Elastic scattering Studies at RIBLL

J. S. Wang[1],* Y. Y. Yang[1], Q. Wang[1], D. Y. Pang[2,3], J. B. Ma[1], M. R. Huang[1], P. Ma[1], S. L. Jin[1,4], J. L. Han[1], Z. Bai[1], W. H. Ma[1,4], Y. J. Zhou[1,4], J. Chen[1,4], L. Jin[1,4], J. B. Chen[1,4], Q. Hu[1,4], R. Wada[1], S. Mukherjee[5]

[1] *Institute of Modern Physics, Chinese Academy of Sciences, Lanzhou 730000, China*

[2] *School of Physics and Nuclear Energy Engineering, Beihang University, Beijing 100191, China*

[3] *International Research Center for Nuclei and Particles in the Cosmos, Beihang University, Beijing 100191, China*

[4] *University of Chinese Academy of Sciences, Beijing 100049, China*

[5] Physics Department, Faculty of Science, M.S. University of Baroda, Vadodara 390002, India *Nuclear Physics*

. * *email: jswang@impcas.ac.cn*

Introduction

The elastic scattering is an important probe to study the structure of a nucleus and the reaction mechanism between two nuclei. Accurate measurements of the elastic scattering differential cross section are very important for the determination of the optical potential parameters and the so-called one quarter angle ($q_{1/4}$). Also, the optical potential parameters of stable nuclei and halo nuclei are found to be different. ^{8}B is a well-known proton-halo nucleus even there is still some arguments. The binding energy of the last proton is only 0.137MeV. Many investigations have been done for ^{8}B by measuring the total reaction cross sections, breakup cross section and inelastic scattering differential cross section. However, the experimental data of elastic scattering of ^{8}B and other light proton-rich nuclei on heavy target are few. Therefore, a series experiments have been carried out for such nuclei at the Radioactive Ion Beam Line in Lanzhou, RIBLL, which was built in 1997 as a major facility in China for studying the RIB physics at intermediate energy.

Experimental Setup

The unstable nuclear beams of ^{7}Be, ^{8,10}B, ^{10,11}C were produced by RIBLL. A 54.2MeV/A primary beam of ^{12}C was accelerated by the Heavy Ion Research Facility of Lanzhou (HIRFL) and delivered to a 2615 μm thick Be production target. The secondary beams were separated and purified by RIBLL [1]. The intensity of the secondary beams was a few hundred to thousand particles per second with a primary beam intensity of 300 enA.

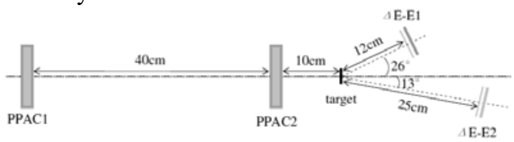

Fig. 1 Schematic view of the experimental setup.

The experimental setup is shown in Fig.1. Two PPACs are used to track the incident particle. After the reaction target, the elastic scattering events and the outgoing directions are determined by two dE-E telescopes composed by a multi-strip Si detector and a stopping Si detector.

Results and Discussion

The elastic scattering of ^{7}Be and ^{8}B by a ^{nat}Pb target was measured at incident energy of 125 MeV and 170.3 MeV respectively. The measured angular distribution of the differential cross section shows that the Coulomb-nuclear interference peak (CNIP) is not suppressed both for the system of ^{7}Be and ^{8}B, in contrast to what was observed in the scattering of neutron halo nuclei, such as ^{6}He and ^{11}Be, by heavy targets at energies around the Coulomb barrier. Analyses of the angular distribution were performed both in terms of the optical model using a single-folding-type potential and the continuum discretized coupled-channels (CDCC) method, which explicitly takes into account the breakup-channel couplings to the elastic scattering. The overall pattern of the differential cross section is well reproduced by the CDCC calculations. The calculations show that the effect of breakup-channel couplings on the elastic scattering is small in the present case. The reason for abnormal behavior of ^{8}B might be due the different structure between neutron halo and proton halo. Further theoretical and experimental studies are in urgent need.

