

Elastic scattering of ^{17}F on ^{208}Pb and ^{17}F breakup cross section at Coulomb barrier energies

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We have studied the elastic scattering of the exotic ^{17}F nuclei from ^{208}Pb at Coulomb barrier energies. For the measurement we used a new detector array with pixel structure and a large solid angle. Optical potential analysis shows that ^{17}F has an imaginary potential much less deep than ^{19}F . Information on the exclusive ^{17}F breakup cross section has been deduced too.

1. INTRODUCTION

First generation Radioactive Nuclear Beams (RIBs) are usually quite poor in energy and position resolution and have low intensity, therefore, to get valuable information, the experimental setups cover the largest possible solid angle, determine energy and position of each detected particle with the highest achievable resolution, allow complete kinematics reconstruction of the event. We have recently developed a new array of Silicon detectors, named EXODET, for particle detection in reactions involving light RIBs such as ^{17}F ($S_p = 0.601$ MeV) that has only one bound state, with a halo structure, below the breakup threshold. We expect that the characteristics of such a nucleus could dramatically influence the interplay of the different reaction channels at energies close to the Coulomb barrier.

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2. EXPERIMENT

2.1. The EXODET array

The EXODET array (EXOtIC DETector) consists of 16 detectors arranged in 8 two-stage ΔE -E telescopes. The detectors, provided by Micron Semiconductor Ltd., are Single Sided Microstrip Detectors with an active area of (50×50) mm² and a strip pitch of 0.5 mm for a total of 100 strips per detector; ΔE detectors are 60 μm thick, while E detectors are 500 μm . The backplane of each detector is a not segmented plane. The detectors are arranged in two cubes placed around the target, one in back direction and the other in forward direction, and, as a whole, they cover 70% of 4π .

The readout system of EXODET requires 16 energy channels coming from the detectors backplanes and 1600 channels from the frontplanes strips. We decided to keep separate the two groups of channels and to use a standard electronic chain for the energy signals while, for the strips signals, we implemented a new readout system, based on an ASIC chip. The ASIC chip, originally developed for high energy physics experiments, was adapted to our detectors by drawing and building a pitch size adapter to connect the strips to the input pads, and by inserting a signal amplitude attenuator to match the dynamical range of the particles we are interested in. The ASIC chip simultaneously gives an output data stream which contains the chip identification number, and, for each hit strip, the hit strip number, the Jitter Time (JT), and the Time over Threshold (ToT). The JT measures the time between the trigger signal and the event signal (time correlation), while the ToT gives a rough information on the energy deposited in the strip (the relation between ToT

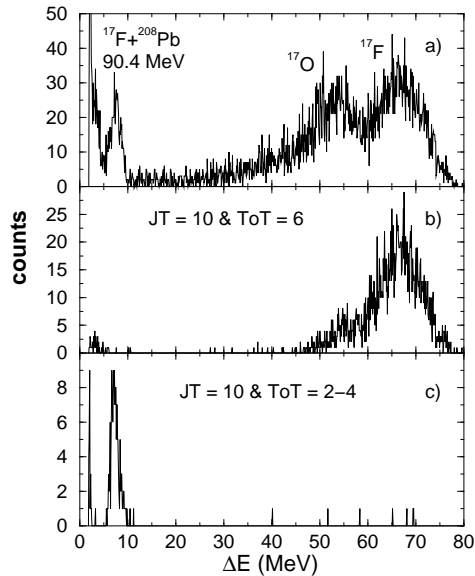


Figure 1. ΔE spectra from the backward detector: top panel shows a ΔE spectrum where light particles are separated from heavy fragments (^{17}O and ^{17}F), central (bottom) panel shows ^{17}F (proton) events selected through conditions on the JT and ToT.

and the energy is not linear). A dedicated VME based acquisition system has been developed too.

2.2. The measurement

The EXODET array was first used, though in a reduced version, at the Argonne National Laboratory (ANL) to measure the scattering of the radioactive ^{17}F beam ($E_{beam} = 90.4$ MeV) from a ^{208}Pb target (target thickness = 1 mg/cm²). The beam (10^6 pps, energy resolution ~ 1.5 % and $\phi = 0.5$ mm) was produced at the ATLAS facility of ANL using the $p(^{17}\text{O}, ^{17}\text{F})n$ reaction[1]. Main contaminant was ^{17}O with same magnetic rigidity as ^{17}F , but with lower energy.

