ion (HI) reactions, for the study of break-up and fusion processes at energies near the Coulomb barrier, involving both the stable and unstable beams. This has primarily been motivated by the availability of radioactive ion beams. However, studies using radioactive ion beams are limited due to low beam intensities. Fusion studies using stable beams have indicated that at energies near the barrier, the fusion is strongly influenced by the structure of the interacting nuclei, and also by the presence of transfer processes. In HI reactions, the complete fusion (CF) is associated with the capture of all the projectile-constituents by the target nucleus. On the other hand, incomplete fusion (ICF) occurs when a part of the projectile is captured by the target nucleus and the remaining part escapes with nearly beam velocity. Thus, total fusion probability 'σ$_{TF}$' may be taken as the sum of these two i.e., $σ_{CF} + σ_{ICF}$. Several models have been proposed to explain the features of these processes. Recently, high intensity beams of $^{6,7}$Li and $^{10,11}$B having large breakup probabilities, have been used [1] as references for developing and testing the Break-up Fusion (BUF) Model [2]. However, the break up of strongly bound ($^{12}$C and $^{16}$O) projectiles giving rise to increase in the total fusion cross-section 'σ$_{TF}$', when bombarded on medium mass range targets ($^{169}$Tm, $^{159}$Tb) are also reported [3, 4]. In this work, a systematic study of the effect of projectile breakup on $^{159}$Tb target from weakly bound nuclei to strongly bound nuclei has been carried out by using recently proposed reduction methodology [5]. One of the important points of investigation is whether the break-up of projectile is responsible for increase in the cross-section.

In the present work the data of the experiments carried out, for $^{12}$C+$^{159}$Tb and $^{16}$O+$^{159}$Tb systems, at the Inter-University Accelerator Center (IUAC), New Delhi, India using recoil-catcher technique followed by offline γ-spectroscopy has been used to obtain the fusion cross-sections. The details of the experiments are given elsewhere [3, 4].

The experimentally measured total fusion cross-section for $^{12}$C,$^{16}$O+$^{159}$Tb systems have been compared with that for $^{6,7}$Li,$^{10,11}$B+$^{159}$Tb systems. However, a comparison of total fusion cross-sections for these widely different projectiles is not justified unless the geometrical and Coulomb effects are not removed. These effects may be eliminated with the renormalization of total cross-section and centre of mass energy [6]. However, it has been recently pointed out [5] that the above mentioned reduction procedure may not completely remove dynamical and static effects arising due to height $V_B$, radius $R_B$ and curvature $\hbar\omega$ of the Coulomb barrier, on the total fusion cross-sections at energies below and above the Coulomb barrier. A large value of $\hbar\omega$ implies that potential drops rapidly as the system moves away from the barrier radius. As such, the transparency of the barrier may change with $\hbar\omega$. The values of the barrier curvature parameter alongwith barrier radius 'R$_B$', potential barrier 'V'_B' and α-separation energy 'Q$_{α}$', for the systems studied for comparison are given in table 1. In order to account for the static effects the experimental fu-
As per the Wong’s formalism [7], F(x) can be written as
quences for the presently studied systems shows that the breakup of these projectiles is responsible for an appreciable part of the total fusion cross-section. Further, the α- separation energies may be used to explain the projectile break-up in a systematic way and will be presented.

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References