Elastic scattering with radioactive ion beam ^{8}Li on ^{9}Be target

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Introduction

It is well known that the properties of nuclei far from stability differ in many aspects from the properties of ordinary nuclei. Recently with the advent of acceleration techniques, it has become possible to produce variable in energy, high intensity beams of radioactive nuclei in a wide range of N and Z. The use of secondary beams of radioactive nuclei considerably widens the possibilities to investigate the properties of atomic nuclei and nuclear reactions. One of the interests is to study all reaction channels: elastic scattering, fusion, transfer and fragmentation reactions. These are closely correlated and give new information both on the structure of the weakly bound nuclei and on the nuclear dynamics in which they participate [1 - 2].

The elastic scattering of light exotic nuclei gives information on the nucleus-nucleus interaction of systems far from stability, which are characterized by large isospin and strong coupling to the continuum, namely the break-up channel of the weakly bound nucleus. The parameters of this interaction are of interest not only by themselves, but also necessary for analysis and understanding of the dynamics of more complicated reactions (fusion, break-up, few nucleon transfer reactions). The theoretical study of elastic scattering of light radioactive nuclei reveal the significant lowering of the depth of the real part of the optical potential compared to the mean (global) quantities, derived for the stable nuclei V_0 (^{6,8}He, ^{8,11}Li, ^{8}B,…) = V_0 (global) – $\Delta V(E)$. Besides, the radial dependence of this potential should contain a long-range component due to the strong coupling to the break-up channel. The imaginary part of the optical potential should be significantly larger (and extended) than the global values. The derivation of these parameters is possible only from the analysis of the experimental cross section of elastic scattering, measured in a wide range of angles and energies.

For the above reasons, the study of the dynamics of low energy elastic scattering cross section with weakly bound nuclei is of great interest. The objective of the present work is to measure the elastic scattering angular distributions of ^{8}Li on light (^{9}Be) target.

Experimental Details

The elastic scattering experiments were performed at 8UD Pelletron accelerator of the University of Sao-Paulo, Brazil. The secondary radioactive ion beam, ^{8}Li with incident energy 20.6 MeV was produced with the RIBRAS (Radioactive Ion Beams in Brazil) system. The description of the production of radioactive ion beams using RIBRAS facility has been discussed elsewhere [3].

The elastic scattered ^{8}Li particles were detected by an array of four Si surface barrier ΔE-E telescopes in an angular range of 8 – 55 degrees in lab system in 5 degree steps, mounted on the rotating plate of the chamber. The thickness of ΔE detectors were 25 μm with an area of 300 mm^2 and the E detectors were 1mm thick with an area of 300 mm^2. The secondary target used in this experiment was self-supporting, pure ^{9}Be targets of thickness 2 mg/cm^2. A gold target of thickness 300 μg/cm^2 was also used to obtain the overall normalization in all the runs at different angles. Since the cross sections in angular interval covered by these detectors could vary up to one order of magnitude, the average detection angle was determined by Monte-carlo simulation, which took into account of collimator size in front of the detectors, the secondary beam spot size on the secondary target (4 mm), the secondary beam divergence and the angular distribution in the range of detector aperture (Rutherford on gold and calculated in an iterative way for the ^{9}Be target). The ratio of elastic scattering angular distribution to the Rutherford scattering for the ^{8}Li + ^{9}Be is shown in Fig. 1 for the present and the previous work.

Optical model analysis of elastic scattering data

Optical model analysis of elastic scattering angular distribution data has been carried out to extract the optical potential parameters and reaction cross sections at the energies at which data were obtained. The elastic scattering angular distribution data for the systems under consideration were analyzed with the optical model (OM) using two different potential models, namely (i) a phenomenological Woods-Saxon potential (WSP) and (ii) the Sao Paulo double folding potential (SPP). Fig.1 shows the comparison of the experimental and calculated results. Simultaneous χ^2-analyses were performed of elastic scattering, reaction cross section data of the present systems at lab energies 14, 19.3 and 27 MeV. The parameters used for the WSP calculations were V=173.10MeV, r_R=1.288fm, a_R=0.78fm, W_V=80.84MeV, r_I=3.02fm, a_I=0.8944fm. Here the radii are given by $R_x = r_x$ x $(A_P^{1/3}+A_T^{1/3})$.Table shows the derived parameters for the SPP calculations for three energies. The corresponding χ^2/n and σ were 21.7 and 1411 mb respectively at 19.3 MeV. χ^2-analyses was also performed with the parameters in the table for different values of normalization factors of the imaginary potential N_I of the SPP, keeping the real part N_R = 1.0. It was observed that χ^2/n was minimum around N_I = 0.8 (Fig. 2). One can observe similar values of χ^2/n and σ for both the potentials. Thus in the nut shell N_i parameter is approximately system-independent, with the present value very close to average value N_I= 0.78. Good elastic scattering cross-section predictions are obtained using this average value for the present data set.

System	Energy (MeV)	N_I	χ^2/n	σ (mb)
^{8}Li + ^{9}Be	14.0	0.8	21.7	1267
	19.3	0.8	21.9	1331
	27.0	0.9	18.2	1370

References

1. P.R.S. Gomes et al., Phys. Rev. C 73 (2006) 064606.
2. P.R.S. Gomes et al., Phys. Letts. B 634 (2006) 356.
3. A. Lepine-Szily and R. Lichtenthaler, Nucl. Phys. A 787 (2007) 94c.
4. O.Camargo et al., Phys. Rev. C 78 (2008), 034605.
5. F.D. Becchetti et al., Phys. Rev. C 48 (1993), 308

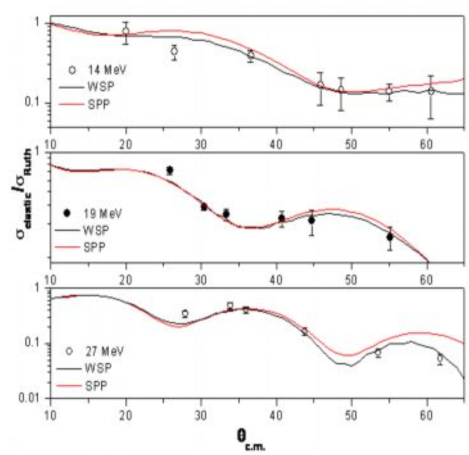

Fig.1. The elastic scattering angular distributions measured for the ^{8}Li+^{9}Be systems together with best fits obtained with the SP & WS potentials. Top [5] & Bottom [4].

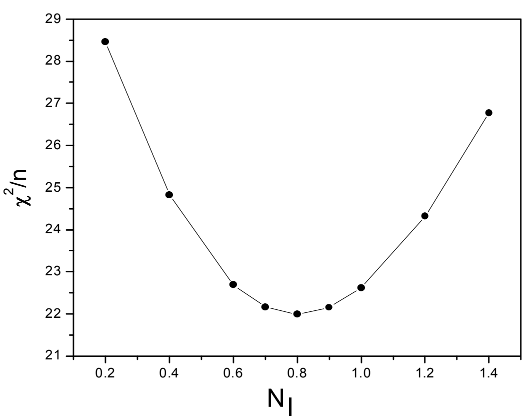

Fig.2. N_I values for the present system at 19.3 MeV as a function of χ^2/n.