Elastic scattering measurements for the ^{12}N + ^{197}Au system at Elab = 70 MeV

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Some light nuclei away from the valley of stability are characterized by low binding energies and long tail matter distributions, leading to the formation of a halo, an extended special distribution of the valence nucleon wave function [1]. This exotic nuclear structure manifests in the cross sections of elastic, fusion, transfer, and breakup reactions, mostly at energies around the Coulomb barrier [2]. The interplay between these unusual structures and reaction channels is paramount to describe experimental data obtained for reactions carried out for "halo" nuclei, such as ^{6}He, ^{8}B, ^{11}Li, and ^{11}Be [3]. For these nuclei, the angular distribution for the elastic cross sections, measured at energies around the Coulomb barrier, exhibits a damping of the Fresnel peak (interference between Coulomb and nuclear components) [4]. In this work, we present new experimental data of the elastic scattering for the ^{12}N+^{197}Au system at E_{lab} = 70 MeV. The experiment was performed at the Cyclotron Institute of Texas A&M University. The radioactive ^{12}N beam was produced by the recoil separator MARS [5] using the ^{3}He(^{10}B,^{12}N) reaction. The radioactive ^{12}N beam had an intensity of 1×10^{3} p/s and was impinged into the 4.7 mg/cm^{2} thick ^{197}Au target at the scattering chamber. The schematic view of the detection system is shown in Fig. 1. The detection setup consisted of three double sided silicon strip detectors (DSSSD) with 128 vertical and 128 horizontal fixed strips producing a highly segmented detection system. The detector pixels were mapped by a simulation of the experimental setup and used to determine the scattering angles.

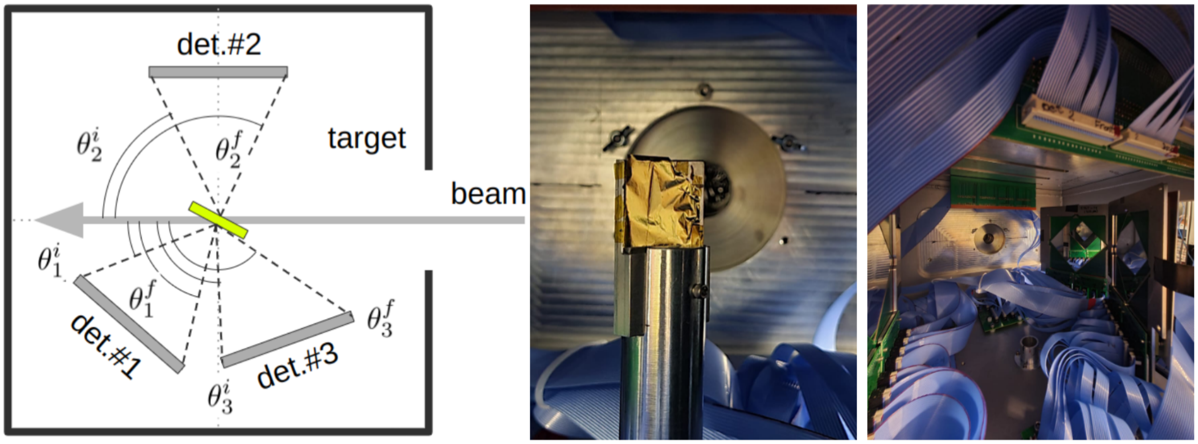

Fig. 1. Schematic view of the experimental setup. On the right is an inside picture of the scattering chamber.

