Quasi-Elastic Scattering Measurements for ^{28}Si + ^{116,120,124}Sn systems near the Coulomb barrier

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Heavy ion collisions at near-barrier energies and, in particular, fusion and quasi elastic reactions have been of increased interest from experimental and theoretical points of view over the last few decades [1-3]. Such studies provides an ideal opportunity to obtain information on nuclear structure and nucleus-nucleus interaction. Based on the quantum tunneling concept, it has been stated that the quasi-elastic scattering (a sum of elastic scattering, inelastic scattering, and transfer channels) is a good counterpart of the fusion reaction in the sense that the former is related to the reflection probability of a potential barrier while the latter is related to the penetration probability. In addition, it has been shown that the fusion barrier distribution generated by the coupling of the relative motion of the nuclei to internal degrees of freedom can be extracted from precisely measured fusion excitation functions. The similarity of the barrier distribution can be extracted from large-angle quasi-elastic scattering excitation functions that can be measured easily than the fusion excitation functions. In the present study, quasi-elastic excitation functions have been measured for ^{28}Si + ^{116,120,124}Sn systems around the Coulomb barrier. The fusion cross section will be extracted from the above measurements, particularly far below the Coulomb barrier energies which will shed light on the sub-barrier fusion enhancement/hindrance in the medium mass systems.

The experiment has been performed at the HIRA [4] beam line at Inter University Accelerator Centre (IUAC), New Delhi. A ^{28}Si pulsed beam with 2 μs pulse separation from the Pelletron accelerator facility was used in the experiment. Three isotopically enriched targets of thickness $\sim$ 230 μg/cm^2 [5], $\sim$ 215 μg/cm^{2}and $\sim$ 100 μg/cm^2 respectively, fabricated on thin carbon backing of $\sim$ 20 μg/cm^2 were used in the experiment. The quasi - elastic excitation function measurements were performed at laboratory beam energies in the range of 88-115 MeV at 1.5 MeV steps around the barrier and 2 MeV steps in sub-barrier region. Two silicon detectors were mounted inside the target chamber at 15.5° with respect to beam direction for beam monitoring and normalization of cross section purposes. To detect the back-scattered quasi-elastic events, a silicon detector was placed at an angle of 150.5° to the beam direction at a distance of 5.8 cm from the target with a collimator of 1.0 mm diameter in front of the detector. As a representative case, back angle detector spectrum obtained for ^{28}Si + ^{120}Sn system at E_{lab}= 94 MeV is shown in Fig.1.

Analysis and Results

The Quasi-Elastic scattering excitation function was obtained by using the expression

$$\frac{d\sigma_{qel}}{d\sigma_R} = \frac{N_{qel}(\theta_{back})}{N_{Mon}(\theta_{mon})} \frac{\frac{d\sigma_R(\theta_{Mon})}{d\Omega}}{\frac{d\sigma_R(\theta_{back})}{d\Omega}} \frac{\Delta\Omega_{Mon}}{\Delta\Omega_{back}} \quad (1)$$

where N_{qel} is the yield in the back angle silicon detector which is as previously men-

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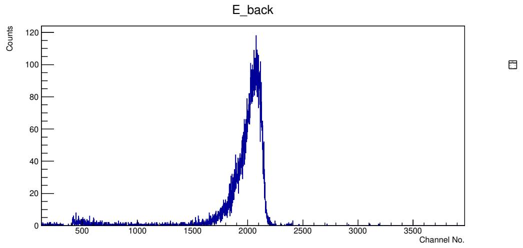

FIG. 1: Raw spectrum of back detector for ^{28}Si $+^{120}$Sn at E$_{lab}$= 94 MeV

tioned, sum of the elastic, inelastic, and transfer events, N_{Mon} is the average yield of the two monitor detectors, second term in the equation is the Rutherford scattering cross section calculated at the corresponding bombarding energy E and monitor angle θ_{Mon} or θ_{back}. To precisely determine the solid angle subtended by the monitors and back angle detector, a low energy run at 84 MeV was taken during the experiment. Since this beam energy is well below the Coulomb barrier, elastic scattering at this bombarding energy is expected to be purely Rutherford. The priliminary experimentally measured quasielastic excitation functions for the ^{28}Si $+^{120,124}$Sn systems are shown in Fig.2 and Fig.3 respectively. The uncertainties in the data points are statistical only. It can be inferred from the quasi elastic excitation plots that the measured values of the excitation function fall from 0.9 to 0.1 within an energy range of ∼ 25 MeV. Further analysis using coupled-channels (CC) theoretical model is under progress. The extracted fusion cross section will be compared with the theoretical predictions. Detailed results and analysis will be presented during the Symposium.

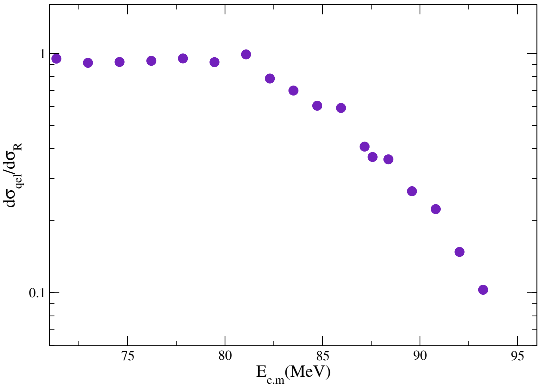

FIG. 2: Quasielastic scattering excitation function for the ^{28}Si $+^{120}$Sn system. The statistical errors are within the size of the symbol.

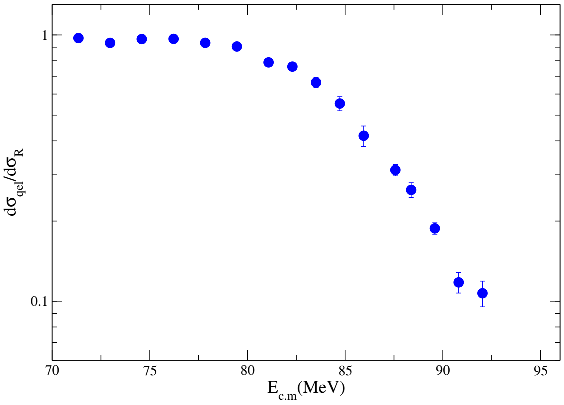

FIG. 3: Quasielastic scattering excitation function for the ^{28}Si $+^{124}$Sn system

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