Study of dynamical model in heavy ion induced fusion reaction

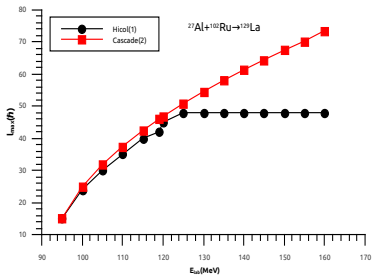
Utkarsha Mishra,* Aman Sharma, Mahesh Choudhary, Namrata Singh, Punit Dubey, Mahima Upadhyay, Nitin Dubey, Shweta Singh, and Ajay kumar†
Department of Physics, Banaras Hindu University, Varanasi 221005, India

Introduction

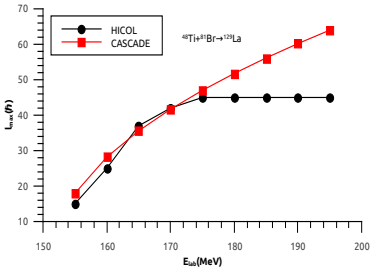
In heavy ion fusion reaction two heavy nuclei collide and offer the highly excited hot rotating and high angular momentum of composite system and after attaining the equilibrium for a short range of time they decay subsequently through various mode by emission of light particles like α,proton and γ rays or fission. Here, we study about the dynamical model by using two different kind of reaction (symmetric and asymmetric), which leads to the formation of same compound nucleus with the same angular momentum and excitation energy. The statistical model computer code CASCADE [1] is used to calculate the fusion cross-section and gives the excitation value and angular momentum of composite system. It also describes the details of evaporated particles which help to determine the reaction mechanism of the fusion process. The dynamical model computer code HICOL [2] given by Feldmeier, is used in the investigation of dynamical evolution of shape of compound nucleus and dissipation process in entrance channel due to which it takes long formation time in composite system. In this model , it assumed that two spheres are connected by conical and their dynamical evolution in sequence of shapes [3]. The statistical model CASCADE gives the angular momentum of compound nucleus while the angular momentum is given by HICOL is that angular momentum which beneficiate to the fusion.

Theoretical Analysis

Statistical model is used to perform theoretical calculation to find the angular momentum of compound nucleus to compare with the angular momentum calculated by dynamical model (HICOL) by changing the projectile energy for both ^{27}Al+ ^{102}Ru $\rightarrow$ ^{129}La and ^{48}Ti+^{81}Br $\rightarrow$ ^{129} La as shown in Fig.1(a) and Fig.1(b). It can be seen in Fig1(a) and Fig.1(b) that after 125 MeV and 174 MeV HICOL Predicated angular momentum does not while angular momentum calculated by cascade increase gradually. This indicates that angular momentum calculated by CASCADE does not contribute to fusion [4]. This cause is known as angular momentum hindrance, Which shows that incident projectile energy is directly proportional to the angular momentum hindrance.



(a)

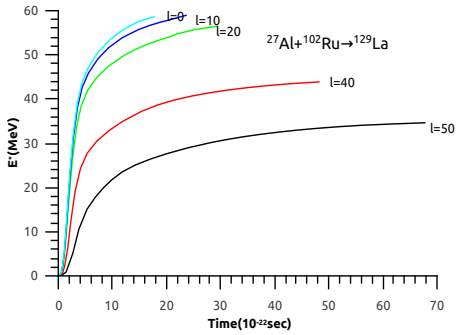


(b)

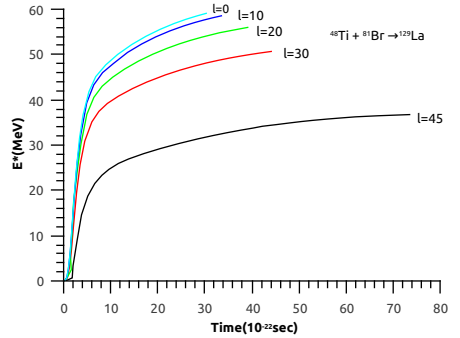
FIG. 1: Variation of angular momentum l_{max} with the incident energy (E_{lab})in Fig.1(a) and Fig.1(b).

Here, another observation is that when pro-

*Electronic address: utkarshmishra.2h@gmail.com
†Electronic address: ajaytyagi@bhu.ac.in



(a)



(b)

FIG. 2: Variation of the evolution of excitation energy of composite system with time on different value of angular momentum.

jectile collides to the target nuclei, energy will be impart to targeted nuclei and then after getting energy it will excite and emission of particles [5] take place.The Excitation energy available for particle emission decreases as the angular momentum increases .The thermal excitation energy plotted as function of time on different value of angular momentum in Fig.2 (a) and (b) on both reaction.

Conclusion

In this study we have done the statistical and dynamical model calculation on two reactions that offer same compound nucleus. We have calculated angular momentum from both models and angular momentum found in the signature of statistical model (CASCADE) that is the angular momentum of compound nucleus on the other hand dynamical model (HICOL) angular momentum contribute to fusion. Also, it was that have maximum angular momentum of partial wave contribute in fusion at low excitation energy .After that we concluded that angular momentum hindrance does not depends only on the incident energy but also depends on the excitation energy .

Acknowledgments

One of the authors(A.Kumar) would like to thank the IUAC-UGC,Government of India (Sanction No. IUAC/XIII.7/UFR-71535), and Institution of Eminence (IoE) BHU (Sanction No. 6031), for the Financial support for this work.

References

[1] F. Puhlhofer et.al., Nucl. Phys. A **280**, 267 (1977).
[2] H. Feldmeier et.al., Nucl. Phys. A **435**, 229 (1985).
[3] A. Kumar et.al., Phys. Rev. C **62** 064606 (2000).
[4] N.K.Rai et.al.,Phys. Rev. C **98** 024626(2018)
[5] A. Kumar et.al., Phys. Rev. C **70** , 044607(2004)
[6] J.Kaur et.al., Phys. Rev. C **70** 017601 (2004)