Searching the effects of N=126 in hot fusion reactions in mass ~ 200 region.

E. Prasad[1],* P. V. Laveen[1], N. Madhavan[2], S. Nath[2], J. Gehlot [2],
K. M. Varier [3], A. Jhingan [2], A. M. Vinodkumar [4], A. Shamlath
[1], B. R. S. Babu [5], B. R. Behera [6], Rohit Sandal [6], Varinderjit
Singh [6], Jhilam Sadhukhan [7], Santanu Pal [8], and S. Kailas [9]
[1]*Department of Physics, Central University of Kerala, Kasaragod 671314, India*
[2]*Inter University Accelerator Centre, Aruna Asaf Ali Marg, New Delhi 110067, India*
[3]*Department of Physics, Kerala University, Trivandrum 695581, India*
[4]*Department of Physics, University of Calicut, Calicut 673653, India*
[5]*Department of Physics, Sultan Quaboos University, Oman, Muscat*
[6]*Department of Physics, Panjab University, Chandigarh 160014, India*
[7]*Variable Energy Cyclotron Centre, 1/AF Bidhan Nagar, Kolkata 700098, India*
[8]*CS-6/1 Golf Green, Kolkata 700095, India and*
[9]*Nuclear Physics Division, Bhabha Atomic Research Centre, Mumbai 400085, India*

Introduction

Remarkable progress has been made in the synthesis of new heavy and super heavy nuclei in recent years using heavy ion fusion reactions. The formation of the heavy and super heavy elements through fusion reactions greatly depends on the survival of the compound nucleus (CN) to produce the evaporation residue (ER) against fission [1]. It is generally believed that the existence of such super heavy elements is solely dependent on the microscopic stabilization through shell effects. Recently, a number of authors have reported signatures of non-vanishing shell effects in heavy-ion fusion even at high excitation energies [2, 3]. The ER is treated as the true signature of CN formation and the best probe to understand the pre-saddle dissipation in fusion reactions. The effect of shell closure on dissipation strength is not well explored. We measured the ER cross section of ^{16}O + ^{194}Pt reaction forming the composite system ^{210}Rn with neutron number N = 124 earlier [4]. Here we report the ER excitation function for ^{18}O + ^{194}Pt forming ^{212}Rn with N=126. The measurements were performed at the 15UD Pelletron accelerator facility of IUAC, New Delhi using the HYRA [5]. Pulsed ^{18}O beam with 4 μs pulse separation was used in the experiment to bombard the isotopically enriched ^{194}Pt target. A time of flight (TOF) setup was formed from the MWPC anode and the RF for unambiguous separation of ERs from other scattered particles reaching the focal plane. FIG. 1 shows the two-dimensional plot of TOF signal versus energy loss signal at 100.2 MeV beam energy.

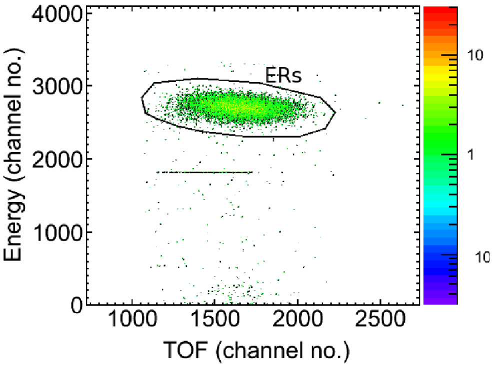

FIG. 1: The TOF vs ΔE plot.

---

*Electronic address: `prasad.e.nair@gmail.com`

Analysis

The ER excitation function is obtained using the standard expression,

$$\sigma_{\rm ER} = \frac{Y_{\rm ER}}{Y_{\rm mon}}\left(\frac{d\sigma}{d\Omega}\right)_{\rm R}\Omega_{\rm M}\frac{1}{\epsilon_{\rm HYRA}} \qquad (1)$$

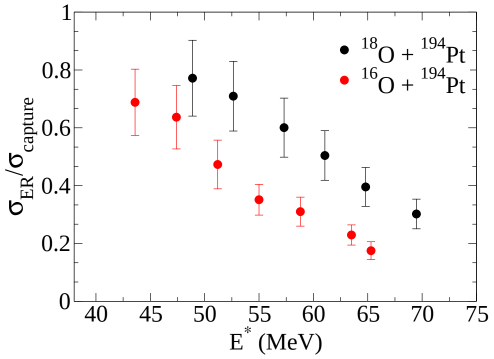

FIG. 2: The survival probabilty of ERs in the two reactions as a function of excitation energy.

The ER survival probability ($\frac{\sigma_{ER}}{\sigma_{capture}}$) is hence calculated as a function of CN excitation energy and the result is compared with that of ^{16}O + ^{194}Pt reaction. ^{18}O + ^{194}Pt reaction shows a larger survival probability at all energies. The ER survival probability as a function of CN excitation energy is shown in FIG. 2

Statistical model calculations

Statistical model calculations [6] have been performed assuming that the system after capture undergoes the formation of the CN. The CN spin distribution obtained from CCFULL by reproducing the experimental total fusion cross section was used as the input in the calculations. It is observed that the model calculations assuming Bohr-Wheeler fission width fail to reproduce the experimental ER cross sections. Calculations assuming Kramers' fission width with definite dissipation strength (β value) reproduce the experimental data at all energies. It has also been observed that a higher value of β (β =3.0) is required to reproduce the cross section data for ^{18}O + ^{194}Pt reaction when compared with ^{16}O + ^{194}Pt reaction (β =1.5). The model calculation results for ^{18}O + ^{194}Pt reaction with different β values are shown in FIG. 3.

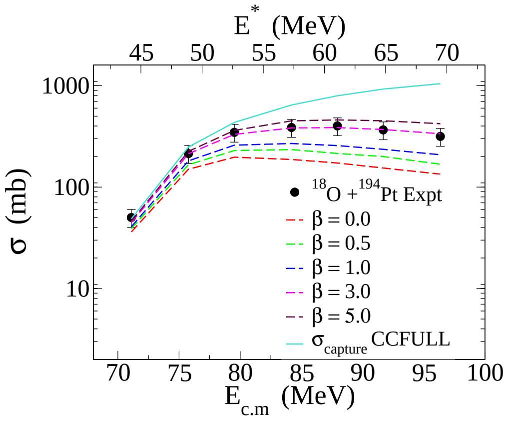

FIG. 3: Statistical model calculations for ^{18}O + ^{194}Pt reaction. CCFULL prediction of total capture cross section is also shown.

The present results indicate that fission of ^{212}Rn (N=126) is slower compared to ^{210}Rn (N=124). The enhanced stabilization of ^{212}Rn against fission may be due to the shell closure effects in compound system with N = 126 even at high excitation energy.

References

[1] Yu. Ts. Oganessian *et al.*, Nature (London), **400**, 242 (1999).
[2] Varinderjit *et al.*, Phys. Rev. C **87**, 064601 (2013).
[3] Rohit Sandal *et al.*, Phys. Rev. C **87**, 014604 (2013).
[4] E. Prasad *et al.*, Phys. Rev. C **84**, 064606 (2011).
[5] N. Madhavan *et al.*, Pramana - J. Phys, **75**, 317 (2010).
[6] Jhilam Sadhukhan and Santanu Pal, Phys. Rev. C **79**, 064606 (2009).