# Role of the critical angular momentum on incomplete fusion dynamics above the Coulomb barrier

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## 1. Introduction

The study of incomplete fusion (ICF) of heavy ions (HI) with different targets has been a growing interest at energies above the Coulomb barrier. Observations of HI induced reactions show that at projectile energies above the Coulomb barrier, complete fusion (CF) and incomplete fusion (ICF) are dominant nuclear reaction mechanisms. In case of CF process, the projectile completely fuses with the target nucleus and the highly excited nuclear system decays by evaporating low energy nucleons and alpha particles. In the ICF process, which is characterized by the partial fusion of the projectile with the target, the projectile is assumed to break-up into two fragments and one of the fragments fuses with the target nucleus, while remnant moves in the forward direction [1]. Semi classical theory of HI interaction categorizes the CF and ICF processes on the basis of driving input angular momentum imparted in the system. In the CF process the driving input angular momentum lying in the range $0< \ell \leq \ell_{crit}$ while in case of ICF process the driving input angular momentum lying in the range $\ell_{crit} < \ell \leq \ell_{max}$. Different theoretical models have been proposed to employed in the study of ICF dynamics. However, no theoretical model is available so far to explain the gross features of experimental data available below E/A=10 MeV. There are very few comparative studies on the basis of critical angular momentum ($\ell_{crit}$) of the system for light mass target nuclei using HI in the literature. An attempt has been made to investigate the effect of $\ell_{crit}$ on ICF dynamics at projectile energy 4-7 MeV/nucleon. Experimentally measured total ER cross-sections for the systems $^{16}O$ + $^{45}Sc$ and $^{16}O$ + $^{74}Ge$ has been taken from the excitation functions data reported in [2]. The theoretical total cross-section has been calculated by using PACE-2 [3] for the systems $^{16}O$ + $^{45}Sc$ and $^{16}O$ + $^{74}Ge$. Using these experimentally measured total and theoretically calculated total cross-section of ERs, critical angular momentum have been calculated for the above projectile target systems at projectile energy ≈4-7 MeV/nucleon. Role of the $\ell_{crit}$ on ICF dynamics above the Coulomb barrier for these two projectile target combinations have been discussed and presented in this paper.

## 2. Calculation of experimental and theoretical critical angular momentum ($\ell_{crit}$)

An attempt has been made to calculate $\boldsymbol{\ell_{crit}}$ from the experimentally measured total ER cross-sections and theoretically calculated total fusion ERs cross-section using PACE-2. The experimental and theoretical $\boldsymbol{\ell_{crit}}$ has been calculated by the formula given in [4]. The experimental values of $\boldsymbol{\ell_{crit}}$ has been calculated by using the measured excitation functions data for the systems $^{16}O$ + $^{45}Sc$ and $^{16}O$ + $^{74}Ge$ at projectile energy ≈ 4-7 MeV/nucleon [2].

## 3. Results and Discussion

Comparisons between experimentally measured and theoretically calculated critical angular momentum for the systems $^{16}$O + $^{45}$Sc and $^{16}$O + $^{74}$Ge have been shown in Figs. 1 (a)-(b). For the $^{16}$O + $^{45}$Sc system, it is found that the experimentally measured $\ell_{crit}$ -values are much lower than the theoretically calculated values at projectile energies from 66 to 114 MeV. The low values of $\ell_{crit}$ -associated with ICF-channels for this system suggests that at these projectile energies, ICF may not be strictly associated with peripheral collision. Instead there appears to be deeper penetration of the projectile with the target at these beam energies. But for the system $^{16}$O +$^{74}$Ge at projectile energies from 65 to 112 MeV, the experimentally measured $\ell_{crit}$ -values are consistent with theoretically calculated values. This shows that $\ell_{crit}$ -values associated with ICF channels for this system suggests that at these projectile energies, ICF may be associated with peripheral collision.

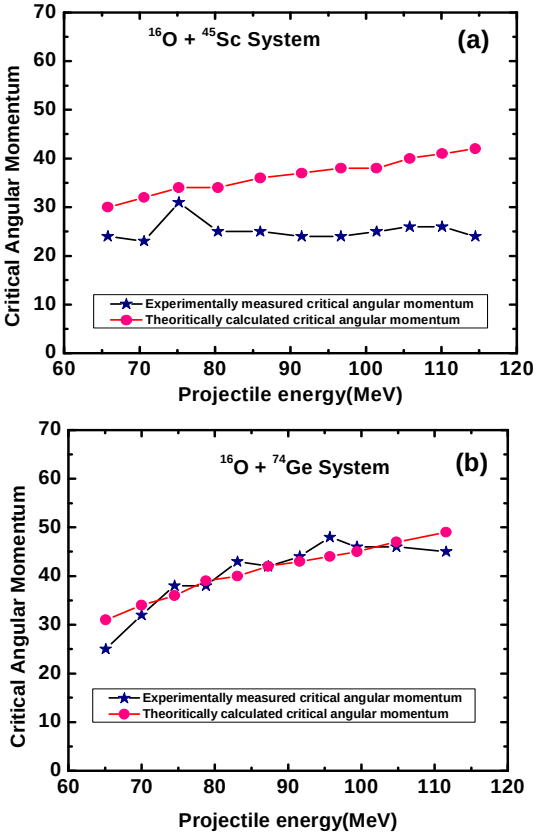


Fig 1(a)-(b) Experimentally measured and theoretically calculated critical angular momentum for the systems $^{16}$O + $^{45}$Sc and $^{16}$O + $^{74}$Ge as function of projectile energy.

## Acknowledgements

D. Singh acknowledges encouragement from the Vice-chancellor of Central University of Jharkhand (CUJ), Ranchi, India. D. Singh is also thankful to the Head, Center for Applied Physics, CUJ, Ranchi, India for providing the required facilities. D. Singh is also thankful to the Department of Science and Technology (DST), New Delhi, India and Inter University Accelerator (IUAC), New Delhi for providing financial support through SERC-Fast Track Scheme for Young Scientist (SR/FTP/PS-005/2011) and project IUAC/XIII.3A/ respectively.

## References

[1] D. Singh, et al., Phys. Rev. C **79** (2009) 054601.

[2] D. Singh, et al., J. Phys. Soc. Japan **75** (2006) 104201; **82** (2013) 114201; Chin. J. Phys. **46** (2008) 27.

[3] A. Gavron, Phys. Rev. C **21** (1980) 230.

[4] P.E. Hodgson, *Nuclear Heavy-Ion Reactions*, Chapter-1, Clarendon Press. Oxford (1978).