Dipole polarizability of deuteron revisited

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Introduction

The recent availability of radioactive ion beams (weakly bound unstable nuclei) at different laboratories around the world have renewed the interest in nuclear reaction and structure studies. The static and dynamic properties of these nuclei play an important role in the reaction mechanism studies. The lightest weakly bound nucleus is deuteron having breakup threshold of 2.23 MeV. The dipole polarizability (α_o) value for deuteron extracted from the high precision elastic data is 0.7 fm^3 [1] within the semiclassical picture. In our recent work, we have employed the similar experimental method with quantum mechanical calculations to extract the α_o value for ^{9}Be [2]. In that work, we have observed that the coupling effect of one neutron stripping on elastic scattering is significant even at 10 MeV below the barrier for the ^{9}Be+^{208}Pb system. Motivated by this observation, we have performed similar calculations for the d+^{208}Pb system to extract the α_o value for deuteron. We have studied the coupling effects of one neutron stripping along with the continuum on elastic scattering for d+^{208}Pb system, because the extracted α_o value is expected to be sensitive to coupling effects other than breakup.

Coupled channels calculations

The continuum discretized coupled channel (CDCC) and coupled reaction channel (CRC) calculations were carried out using the code FRESCO, version FRES 2.3. The ground state (1^+) wave function of deuteron is predominantly in the $^3S_1$ state (96 %) with a small admixture of $^3D_1$ state (4 %). Both these configurations were used in the calculations. The nuclear potential of Wood-Saxon form between n and p was taken to reproduce the ground state. The diffuseness was taken as 0.50 fm. The radius parameter was varied to 1.02 fm so that the model ground state quadrupole moment matched the measured value of Q=2.82 fm^2. The depth of the potential was varied to get the correct binding energy. The interaction potentials between d and ^{208}Pb were obtained by folding the fragment target potentials n + ^{208}Pb and p + ^{208}Pb. The n + ^{208}Pb and p + ^{208}Pb

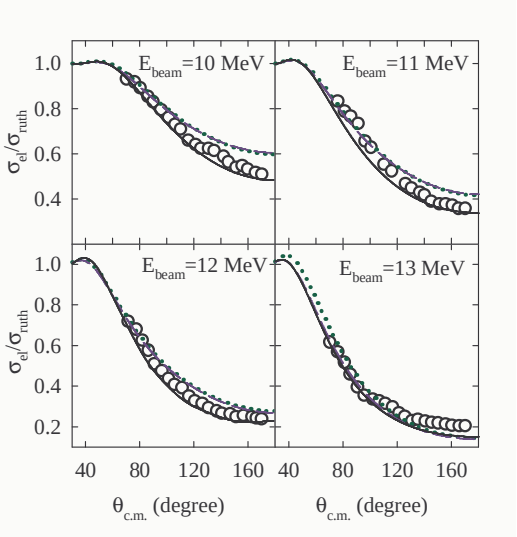

FIG. 1: The elastic scattering angular distribution for d+^{208}Pb at E_{lab} = 10,11,12 and 13 MeV. The data are taken from Ref. [3]. The calculations with no coupling, coupling to breakup only, and breakup plus ^{208}Pb$(d,p)^{209}$Pb transfer are denoted by the dotted, dashed and solid lines, respectively.

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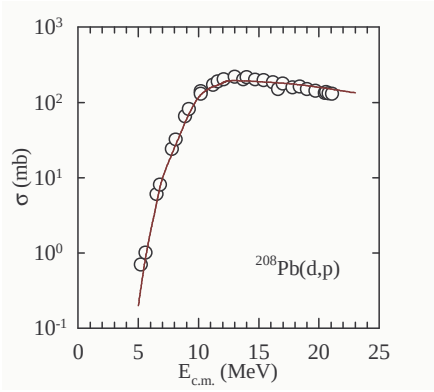

FIG. 2: Calculated cross section along with data for the one neutron stripping reaction ^{208}Pb(d,p).

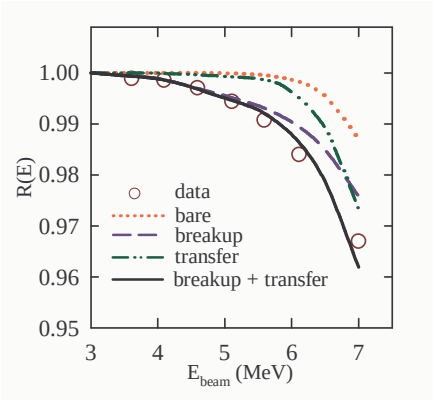

FIG. 3: The measured ratio $R(E)$ of the elastic scattering cross-sections [1]. Calculations with no coupling, coupling to breakup only, coupling to transfer only, and breakup plus ^{208}Pb$(d,p)^{209}$Pb transfer are denoted by the dotted, dashed, dash-dotted and solid lines, respectively.

optical potentials were taken from the fits to the d + ^{208}Pb elastic scattering at beam energy E = 23 MeV using the Wood-Saxon form for the real and imaginary potentials. We have carried out CRC calculations for the one neutron transfer channel. The following states of ^{209}Pb: ground state $(9/2^+)$, 0.78 $(11/2^+)$, 1.42 $(15/2^-)$, 1.57 $(5/2^+)$, 2.03 $(1/2^+)$, 2.49 $(7/2^+)$ and 2.54 $(3/2^+)$ MeV states were included. The spectroscopic factors for all these single particle states of ^{209}Pb were taken from Ref.[4]. The calculated elastic scattering angular distribution for d+^{208}Pb at E_{lab} = 10,11,12 and 13 MeV with no coupling, coupling to breakup only, and breakup plus ^{208}Pb$(d,p)^{209}$Pb transfer are shown by the dotted, dashed and solid lines, respectively in Fig.1. It is seen from Fig.1 that the breakup coupling effect is negligible at and above 10 MeV where only coupling effect of one neutron stripping channel is significant. The calculated one neutron stripping cross section results are plotted in Fig.2 and compared with existing data [5].

Results and Conclusion

The breakup and one neutron stripping calculations for d+^{208}Pb system have been presented here. The calculated elastic scattering ratio $R(E)$ (as defined in [1]) with no coupling, coupling to breakup only, coupling to transfer only, and breakup plus one neutron stripping are denoted by the dotted, dashed, dash-dotted and solid lines, respectively in Fig.3. It is observed that the effect of breakup coupling is significantly larger than that of transfer at energies below 6 MeV. The coupling effect of one neutron stripping channel is visible only above 5.5 MeV beam energy, and it is more than the effect due to breakup coupling after 7 MeV. However,as the the suitable energy region for extraction of α_o value for deuteron is below the 7 MeV, one neutron stripping channel was not affecting the extracted α_o value. The value of α_o extracted from the present work is close to the value 0.7 fm^3 that was extracted by Rodning *et al.* [1].

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