Study of one proton breakup in the ^{17}F + ^{208}Pb

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Introduction

The reaction dynamics near the Coulomb barrier involving loosely bound nuclei shows fascinating features due to the presence of breakup channels. While the breakup of loosely bound neutron-rich nuclei has been studied extensively and is reasonably well understood, this is not true for proton-halo nuclei in which the loosely bound valence protons actively participate in the reaction. The study of proton rich nuclei present a number of unusual features such as the two proton radioactivity or beta-delayed proton emission and have important astrophysical implications. The breakup of light proton rich loosely bound nuclei provides useful information about the low-lying dipole strength, the influence of quadrupole transitions and higher-order Coulomb processes, the role of nuclear induced breakup.

In the present work, we have studied the effect of the breakup of the radioactive proton -rich nucleus, ^{17}F into a proton and ^{16}O for the ^{17}F + ^{208}Pb system at 120 MeV and 170 MeV. ^{17}F is the lightest particle-stable fluorine isotope, with a proton binding energy of 0.6 MeV. Its only excited level has a binding energy of only 0.105 MeV and is connected to the $5/2^+$ ground state through a transition with a significantly large $BE2$ value: 66.4 e^2 fm^4 . While the $d_{5/2}$ structure of the ground state suppresses the halo character, the l = 0 structure and the small binding energy of the $1/2^+$ excited level make it a good proton halo candidate.

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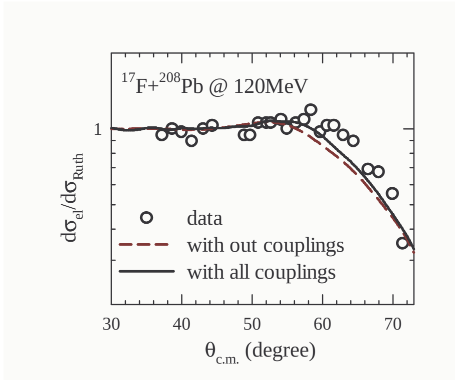

FIG. 1: Calculated ^{17}F + ^{208}Pb elastic angular distributions at 120 MeV compared to measured data

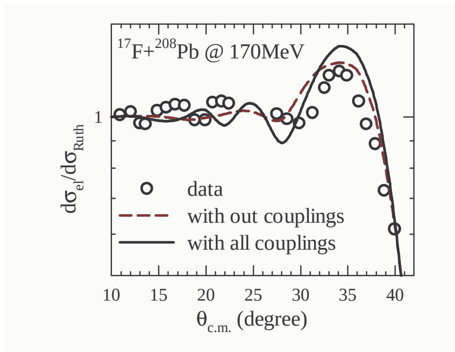

FIG. 2: Calculated ^{17}F + ^{208}Pb elastic angular distributions at 120 MeV compared to measured data.

Coupled channels calculations:

We have performed continuum discretized coupled channel (CDCC) calculations for the ^{17}F + ^{208}Pb system using the code FRESCO, version frxy.18 [1]. The bound states and the continuum of ^{17}F has been generated using a single particle model where the valence proton

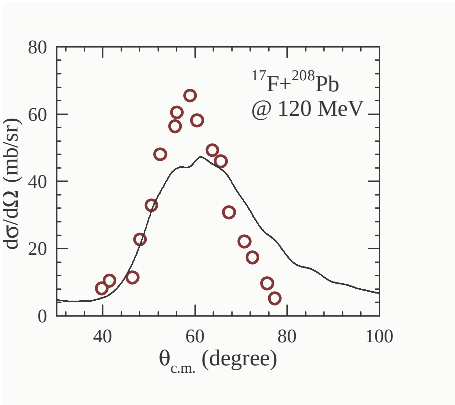

FIG. 3: Calculated ^{17}F + ^{208}Pb elastic angular distributions at 120 MeV compared to measured data.

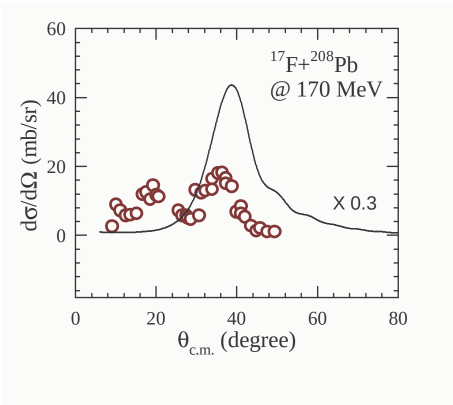

FIG. 4: Calculated ^{17}F + ^{208}Pb breakup angular distributions at 170 MeV compared to measured exclusive breakup data.

is in a Coulomb and Woods Saxon nuclear potential relative to ^{16}O core. The depth of the Woods Saxon potential has been adjusted to reproduce the known one-proton separation energies for the bound states. The interaction potentials between ^{17}F and ^{208}Pb were obtained by folding the fragment target potentials ^{16}O + ^{208}Pb and p + ^{208}Pb. The continuum up to 7 MeV has been considered in the calculations. We have included s-, p-, d- and f -waves in the continuum with all transitions of multipolarity 0,1 and 2. The coupling effects of ground state ($5/2^+$) to first excited state ($1/2^+$) quadrupole transition, couplings from the ground state and first excited state to the continuum and continuum -continuum couplings have been considered .

Results and Conclusions

The calculated elastic scattering angular distribution for ^{17}F + ^{208}Pb at E_{lab} = 120 and 170 MeV are shown in Fig.1 and Fig.2 respectively along with the measured data [2, 3]. The calculations with no coupling and coupling to inelastic state and continuum states are shown by the dashed and solid lines in these figures. The observed coupling effects are much less than those observed due to coupling effects of one neutron breakup in one neutron halo nuclei such as, ^{11}Be [4]. The angular distribution of breakup states obtained from calculations are compared with the exclusive one proton breakup data at E_{lab} = 120 and 170 MeV as shown in Fig.3 and Fig.4 [2, 3]. While the calculations describe the measured data at the E_{lab} = 120 MeV to some extent, at higher energy the calculations show a higher contribution from breakup than the measured data.

In summary, we find that the coupling effects of the breakup channels is not found as significant as in the neutron-rich nuclei. This is because the formation of a halo in loosely bound proton rich system is hindered due to presence of Coulomb repulsion of the charged core unlike the neutron-rich systems. Further calculations to compare these results with those for the systems involving the lighter proton rich nucleus ^{8}B, are in progress.

References

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