3. DATA ANALYSIS

3.1. ^{17}F scattering events

To get the $^{17}\text{F} + ^{208}\text{Pb}$ system scattering cross section we need to clearly identify the ^{17}F events and information collected from the strips are quite helpful. In fact, the JT spectrum establishes that time correlated events fall in a narrow peak at about $JT = 10$, while ToT spectrum shows that high (low) energy events have $ToT = 6$ (< 4). Fig. 1 shows some experimental spectra: in the top panel a ΔE spectrum with no conditions is shown, in the central panel previous events have been analyzed requiring that $JT = 10$ and $ToT = 6$ to select ^{17}F events, the bottom panel gives the low energy events corresponding to $JT = 10$ and $ToT < 4$.

The derived differential cross section are shown in Fig. 2. To normalize our data we used scattering events taken in forward directions (pure Rutherford events). Due to the non spherical geometry of our detector array, geometrical corrections, estimated with a Monte-Carlo simulation[2], were included.

3.2. Breakup event analysis

The collected data allowed also to determine the $^{17}\text{F} \rightarrow ^{16}\text{O} + p$ ($S_p = 0.601$ MeV) breakup cross section. Of the two fragments, ^{16}O was stopped into the ΔE detector, while the p could reach the E detector allowing its identification through the ΔE - E matrix. For this analysis the pixel structure of EXODET has been the clue point. To select our events we required that two ΔE strips and one E strip had fired, JT of both hit strips is in the correlation peak ($JT = 10$), the ToT of the two ΔE strips should be different (one high energy event (^{16}O) and one low energy event (proton)), the total energy released in the ΔE detector should be in the spectrum region of ^{17}F and ^{17}O elastic peaks.

The evaluated breakup cross section, after geometrical correction, turned out to be (3.1 ± 1.4) mb inside the estimated range $(1.6 - 3.2)$ mb[3].

4. THEORETICAL ANALYSIS AND CONCLUSION

The experimental data were fitted in the framework of the optical model potential using the fitting subroutine SFresco, and were compared with the results of the code FRESKO[4]. Main outcomes of such analysis have been the optical model parameters set obtained from the fitting procedure, fixing $r_0 = 1.2$ fm and varying the diffuseness and the potential around the strong absorption radius[5]. As a last point we compared these

results with those obtained for similar systems involving well bound isotopes (see Fig. 2): it can be noted that the $^{17}\text{F} + ^{208}\text{Pb}$ system has a behaviour rather close to those of well bound systems like $^{16}\text{O} + ^{208}\text{Pb}$ [6] and $^{17}\text{O} + ^{208}\text{Pb}$ [7], while the $^{19}\text{F} + ^{208}\text{Pb}$ [8] system, because of a ground state rotational band[9], has a totally different behaviour.

In conclusion we can say that, surprisingly, the ^{19}F has a much deeper imaginary potential than the exotic ^{17}F .

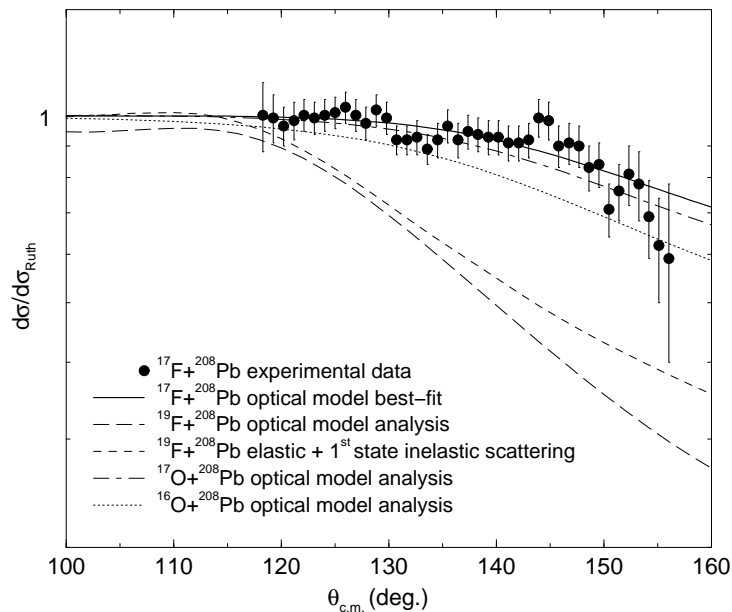


Figure 2. Comparison of the optical model analysis of the experimental elastic scattering angular distribution for 4 different systems. The potential parameters used for the curves are those given in[5].

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