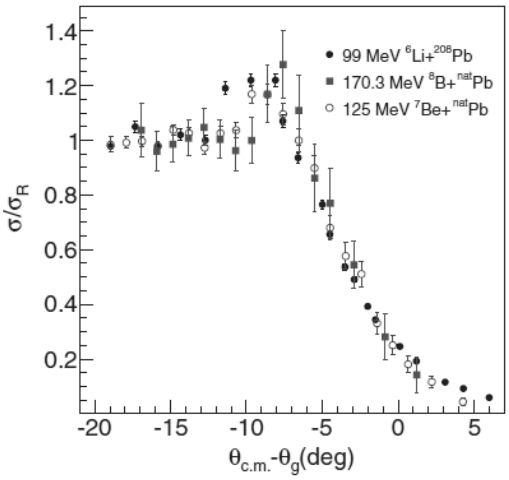

Fig. 2 Data for 99 MeV ^{6}Li + ^{208}Pb elastic scattering [2], 125 MeV ^{7}Be + ^{nat}Pb quasielastic scattering [3], and 170.3 MeV ^{8}B + ^{nat}Pb quasielastic scattering plotted as a function of $\theta_{c.m.} - \theta_{g.}$ Note the linear cross section scale. (From Ref. [4])

In Fig.3, Angular distributions of the differential cross sections were measured for the quasi-elastic scattering from a ^{nat}Pb target by ^{10}C at 226 and 256 MeV, by ^{11}C at 222 MeV and 226 MeV, and by ^{10}B at 173 MeV. The systematic potentials are that of Xu in Ref. [5] (solid curves) and SPP in Ref. [6] (dashed curves). Results of phenomenological potentials by fitting the experimental data are also shown with dotted curve. It can be seen that these data can be well reproduced by optical model calculations with systematic nucleus-nucleus potentials. And the contributions from the inelastic scattering channels to these data are found to be negligibly small with coupled-channel calculations within the angular range covered by this experiment.

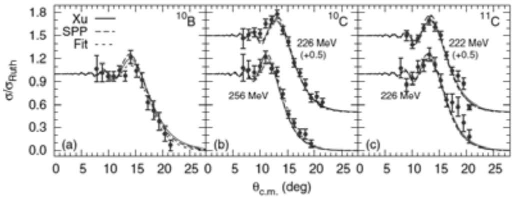

Fig3. Comparisons between experimental data and optical model calculations with systematic nucleus-nucleus potentials for (a) ^{10}B, (b) ^{10}C, and (c) ^{11}C from the lead target. (From Ref. [7])

Summary

The elastic scattering angular distribution of ^{7}Be,^{8,10}B,^{10,11}C + ^{nat}Pb at incident energy of around three times the Coulomb barrier were measured. Optical model calculations using the systematic nucleus-nucleus potentials of both Ref. [5] and SPP [6] were performed. The results of our calculations are in good agreement with the experimental results. We have also compared the reduced total reaction cross sections with some other existing data. It is found that the reduced reaction cross sections for exotic, weakly bound nuclei, and tightly bound nuclei follow the same trend at energies around 3 times of Coulomb barriers. However, it is a paradox for ^{8}B, a proton halo nucleus, that the suppression of CNIP is not observed.

References

[1] Z. Sun *et al.*, Nucl. Instrum. Methods Phys. Res., Sect. A 503,496 (2003).

[2] D. P. Stanley, F. Petrovich, and P. Schwandt, Phys. Rev. C 22,1357 (1980).

[3] Y. Y. Yang, J. S. Wang, Q. Wang *et al.*, Nucl. Instrum. Methods Phys. Res., Sect. A 701, 1 (2013).

[4] Y. Y. Yang, J. S. Wang, Q. Wang *et al.*, Phys. Rev. C 87, 044613 (2013).

[5] Y. P. Xu and D. Y. Pang, Phys. Rev. C 87, 044605 (2013).

[6] L. C. Chamon *et al.*, Phys. Rev. C 66, 014610 (2002).

[7] Y. Y. Yang, J. S. Wang, Q. Wang *et al.*, Phys. Rev. C 90, 014606 (2014).