Study of Evaporation Residue Cross sections for the ^{32}S + ^{182,184}W reactions

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Introduction

The interplay between fusion-fission and quasi fission in the formation of compound nucleus is one of the important subjects of recent research[1–3]. Zhang et al. [3] recently measured the capture cross section for the ^{32}S+^{182,184}W and analysed their data using di-nuclear system model (DNS) wherein they attempted to explain the measured capture, fast fission, quasi-fission, fusion and evaporation residue (ER) cross sections. The ER cross sections for one of the systems, namely ^{32}S + ^{184}W have been measured by Back et al. [1] using FMA at Argonne National Laboratory and compared with statistical model calculation using CASCADE. They used Sierk fission barriers scaled by a factor of 0.9 to approximately account for the cross section at low beam energies with level density parameters of $a_n = a_f = A/8.8$ MeV. Back et al. results show that the measured cross section increases with beam energy, whereas the statistical model predicts a decreasing cross section because of an increasing probability for fission during the longer evaporation cascades. Also, Back et al. compared their experimental ER cross sections with statistical model calculations wherein the effect of viscosity was included using a linear normalized dissipation coefficient gamma. They were able to explain the increase in the ER cross sections with gamma varying between 5 to 15, corresponding to a strongly over damped motion in the fission degree of freedom. However, such a description has some inconsistency since the value of the dissipation strength is not allowed to vary as the system cools down during the particle evaporation. Mitsuoka et al. [2] measured the ER cross section for ^{32}S+^{182}W system. They compared the fusion evaporation residues in the case of ^{32}S+^{182}W and ^{60}Ni+^{154}Sm systems and found that there is a large fusion hindrance in the latter case.

Analysis

In this report, we bringout a comparison between these two systems in the case of evaporation residues. In Fig.1 , the cross sections of the evaporation residues measured for ^{32}S+^{184}W [1] and ^{32}S+^{182}W [2] were compared along with the capture cross sections [1, 2, 4]. Capture cross sections measured for ^{32}S+^{184}W system[1, 4] and ^{32}S+^{182}W system [2] show similar character for below and above barrier energies. However, in the case of measured evaporation residue cross sections, both systems show very different behaviour. For ^{32}S+^{184}W system the ER cross sections measurement is not extended to energies well below the Coulomb barrier. For ^{32}S+^{182}W system, the evaporation residue cross section shows a decrease when going to higher excitation energies. However, in the case of ^{32}S+^{184}W system, the evaporation residue cross section does not show any decrease when going to higher excitation energies. From Fig.1 we can clearly see that capture cross section for ^{182}W by Back et al., Mitsuoka et al., and Keller et al., very closely agree with the capture cross section for ^{184}W of Zhang et al. However, the cross section for ER for both the targets ^{182}W and ^{184}W widely differ from each other. It is also worth noting that while ER cross section for ^{182}W shows a well defined distribution reaching a maximum at around 60 MeV excitation energy, no such distribution is seen in the case of ER cross section of ^{184}W.

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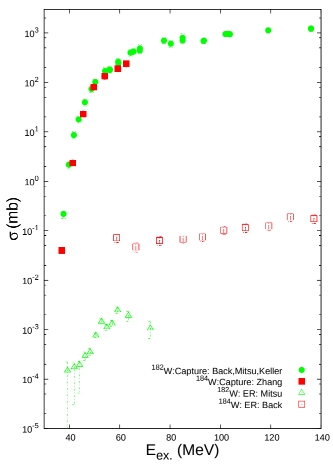

FIG. 1: Comparison of evaporation residue cross sections for ^{32}S + ^{184}W [1] and ^{32}S + ^{182}W [2] along with capture cross sections[1, 2, 4]. Capture cross sections for ^{184}W target are from [3]. Red color represents ^{184}W and green color represents ^{182}W.

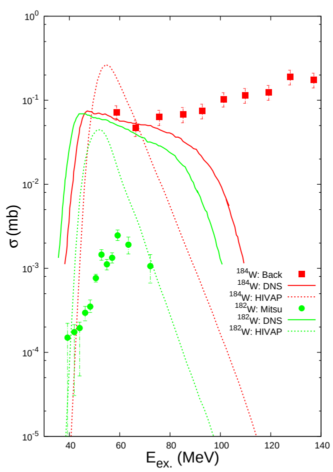

FIG. 2: Comparison of evaporation residue cross sections for ^{32}S + ^{184}W [1] and ^{32}S + ^{182}W [2] along with theoretical calculations. DNS calculations were taken from [3]. Red color represents ^{184}W and green color represents ^{182}W.

For a better understanding in Fig.2, we display ER cross sections only for both systems studied here. This plot shows the comparison of experimental ER cross section for ^{182}W and ^{184}W with calculations based on DNS model and HIVAP. While the DNS model calculations are reproduced from Zhang's work [3], we have made the statistical model calculations with HIVAP code[7] using parameters obtained from[8]. We can see that in the case of ^{182}W, the observed experimental ER cross section of Mitsuoka et al. [2] follows the HIVAP calculation at least in shape, though there is significant difference in absolute magnitudes. However, DNS calculations in this case deviate significantly. Fig.2, also shows the experimental ER cross section of Back et al. [1] for ^{184}W where it is clear that both DNS and HIVAP deviate from the experimental trend significantly though Zhang et al. [3] claim that the ER cross section at low energies are very close to DNS calculations.

This means that none of these calculations are able to reproduce the experimental results. In conclusion, it is very important to have more experimental data and theoretical analysis on these systems to identify the role of shell stabilizing effects of N=126.

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