Analyzing reaction cross sections of $^{8}B+^{208}Pb$ system using CDCC-FRESCO at slightly above barrier energies.

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Introduction

Since last few decades, the reactions involving weakly bound projectiles such as $^{6,7,8}Li$, ^{8}B, ^{11}Be, ^{17}F are being investigated around the world with a motive to understand the unusual behavior shown by these nuclei [1,2]. The characteristics like low binding energy and consequent presence of halo structure give rise to new possibilities of interaction with target.

Further the tendency of such loosely bound projectiles to breakup up into fragments contribute to different reaction processes such as breakup, fusion and transfer reactions. Moreover, it has also became an established fact that the breakup continuum couplings do play significant role in prediction of cross sections of reactions initiated by these nuclei [3]. Therefore, in this contributory work, we calculated the reaction cross sections by employing CDCC method for the system $^{8}B+^{208}Pb$ with beam energy ranging from 48 MeV to 57 MeV using FRESCO code [4].

In present calculations, ^{8}B is considered as core (**^{7}Be**) + valence (**p**) system with the valence proton having separation energy (Sp) = 0.137 MeV and the target ^{208}Pb is considered as inert and undeformed. For the inclusion of breakup couplings up to a threshold energy E_{max}= 8 MeV, the continuum discretization of unbound states into a number of bins is done. The resonant continuum states in L=3 ($5/2^-$, $7/2^-$) are also considered by reducing the step size in the binning process. The optical model potential parameters corresponding to $^{7}Be+^{208}Pb$, $p+^{208}Pb$ and $p+^{7}Be$ are taken from the ref. [5-7] and for ready reference of readers are given in table. The surface terms are included in potential parameters to account for the contribution by valence proton to reaction cross section. Now reaction cross section is calculated by considering three different coupling configurations and also compared with experimental data and the predictions made by B. Mukeru et al. [8] (See Figure.).

Results and Discussion

From the figure it is noticed that the previous calculations done by B. Mukeru team significantly overpredict (~55%) the experimental data. The line-circle (green) shows that the overprediction of the results decreases as we move slightly above the Coulomb barrier energies. One of the possible reasons for this could be non-convergence of the calculations done in ref. [8].
Moving further we have also considered three different coupling contributions as (1) no coupling (L=0), (2) Resonant states (R.S.), (3) Total (resonant + non-resonant states (L=0-3)).

Real and Optical potential parameters including surface terms (W_d, W_{dr}, a_{wd})

Reaction system	V (MeV)	r_V (fm)	a_V (fm)	W (MeV)	r_w (fm)	a_w (fm)
$^{7}Be+^{208}Pb$	114.2	1.286	0.853	12.4	1.739	0.807
$p+^{208}Pb$	59.1	1.244	0.646	0.52 W_d= 8.41	1.244 W_{dr}= 1.246	0.646 a_{wd}=0.58
$^{7}Be+p$	44.65	2.391	0.52	v_{so}=19.59	r_{so}=2.391	a_{so}= 0.52

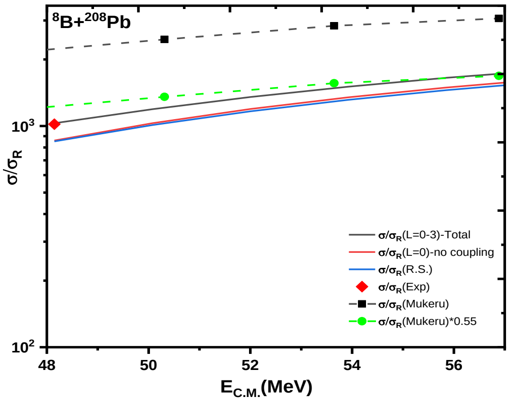

Figure (color online) Reaction cross sections (σ/σ_R) for $^{8}B+^{208}Pb$ at beam energies 48-57 MeV. The previous theoretical calculations by B. Mukeru et al. are shown by line +square (black) curves taken from ref. [8]. The Line + circle (green) represents the reaction cross sections multiplied by 0.55. The Diamond (red) represents the corresponding experimentally observed data taken from ref. [9].

The contribution considering all states (Total) predicted exactly the reaction cross sections as shown in figure. Due to paucity of experimental data, we were not able to compare it at different energies. Thus taking 50 MeV prediction as a benchmark we compared it to previous theoretical predictions [8]. The R.S. contribution seems to assimilating with that of no coupling contribution. The reason for this could be non-consideration of resonant state precisely or it could be asserted that the resonant states contributions suppress the reaction cross section above the barrier. Thus, more work needs to be done on this projectile-target system both experimentally as well as theoretically to resolve these ambiguities.

References

[1] L. Canto, et al., Phys. Rep. 596, 1 (2015).
[2] N. Keeley, et al., Prog. Part. Nucl. Phys. 59, 579 (2007).
[3] J. Rangel, et al., Phys. Lett. B 803, 135337 (2020).
[4] I. J. Thompson, Comput. Phys. Rep. 7, 167 (1988).
[5] S. J. Wang, et al., J. Phys. Conf. Ser. 420, 012075 (2013).
[6] B. Mukeru, et al., Nucl. Phys. A935, 18-27 (2015).
[7] Y. Kucuk, et al., Phys. Rev C86, 034601 (2012).
[8] B. Mukeru et al., Pramana – J. Phys. 95:106 (2021).
[9] Mazzocco M et al., Eur. Phys. Journal, Web of Conferences 117, 06006 (2016).