The measured angular distribution was obtained from 40° to 140° in the center of the mass frame, as shown in Fig. 2. The error bars in the experimental cross sections correspond to the statistics and the systematic uncertainties due to the normalization method used. In the first approach for the analysis of experimental angular distribution, we considered the optical model (OM) calculations, with the phenomenological Woods-Saxon (WS) and double folding São Paulo potentials for real and imaginary parts. The parameters for the WS-1 potential were obtained from another proton-rich projectile 10C+208Pb data at Elab = 66 MeV [6]. In contrast, the WS-2 parameters correspond to a fitting procedure with initial parameters from the previous calculation. These parameters are shown in Table I. Also, São Paulo Potential (SPP) [7], with standard (NR=1.0 and NI=0.78) and adjusted normalizations (NR=0.1 and NI=25) for the real and imaginary parts, were applied. The results of these calculations are also shown in Fig. 2. As can be observed in the figure, a strong absorption damps the Fresnel peak, which can be attributed to the possible halo formation of the valence proton in 12N. Although the adjusted potentials could reproduce the data quite well, the normalization parameters for the SPP are unrealistic. A large imaginary potential for the Woods-Saxon is also obtained to describe the strong absorption. As the results, the obtained total reaction cross section is quite large.

Table I. Parameters of the optical potentials obtained by fitting the elastic scattering.

projectile	V	r_V	a_V	W	r_W	a_W	σ_R (mb)
^{10}C	82.2	1.19	0.12	17.6	1.60	0.14	753
^{12}N	28.6	1.28	0.39	79.9	1.85	0.11	1297

Since the binding energy of ^{12}N for the breakup to ^{11}C+p is relatively small (S_P=0.60 MeV), the breakup might be an important channel for decay. To investigate the effect of this channel on the elastic scattering, we performed continuum discretized coupled-channels calculations (CDCC). For this, some potentials of the three-body system ^{12}N (^{11}C+p)+^{197}Au must be considered. For the ^{11}C+^{197}Au sub-system, the Arkyus-Winther and SPP potential, while for p+^{197}Au, the Koning-Delaroche Potential and for p+^{11}C, a standard WS potential (r=1.25 and a=0.65 fm). By using these potentials, without any couplings (one-channel calculation), the data's description is reasonable, again indicating the importance of the model structure of ^{12}N as formed by ^{11}C+p. The couplings to the continuum (CDCC) calculations have also been performed, and preliminary results are shown in Fig. 2. The Next step is to perform the reaction channel calculation (CRC) to describe the rising of the cross sections for the backward angles.

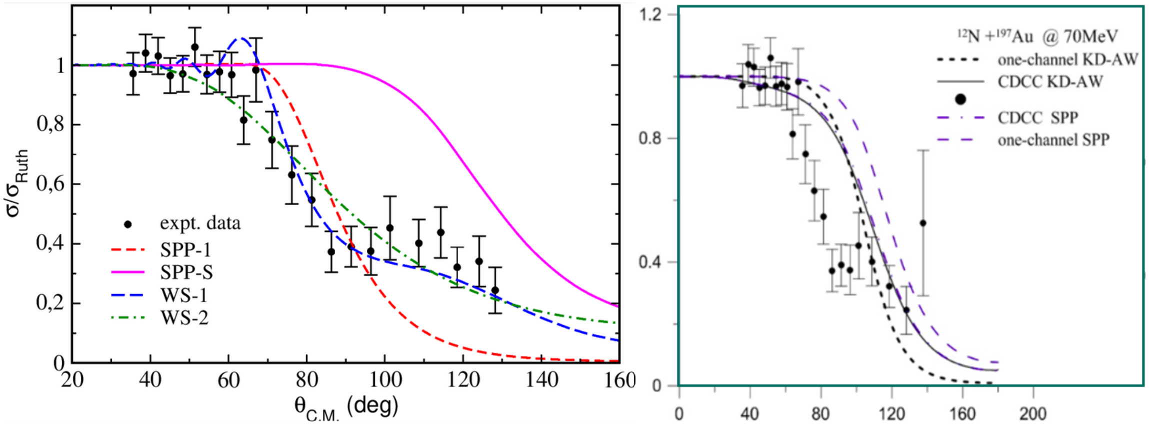

Fig. 2. Angular distribution for the ^{12}N+^{197}Au at E$_{\mathrm{lab}}$ = 70.0 MeV. On the left are the results of the OM analysis, and on the right are the results of one-channel and CDCC calculations with Arkyus-Winther and SPP potentials.

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