PROPOSAL FOR EXPERIMENT AT BARC-TIFR PELLETRON

01st April 2024

TITLE: Exploring the di-neutron transfer reactions and their effect on barrier distributions using ^{16,18}O off a ^{159}Tb target

Scientific Motivation

The methods of extracting fusion barrier distribution from quasi-elastic scattering measurements have been found to be very sensitive to the structure of colliding nuclei [1,2]. The strong interplay between nuclear structure effects and the relative motion of the two colliding nuclei leads to a distribution of fusion barriers instead of giving a single barrier. These barrier distributions may directly indicate a signature of nuclear structure effects of the colliding nuclei. Quasi-elastic scattering could also provide a useful probe to determine the ground state deformation of atomic nuclei [3-5].

We have recently conducted measurements on quasi-elastic scattering using ^{16,18}O projectiles directed at ^{90}Zr nuclei at energies near the Coulomb barrier. Our findings reveal notable discrepancies between the data obtained for ^{18}O and ^{16}O, suggesting a distinct involvement of di-neutron transfer in the fusion process of ^{18}O with ^{90}Zr. Specifically, the fusion barrier distribution for ^{18}O+^{90}Zr exhibits a skew towards lower barrier heights, contrasting sharply with the nearly Gaussian distribution observed in the case of ^{16}O+^{90}Zr reactions. This discrepancy implies that ^{16}O behaves like an inert nucleus during fusion processes [6]. Neutron transfer events yielding positive Q-values have been identified as significant contributors to the observed enhancement of sub-barrier fusion [7,8].

This current proposal focuses on utilizing the same projectile beams while introducing target nuclei possessing an odd nucleon number, specifically ^{159}Tb(Deformed). This approach aims to investigate potential variations in the di-neutron transfer effect when compared to previous measurements conducted with a spherical target. Our proposed methodology involves conducting quasi-elastic scattering and measuring angular distributions of nucleon transfer at two distinct projectile energies.

We propose to carry out Quasi-elastic scattering and nucleon transfer angular distribution measurements (at two different energies at above the barrier energy) using ^{16,18}O projectiles off a ^{159}Tb target to explore nucleon transfer reactions and their effect on barrier distributions.

Beamtime requirement

Experimental Data will be acquired at back angles in the range of 140◦ to 170◦ at different beam energies around 20% above and below the fusion barrier (E_{lab} ~70MeV), spanning 58 to 80 MeV with an energy step of 2 MeV. Also, a transfer angular distribution measurements will be performed using ^{16,18}O projectiles. A beam Current of around 2-5 pnA would be sufficient. With our recent experience of ^{16,18}O, we have estimated the required beam time of 7 days for complete measurement.

Running Time:

Electronics Setting up	1 day
Data runs for ^{16,18}O including beam change over	6 days
The total beam time request	7 days

Collaborators:

Full Name	**Institution**
Dr. Y. K. Gupta and his Group members	Nuclear Physics Division, Bhabha Atomic Research Centre
Dr. B. K. Nayak	Homi Bhabha National Institute, BARC

References:

1. H. Timmers, J. R. Leigh, M. Dasgupta, D. J. Hinde, R. C. Lemmon, J. C. Mein, C. R. Morton, J. O. Newton, N. Rowley, Nucl. Phys. A 584 (1995) 190.
2. K. Hagino, N. Rowley, Phys. Rev. C 69 (2004) 054610.
3. M. Dasgupta, D.J. Hinde, N. Rowley, A.M. Stefanini, Annu. Rev. Nucl. Part. Sci. 48 (1998) 401.
4. K. Hagino, N. Takigawa, Prog. Theor. Phys. 128 (2012) 1061.
5. Y. K. Gupta et al., Phys. Lett B 806 (2020) 135473.
6. V. Katariya, Y.K.Gupta, D. Patel et al., DAE Symp. (2023).
7. B. B. Back, H. Esbensen, C. L. Jiang and K. E. Rehm, Rev. Mod. Phys. 86, 317 (2014).
8. Khushboo et al., Phys. Rev. C 96, 014614 (2017).