$^{13}C+^{4}He$ resonant elastic scattering on a thick gas target

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^{13}C+^{4}He resonant elastic scattering on a thick gas target

L Prepolec[1], M Freer[2], N I Ashwood[2], N Curtis[2], A Di Pietro[3], P Figuera[3], M Fisichella[3], L Grassi[1], D Jelavić Malenica[1], Tz Kolalova[2], T Mijatović[1], M Milin[4], V Scuderi[3], N Skukan[1], N Soić[1], S Szilner[1], V Tokić[1], D Torresi[3,5] and C Wheldon[2]

[1] Ruđer Bošković Institute, Bijenička 54, HR-10000 Zagreb, Croatia
[2] School of Physics and Astronomy, University of Birmingham, Birmingham B15 2TT, United Kingdom
[3] INFN, Laboratori Nazionali del Sud, Via S. Sofia 44, Catania, Italy
[4] Department of Physics, Faculty of Science, University of Zagreb, Bijenička 32, HR-10000 Zagreb, Croatia

E-mail: `lovro@lnr.irb.hr`

Abstract. Resonant elastic scattering of ^{13}C on a thick ^{4}He target has been measured. Reaction products from ^{13}C(^{4}He, ^{4}He) were detected at several beam energies and gas pressures. Raw yield was efficiency corrected using Monte Carlo simulations and an averaged yield spectrum was produced. The observed peaks correspond well to the previously measured elastic scattering data.

1. Introduction

The cluster structure of light nuclei is a topic of great interest. Such structure has been well established in the excited states of many nuclei [1], among them in ^{16}O and ^{18}O, but not yet in ^{17}O. Cluster state candidates in ^{17}O have been observed by studying ^{13}C+^{4}He coincidences from the ^{13}C+^{9}Be $\rightarrow$ ^{13}C+^{4}He+^{4}He+n reaction [2] (Fig. 1). The authors proposed spin and parity assignments for known states which could be members of a rotational band analogous to the known one in ^{16}O (Fig. 2).

The aim of experiment was to investigate ^{17}O in the excitation energy range between 7.5 and 13.5 MeV. Using the resonant elastic scattering on a thick gas target method we measured the excitation function. An R-matrix analysis will be used to obtain J^{π} assignments.

2. Experimental setup

The experimental apparatus (Fig. 3) consists of a single large-area double-sided silicon strip detector of 50 $\times$ 50 mm size. The active area of the detector was divided into sixteen strips, both at front and back face, which were mutually perpendicular. The detector was placed at 0°, 42 cm far from the foil.

[5] Present address: Dipartimento di Fisica “Galileo Galilei”, Università di Padova, via Marzolo 8, I-35131 Padova, Italy

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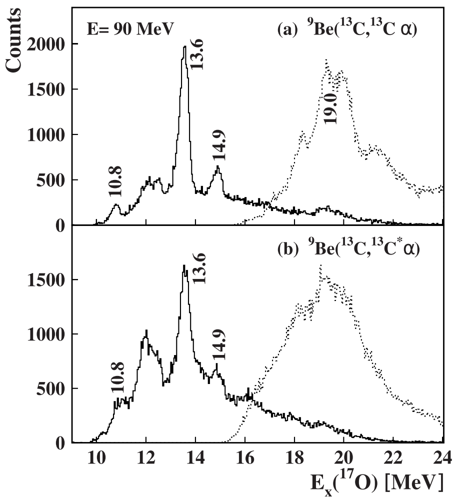

Figure 1. Figure adopted from [2]. ^{17}O excitation energy spectrum obtained from the ^{13}C+^{4}He with ^{17}O in its (a) ground state, and (b) excited state(s) at $E_x = 3.7$ MeV.

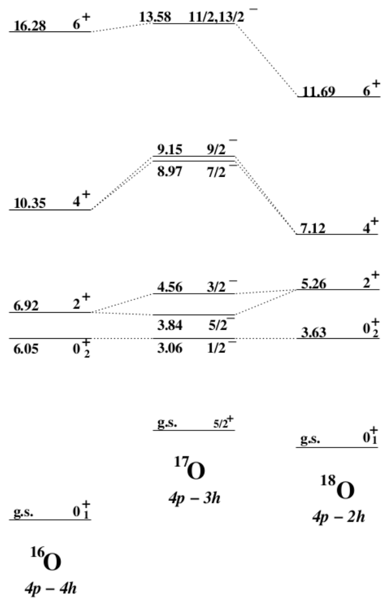

Figure 2. Figure adopted from [2]. Plot of the 4p-nh (where $n = 2, 3, 4$ energy levels for $^{16-18}$O.

The entire volume of the scattering chamber was filled with a pure helium gas, separated from the vacuum by a 2 μm thick Havar membrane.

