# Probing Shell Closure Effect via Evaporation Residue Excitation Function Measurements for $^{48}$Ti + $^{140,142}$Ce Systems.

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## Introduction

Over the last few decades, the role of neutron shell closure of either target or projectile nuclei on the fusion probability is a topic of considerable interest. A significant increase in the evaporation residue (ER) cross-sections for the heavy-ion induced reactions with closed neutron shell projectile/target (N=82) has been reported in the past [1-3]. All these investigations involves reactions initiated by heavy projectile nucleus with atomic number, Z > 34. Recently, an attempts have been made to search for the shell effect in $^{48}$Ti induced reactions [4,5]. However, no enhancement in the ER cross-sections due to neutron shell closure were observed. So, it would be of interest to further investigate the dependence of shell effect on fusion probability of $^{48}$Ti induced reactions.

In present work, the ER excitation functions have been measured for $^{48}$Ti + $^{140,142}$Ce systems populating $^{188,190}$Hg compound nucleus (CN). Here, target nuclei $^{140}$Ce has N = 82 and other target ($^{142}$Ce) has two neutrons more than shell closure (N = 84).

## Experimental details

The experiment was carried out using 15 UD Pelletron + LINAC accelerator facility at IUAC, New Delhi. A pulsed $^{48}$Ti beam was bombarded on isotopically enriched $^{140,142}$Ce targets of thickness 100μg/cm$^2$ deposited on 20μg/cm$^2$ carbon backing. To make these targets stable, carbon capping of 5μg/cm$^2$ was placed on both targets. The ERs produced in this reaction were separated from intense beam background using first stage of HYRA facility [6] in gas filled mode.

## Analysis

The absolute ER cross-sections (in mb) were calculated using the formula

$$\sigma_{ER} = \frac{Yield(ER)}{Yield(Mon)}\,\Omega Mon\,\frac{d\sigma}{d\Omega}\,\frac{1}{\eta HYRA} \qquad (1),$$

where Yield(ER) is the ER yield at the focal plane, Yield(Mon) is the yield in the monitor detector, $\Omega_{Mon}$ is the solid angle subtended by the monitor detector, (dσ/dΩ) is the differential Rutherford cross section in the laboratory system. and $\eta_{HYRA}$ is the transmission efficiency of HYRA. We followed the method outlined in Ref. [4] to get transmission efficiency of the HYRA for the given reactions.

Experimentally extracted ER excitation functions for the two systems as a function of $E_{C.M.}/V_B$ are shown in Fig. 1.

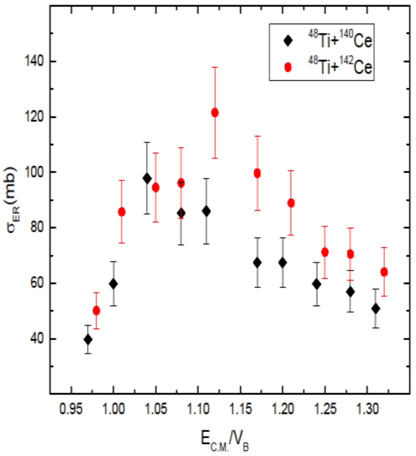

**Fig. 1** The extracted absolute ER cross-sections as a function of $E_{C.M.}/V_B$ for $^{48}$Ti + $^{140,142}$Ce systems.

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The statistical model calculations were performed using Bohr-Wheeler formalism by adjusting the barrier factor (K) to reproduce the ER cross-sections with including the shell effects in the level density and in the barrier height [7] in the measured excitation energy range as shown in Fig. 2. The collective enhancement of level density (CELD) effect was also included in the present calculations [8]. The above features were given in detail and implemented in an updated version of the statistical model code VECSTAT [9]. We used this code to calculate the theoretical ER cross-sections for $^{48}$Ti + $^{140,142}$Ce systems.

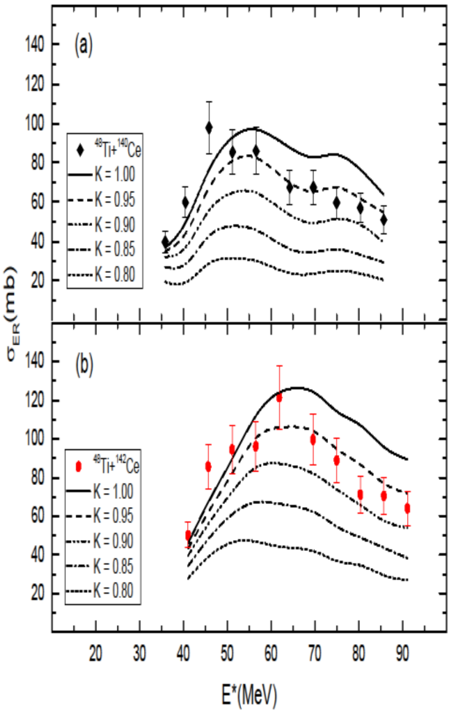

**Fig. 2** The statistical model calculation results for $^{48}$Ti + $^{140,142}$Ce systems with including the shell effects.

## Results and Conclusions

The ER cross-sections near the Coulomb barrier for the two reactions being similar, no evidence of fusion enhancement due to neutron shell closure in the $^{140}$Ce (N = 82) target is observed in the present data. At higher excitation energies, the ER cross-sections of the $^{190}$Hg CN were larger than those of $^{188}$Hg due to the lower fissility of the former. Theoretically, It was found that a scaling factor of 0.95 can fit the data of both the systems. The present results thus show that the entrance channel shell correction energies of the $^{48}$Ti + $^{140,142}$Ce systems are not adequate for fusion enhancement in the near barrier region. The small values of the shell correction energies, along with the use of a lighter projectile could be the possible reasons for the absence of a discernible signature of fusion enhancement in the present data [10]. In order to explore the possibility of fusion enhancement using projectiles with A < 50, it is thus necessary to choose systems with higher entrance channel shell correction energies. The details of this analysis will be presented.

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