Comparisons of evaporation residue cross-section of ^{16}O and ^{18}O induced reactions on W isotopes

P. Jisha[1], A. M. Vinodkumar[1], S. Sanila[1], K. Arjun[1], B. R. S. Babu[1],
J. Gehlot[2], S. Nath[2], N. Madhavan[2], Rohan Biswas[2], A. Parihari[2],
A. Vinayak[3], Amritraj Mahato[4], A. C. Visakh[5], and E. Prasad[5]
[1]*Department of Physics, Calicut University, Calicut-673 635, India*
[2]*Nuclear Physics Group, Inter-University Accelerator Centre,*
Aruna Asaf Ali Marg, New Delhi 110067, India
[3]*Department Of Physics, Karnataka University, Dharwad 580003, India.*
[4]*Department of Physics, Central University of Jharkhand, Brambe 835205, India. and*
[5]*Department of Physics, SPS, Central University of Kerala, Kasaragod 671314, India.*

It is well known that fusion dynamics are affected by the nuclear structure and neutron transfer channels of the colliding nuclei [1]. Existing theoretical models have already established the role of nuclear deformation and vibration through the coupling of inelastic excitations in theoretical models [2]. However, a comprehensive understanding of the role of neutron transfer channels in fusion enhancement remains incomplete. Enhancement in fusion cross-section after the neutron transfer is suggested as an indirect effect of the quadrupole deformation [3]. Also, it was identified that reactions with positive Q-values transfer channel (PQNT) channels play a vital role in sub-barrier fusion cross-section enhancement [3]. However, many systems with positive Q-value neutron transfer (PQNT) channels do not exhibit a below-barrier fusion enhancement. Hence, more investigations are needed to find the role of the positive Q-value of neutron transfer in fusion enhancement below the Coulomb barrier energy region.

In order to study the effect of positive transfer Q-value on fusion enhancement, we have performed the Evaporation Residue (ER) measurements of ^{18}O+^{182,184,186}W reactions, which have positive 2n-transfers Q-values. One of the main objectives of this work is to compare the ER cross-section with nearby systems, ^{16}O+^{182,184,186}W [4, 5], which have negative Q-values for 2n-transfer.

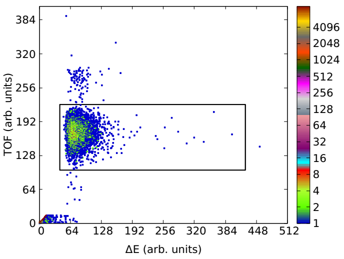

FIG. 1: ΔE vs TOF spectrum for ^{18}O+ ^{186}W at $E_{c.m.}$ = 72.94 MeV (80 MeV E_{lab}).

I. EXPERIMENTAL DETAILS

In the present studies we have used a pulsed beam of ^{18}O with 4 μs pulse separation to bombard on the enriched ^{182,184,186}W targets of thickness 70 μg/cm^2, 300 μg/cm^2 and 100 μg/cm^2, respectively. Heavy Iron Reaction Analyzer (HIRA) at IUAC was used to measure ERs from 68 MeV to 104 MeV in 2-4 MeV steps. A Multi-Wire Proportional Counter of active area 150 ×50 mm^2 was placed at the focal plane of HIRA to detect the ERs. Two silicon surface barrier detectors, each with a collimator diameter of 1 mm, were placed at a distance of 90.0 mm to normalize cross-sections. A time of flight (TOF) was set up between the anode of MWPC and the RF signal for further separation of the beam-like particles from ERs. A two-dimensional spectrum between energy loss in MWPC and TOF for ^{18}O+^{186}W at 80 MeV E_{lab} is shown in Fig. 1.

II. DATA ANALYSIS

The total ER cross-section was calculated using the formula of Equ. 1

$$\sigma_{ER} = \frac{Y_{ER}}{Y_{norm}} \left(\frac{d\sigma}{d\Omega}\right)_{Ruth} \Omega_{norm}(1/\epsilon_{HIRA}) \tag{1}$$

where Y_{ER} is the number of ERs detected at the focal plain of the HIRA, Y_{norm} is the number of scattered beam particles detected by any of the monitor detectors, Ω_{norm} is the solid angle subtended by monitor detectors, $(\frac{d\sigma}{d\Omega})_{Ruth}$ is the differential Rutherford-scattering cross-section in the laboratory system and ϵ_{HIRA} is the transmission efficiency of the HIRA.

III. RESULTS

Based on the positive 2n-transfer Q-value, one would have expected fusion enhancement in ^{18}O+^{182,184,186}W reactions. Experimental cross-sections of both ^{16}O and ^{18}O induced reactions showed a strong enhancement compared to the one dimensional barrier penetration model predictions at below Coulomb barrier energy regions as in Fig. 2. Including rotational excitation of targets, Coupled Channel (CC) calculations explained the enhancement of ^{16}O+^{182,184,186}W. For ^{18}O+^{182,184,186}W reactions along with target excitations 2^+ vibrational state of ^{18}O were included in CC calculations to reproduce the experimental data. The PQNT channels present in all ^{18}O induced reactions are not needed in CC calculations to satisfactorily describe the experimental cross-sections of the same.

IV. ACKNOWLEDGMENTS

We are thankful to Pelletron Group of IUAC for providing good quality beams through out the experiment.

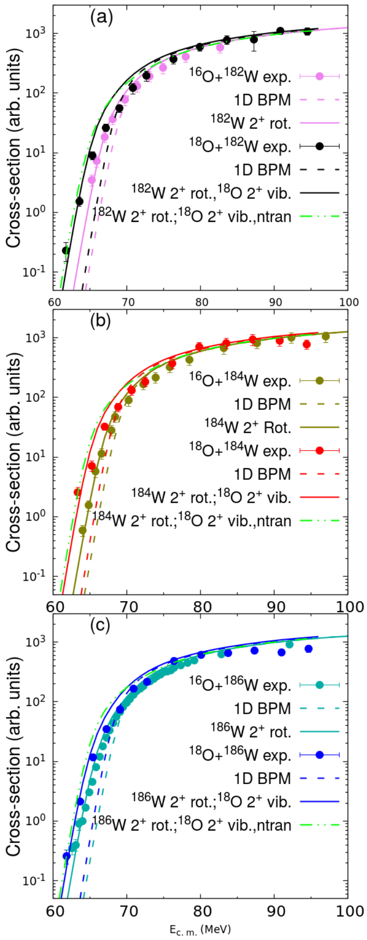

FIG. 2: Comparisons of experimental cross-sections of ^{16,18}O+^{182,184,186}W reactions with CC calculations.

References

[1] M. Beckerman, Rep. Prog. Phys. 51, 1047 (1988).

[2] K. Hagino, et al. Prog. Theor. Phys. 128, 1061 (2012).

[3] V. V. Sargsyan, et al. Phys. Rev. C. 91, 014613 (2015).

[4] J. R. Leigh, et al. J Phys. G Nucl. Part. Phys. 14, L55 (1988).

[5] M. Trotta, et al. Phys. Rev. C. 65, 011601. (2001)