Excitation functions and barrier distribution studies of $^{16}O +^{193} Ir$ system at sub and near barrier energies

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Introduction

Fusion excitation functions of actinide compound nucleus ^{209}At via $^{16}O+^{193}Ir$ are found together with the aim of learning sub barrier enhancement and the barrier distribution.Analysis is based on measuring ER cross sections.A single barrier as in Bass model is modified by various factors like collective excitation of low lying rotational, vibration states in target and projectile as well as target deformation.Hagino et al.[1] indubitably have shown surface vibrations and contortion of heavy target mass plays a prominent role in barrier lowering and betterment of sub barrier counts.In the coupled channel Hamiltonian, a single barrier height is dispersed to a cluster of delta barriers which are weighed functions of a characteristic distance (R_b).Here fusion barrier distribution is explored through a second order energy derivative (non-scaled) of σE_{cm} following H.Timmers et al.,[2].

Experimental Details

The present experiment was conducted using HIRA facility in Inter University Accelerator Center(IUAC),New Delhi.Optically flat glass slides are coated with a parting agent $BaCl_2$ and then with carbon in a high vacuum coating unit($\sim 5 \times 10^{-6} Pa$).Enriched sample of ^{193}Ir(Isoflex,98.4 %) is heated in ultra high vacuum chamber($\sim$ $4 \times 10^{-8} Pa$) because of high melting point ($2450^0 C$) and coated on a carbon backing($\sim$ $20\mu\ gm\ cm^{-2}$).Prepared target thickness($\sim$ $120\mu\ gm\ cm^{-2}$) was found to be optimum for computational accuracy due to minimum loss of beam energy in (backing+ target thickness), which confined values within error limits .Excitation energies ranging from 36.41 MeV to 65.11 MeV are used with energy steps $\Delta E_{lab} = 1.5 MeV$.Beam energies chosen explore 18% below to 23% above PACE4 barrier(V_b). Step size was slightly increased to 2MeV and then to 4MeV above 14% of V_b.

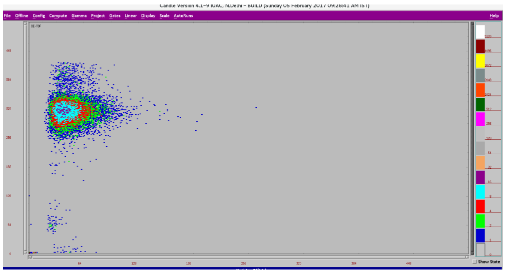

FIG. 1: ΔE - TOF spectrum at $E_{ex} = 56.12$ MeV

Dispersion in beam energy was kept within few KeVs which ensured consistency in analysis near to PACE4 barrier.Counts from monitor detectors were agreeing with their harmonic mean and used for beam positioning

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*Electronic address: `amarnadh2010@rediffmail.com` before every energy step.An MWPC of active cross sectional area 12 sq.inch at an isobutane pressure of 2mbar was used in the focal plane. dE-TOF spectrum shows good separation of ERs from beam like particles (fig.1)

Analysis and Results

ER cross sections are derived using the relation

$$\sigma = \frac{Y_{ER}}{Y_M}\left(\frac{d\sigma}{d\Omega}\right)_R \Omega_M \frac{1}{\eta}$$

where Y_{ER} and Y_M are ER counts and harmonic mean of left and right monitor detectors. $\left(\frac{d\sigma}{d\Omega}\right)_R$ is the Rutherford scattering cross section at center of monitor detectors which derived after applying lab correction and η is the transmission efficiency of HIRA computed by weighted average of dominant exit channels at each energy. Using semi microscopic code TERS which employs Monte Carlo routines for event generation[3], transmission efficiency was computed within error of $\frac{1}{3}\%$.

Then non-scaled barrier distribution is derived using [2]

$$D(E) = \frac{d^2(E_{cm}\sigma)}{dE^2}$$

which is evaluated using three point formula.CCFULL analysis has done with uncoupled and coupled inputs.Analysis is mainly concerned with distribution of second derivatives below V_b, where fission probability does not alter ER cross sections by a pronounced magnitude. Low lying vibrational states are assumed to be coupled and results show an enhancement as the number of input channels increase (fig.2). As the energy goes to sub barrier, the present number of channels seems to be incapable to account the experimental points which suggests the need of inclusion of more rotational channels,ground and excited state deformations (hence the polarisation effects)and scaling of level density .

Barrier distribution points are scattered around the uncoupled barrier as shown in figure and multiple peaks seems to be present.Effective nuclear parameters like curvature ($\hbar\Omega$) and diffuseness parameter are viable to vary and improve the location of barrier points.Only results of preliminary analysis has shown here(fig.3).

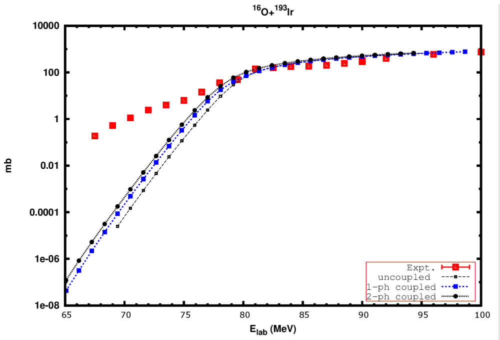

FIG. 2: Excitation functions of experimental , uncoupled and coupled methods

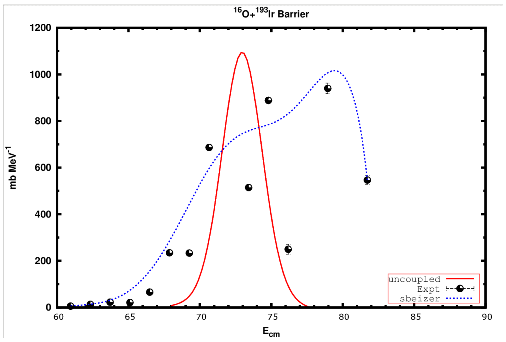

FIG. 3: Barrier Distribution of $^{16}O +^{193} Ir$

Acknowledgments

We thank S R Abhilash, Target laboratory,IUAC for meticulous guidance given in target preparation.

References

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