# Study of angular momentum hindrance due to mass variation in heavy ion fusion reaction

Sarjeeta Gami,* Punit Dubey, A. Gandhi, Aman Sharma, Mahesh Choudhary, Namrata Singh, Mahima Upadhyay, A. Kumar*
*Department Of Physics, Banaras Hindu University, Varanasi 221005, India*
** email: sarjeetagami28@gmail.com; ajaytyagi@bhu.ac.in*

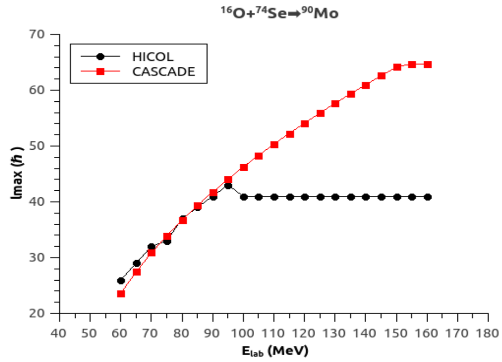
## Introduction

Fusion of the two heavy ions leads to the formation of hot rotating nuclei with high excitation energy and high angular momentum. This highly excited nuclei decays through various modes i.e. either by emission of charged particles (alpha, proton), neutron, gamma rays or by fission. By detecting these particles we get the information about the reaction mechanism of the fusion process [1-13].

The statistical model predicts the average properties of the nuclei for a given excitation energy and angular momentum. This model is important because it predicts the level density and transmission coefficient. Computer code CASCADE [14] is used to perform statistical model calculation. Dynamical model developed by Feldmeier [15] is used to study nuclear dissipation phenomenon. The angular momentum hindrance is due to this nuclear dissipation in the entrance channel which lead for a longer formation time for compound formation. This implies that the entrance channel plays very crucial role in the fusion reactions. Dynamical model based code HICOL calculates the dynamical evolution of nuclear shapes and the formation time for the compound system. The angular momentum calculated by statistical model (CASCADE) is the angular momentum of the compound nucleus, while the angular momentum predicted by HICOL is the angular momentum which is contributing to the fusion. The whole angular momentum calculated by statistical model (CASCADE) does not contribute to the fusion and these cause the angular momentum hindrance during the fusion reaction [1].

## Theoretical Analysis

To investigate the effect of mass number variation on the dissipative evolution of the system, we have carried out CASCADE and HICOL calculation for four different reactions which leads to the formation of the compound nucleus in the mass range 80<A<130.



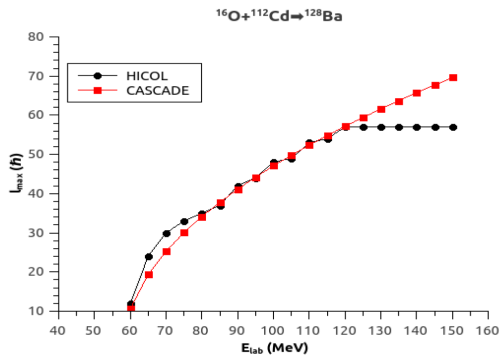




**Fig.1.** Variation of the angular momentum ($\ell_{max}$) with respect to incident energy

It can be seen from Fig.1, that for compound nucleus $^{90}Mo$ the CASCADE and HICOL predicted angular momentum starts deflecting from 95 MeV but for $^{128}Ba$ angular momentum starts deflecting from 120 MeV. From these calculation we conclude that as the mass of the compound nucleus increases angular momentum hindrance occurs at successively higher energies.

In our another study, we have calculated $\Delta\ell_{max}$ (angular momentum hindrance) for the three different systems like $^{12}C+^{108}Cd$, $^{16}O+^{104}Pd$, $^{24}Mg+^{96}Mo$, leading to the formation of same compound nucleus $^{120}Xe^*$ at the different excitation energies. The variation of $\Delta\ell_{max}$ with respect to charge asymmetry$[\eta_Z=(Z_TZ_P)/(Z_T+Z_P)]$ and entrance channel parameter $[\zeta=Z_1Z_2\sqrt{\mu}]$ are shown in Fig.2 and Fig.3.

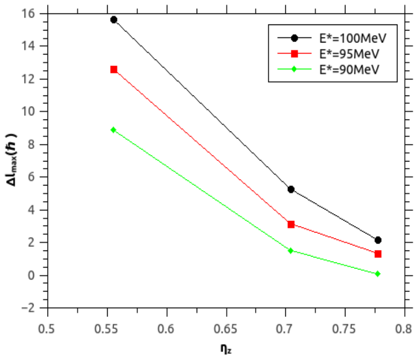



**Fig.2.** Variation of $\Delta\ell_{max}$ with charge asymmetry

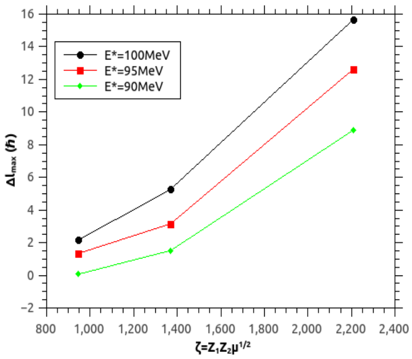



**Fig.3.** Variation of $\Delta\ell_{max}$ with entrance channel parameter

It was observed that $\Delta\ell_{max}$ decreases with the increase in their charge asymmetry and also the overall $\Delta\ell_{max}$ increases with increase in excitation energy as shown in Fig.2 also it is clear from Fig.3, that $\Delta\ell_{max}$ increases with the increase in entrance channel parameter.

## Conclusion

In the present study, we have observed that the angular momenta calculated by the statistical model calculation (CASCADE) and dynamical model calculation (HICOL) shows different values in the higher energy region and as the mass number of the compound nucleus increase angular momentum hindrance occurs at successively higher projectile energies. From this we conclude that angular momentum hindrance is not only depends on incident energy of projectile but also depends on mass of the compound system. Moreover, the dissipative nature of the fusing nuclei is also studied with charge asymmetry parameter ($\eta_Z$) and entrance channel parameter ($\zeta$) at same excitation energy and we observed that angular momentum hindrance decrease with increase in charge asymmetry and it is increase with entrance channel parameter. Detailed study for different kind of systems in the mass range of 80<A<130 will be presented during conference.

## References

[1] N. K. Rai, Phys. Rev. C 98, 024626 (2018).
[2] A. Kumar et al., Phys. Rev. C 62, 064606 (2000).
[3] J. Kaur, A.Kumar et al., Phys. Rev. C 66 034601 (2002).
[4] A. Kumar et al., Phys. Rev. C 70, 044607 (2004).
[5] A. Kumar et al., Phys. Rev. C 68, 034603 (2003).
[6] A. Kumar et al., AIP conference proceeding. 704, (501) (2004).
[7] J. Kaur, A. Kumar et al., Phys. Rev. C 70, 017601 (2004)
[8] A. Kumar et al., EPJ web conference. 86, 00019 (2005).
[9] A. Kumar et al., AIP Conf. Proc. 1224, 14 (2010).
[10] A. Kumar et al., AIP Conf. Proc. 1524, 292 (2013)
[11] A. Kumar et al., EPJ Conf 66, 03091 (2014)
[12] A. Kumar et al., Nuclear Physics A. 798, 1-15 (2008)
[13] A. Kumar et al., EPJ web 86, 00019 (2015).
[14] F. Puhlhofer, Nucl. Phys A 280, 267 (1977).
[15] H. Feldmeier, Rep. Prog. Phys. 50, 915 (1987).