The gas pressures and beam energies for every run were adjusted in order to stop the ^{13}C beam approximately 5 cm from the detector. Beam energies of 20.0, 25.0, 30.0, 33.0 and 35.0 MeV were used with ^{4}He gas pressures of 313, 461, 591, 699 and 790 mbar, respectively.

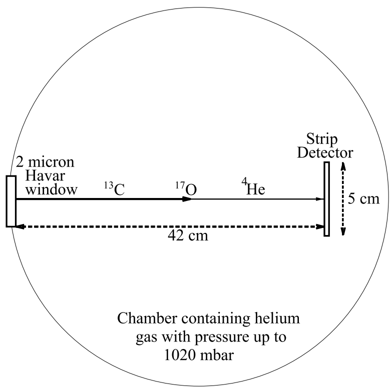

Figure 3. Sketch of the experimental setup.

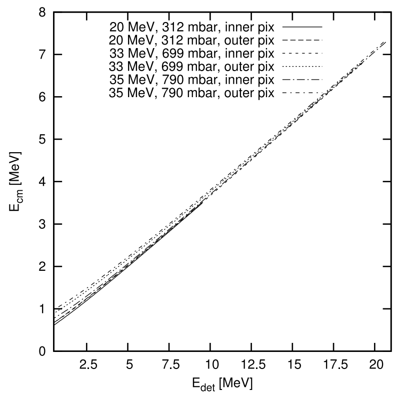

Figure 4. Plots used to calculate centre-of-mass energy from the detected energy.

In this way for every incident beam energy we covered continuous range of centre-of-mass energies in the gas. Scattering and reactions occurred along the entire beam path in the gas. Due to a smaller stopping power of ^{4}He than ^{13}C ions in the gas, we were able to detect the outgoing ^{4}He ions for all the depths of the interaction in a gas.

3. Data analysis

The data analysis was performed event-by-event, assuming that all detected events were ^{4}He ions from the elastic scattering. The analysis is similar to one described in [3].

The measured energy was related to the centre-of-mass energy using kinematics and energy loss calculations [4]. In order to take into account appropriate kinematics and energy loss for the events originating close to the detector (low centre-of-mass energy), the detector was divided into 28 rings of pixels (Fig. 4). For each ring the calculated points were interpolated with polynomials. Interpolations were used to calculate raw yield versus centre-of-mass energy.

The next step in our analysis was to correct the data for the detector efficiency. The detection efficiency depends on: *i)* the solid angle of the detector, *ii)* the energy loss of the scattered ^{4}He ions and *iii)* the centre-of-mass decay angular distribution, assumed to be isotropic.

A Monte Carlo simulation, taking into account the three aforementioned contributions, was used to calculate the efficiency correction factors.

Efficiency corrected yields from all runs are displayed in Fig. 5. All runs give consistent yield without significant contributions from inelastic processes.

All spectra in the Fig. 5 were averaged and the efficiency corrected averaged yield was obtained (Fig. 6).

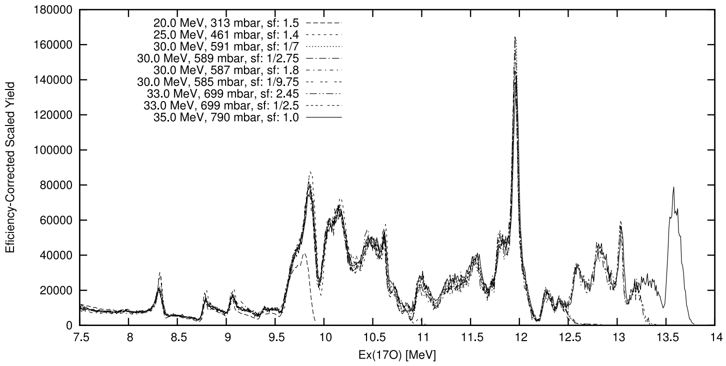

Figure 5. Monte-Carlo efficiency-corrected yields for all runs (sf is the scaling factor).

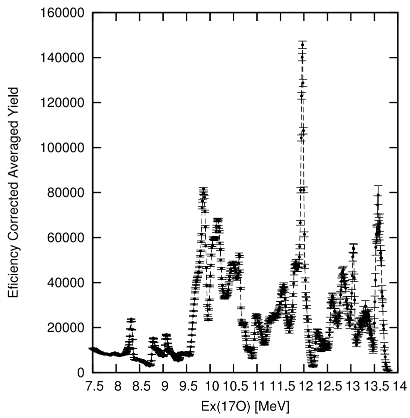

Figure 6. Averaged Monte-Carlo efficiency-corrected yield.

The averaged yield corresponds well to other elastic scattering data measured at similar angles [5].

In our experiment we had no means for the beam current measurement. In order to convert the Monte Carlo-corrected averaged yield to the cross-section, we will try to fit the low-energy part to the elastic scattering cross section.

The R-matrix analysis, which is in progress, has to contain many levels and, apart from the elastic channel, at least three other channels [5]. The starting point for our fit are the energy level parameters published in [5].

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