The ^{7}Be + ^{12}C reaction to study the ^{15}O nucleus

K. Kundalia[1],* D. Gupta[1],† Sk M. Ali[1], S. Maity[1], Swapan K Saha[1],‡
O. Tengblad[2], J.D. Ovejas[2], A. Perea[2], I. Martel[3], J. Cederkall[4], and J. Park[4§]
[1]*Department of Physics, Bose Institute,*
93/1 APC Road, Kolkata 700009, India
[2]*Instituto de Estructura de la Materia – CSIC,*
Serrano 113 bis, ES-28006 Madrid, Spain
[3]*University of Huelva, Avenida Fuerzas Armadas sin*
numero Campus "El Carmen", 21007, Huelva, Spain and
[4]*Department of Physics, Lund University, Box 118, SE-221 00 Lund, Sweden*

Introduction

The study on the modifications of single-particle orbitals away from the line of stability draws significant attention [1]. In particular, there is a well known level inversion of $0d_{5/2}$ and $1s_{1/2}$ in case of ^{15}C [2]. Primarily, the neutron-rich nuclei of $A = 15$ isobars were studied [2–4], as compared to the proton-rich counterparts [1, 5–7]. The present work focuses on the proton-rich nucleus ^{15}O. It is a radioactive nucleus with a half life of $\sim$ 122s [8] and forms the core of the borromean nucleus ^{17}Ne [1]. It has important astrophysical significance. The ground state ($1/2^-$) and the 6.79 MeV ($3/2^+$) subthreshold state of ^{15}O play important roles in determining the rate of the ^{14}N(p,γ)^{15}O reaction [9]. This reaction is one of the most important reactions in the CNO cycle [9–11]. Being the slowest reaction in the cycle, it regulates the rate of energy generation in stars [9–11]. The present study involves the ^{12}C(^{7}Be,α)^{15}O* transfer reaction, using a ^{7}Be radioactive beam. The ^{7}Be nucleus has a $\alpha-^{3}$He cluster structure [12] and is expected to have significant transfer and breakup channels. It has been found earlier that ^{7}Be-induced alpha-transfer reactions are more predominant as compared to breakup [13, 14]. Thus, the present transfer reaction is suitable for the study of the ^{15}O nucleus.

Experiment

The experiment was carried out at the HIE-ISOLDE radioactive ion beam facility of CERN. A 5 MeV/u ^{7}Be beam was used, impinging on a 15 μm thick CD_2 target. The average beam intensity was around 5×10^5 pps. The scattering chamber at the third beamline of HIE-ISOLDE was used. The detectors consist of an array of $\Delta E - E$ telescopes in the angular range of $40^\circ - 80^\circ$ and $127^\circ - 165^\circ$. An annular E detector covered the forward angles $8^\circ - 25^\circ$. A detailed description of the experimental setup can be obtained from Ref. [14, 15].

Results and Discussion

The Monte Carlo simulations for the present experiment were carried out using NPTool [16]. The plot of energy (E) vs scattering angle (θ) from simulations are shown in Fig. 1, for the ground state, 5.24 and 6.79 MeV excited states of ^{15}O. The inset in the figure also shows the angular ranges of the α-particles and ^{15}O from the reaction. The maximum angle of ^{15}O is about 50°. The excitation energy spectrum from the experimental data is shown in Fig. 2. The ground state is clearly separated as opposed to the excited states. The peak around 6 MeV include contributions from the 5.24 and 6.79 MeV excited states. Further work

*Electronic address: kkabita@jcbose.ac.in
†Electronic address: dhruba@jcbose.ac.in
‡Former faculty
§Present Address: Center for Exotic Nuclear Studies, Institute for Basic Science, 34126 Daejeon, South Korea

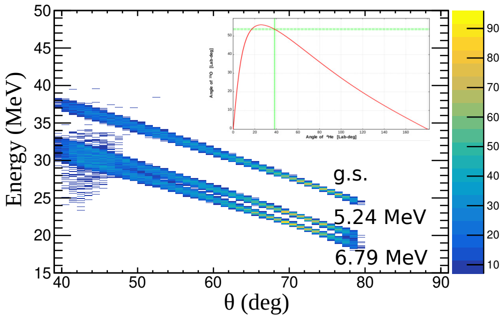

FIG. 1: The NPTool simulations of energy (E) vs scattering angle (θ) of α-particles from ^{12}C(^{7}Be,α)^{15}O* transfer reaction at 5 MeV/u. The inset shows the angular ranges of α and ^{15}O from the above reaction.

is in progress to extract the contribution of the excited states and generate an angular distribution. Relevant DWBA calculations would be carried out using FRESCO [17].

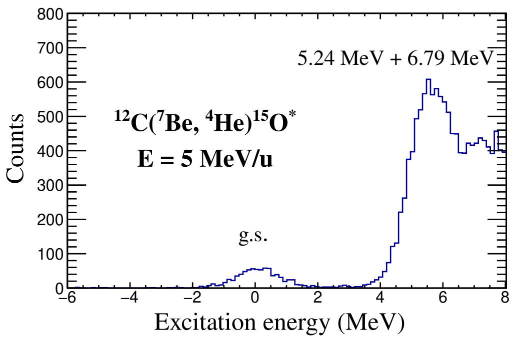

FIG. 2: Excitation energy spectrum of ^{15}O.

Acknowledgements

The authors thank the ISOLDE engineers in charge, RILIS team and Target Group at CERN for their support. D. Gupta acknowledges research funding from the European Union's Horizon 2020 research and innovation programme under grant agreement no. 654002 (ENSAR2) and ISRO, Govt. of India under grant no. ISRO/RES/2/378/15−16.

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