Probing Hoyle analogue state in ^{16}O

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Introduction

After the discovery of Hoyle state of ^{12}C plenty of researches have been devoted to decipher its structure and the α-cluster nature of this state is now well established, though there are ambiguities regarding the arrangements of α's whether it is linear chain like or Bose condensate like or something else [1,2]. It was predicted hypothetically that similar state can be found in ^{16}O near its threshold for break up to 4α's i.e. 14.44 MeV, by Ikeda et al. long back in 1968[3]. Recently from microscopic calculations it was proposed that the analogue to the Hoyle state exist as the 0_6^+ state, possible candidate being the 15.1 MeV state in ^{16}O [4]. The identification of this state and extraction of its structure is still an open problem.

Experimental details

The experiment has been performed with 60 MeV alpha beam from K130 cyclotron, VECC, Kolkata on Mylar ($C_{10}H_8O_4$) and ^{12}C target.

Pic. 1 Experimental set up

Two Si-strip telescopes, each consisting of ΔE, 50μm single sided silicon strip detector (SSSD, 16 vertical strips, each of area 0.3cm X 5cm) and E, 1mm double sided silicon strip detector (DSSD, 16 strips per side, front: made up of vertical strips and back: horizontal strips), were used at one side and two Si-strip E, 1mm (DSSD) detectors were used on the other side of the beam direction to detect the break up particles of ^{16}O (^{12}C) and inelastic alpha in coincidence. Both the telescopes as well as two single detectors were placed at a distance approximately 8 cm from the target. The data were taken with a condition that at least two strips fire out of 64 strips (16 vertical strips in each DSSD, total of 64 strips in four detectors) of all four detectors.

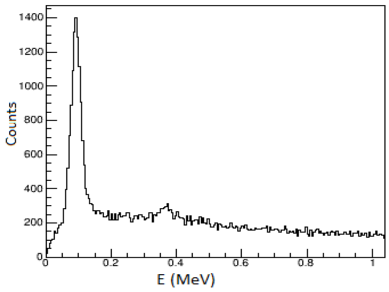

Fig. 1 Decay energy of ^{8}Be

Analysis and results

The excitation function of ^{16}O around the 4α break-up threshold and the decay mechanism of the resonance states have been studied. During offline analysis, we selected the events with 4 hits in the single detector side and reconstructed them to obtain the excitation function of ^{16}O. It was assumed that each hit corresponded to an α particle and the momentum of each particle was deduced from the recorded energy and position. We wanted to examine the states of ^{16}O decaying through ^{8}Be + ^{8}Be, ^{12}C (7.65 MeV, 0^+) + α, and

^{12}C (9.64 MeV, 3^-) + α channels. So excitation function for different decay channels were reconstructed accordingly using energy and momentum conservation. Fig.1 shows the decay energy of the ^{8}Be reconstructed from two hits. A peak is seen at an energy equal to the Q value of the α decay (= 92 keV) of the ^{8}Be ground state.

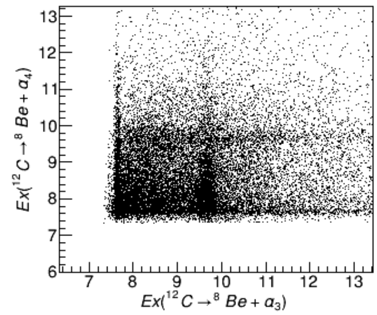

Fig. 2 Excitation function of ^{12}C (^{8}Be$_{g.s.}$ + α)

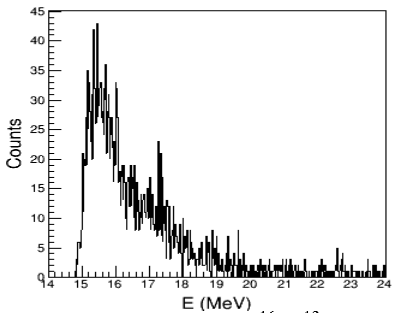

Fig. 3(a) Excitation energy of ^{16}O(^{12}C(7.65)+α)

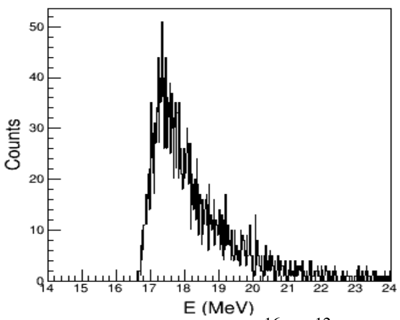

Fig. 3(b) Excitation energy of ^{16}O (^{12}C(9.64)+ α)

Decay through ^{12}C (7.65) and ^{12}C (9.64) states:
We selected those events for which at least one pair of hits (say $\alpha_1$and α_2) reconstruct to ^{8}Be$_{g.s.}$. and then combined it with each of the other two hits (mentioned as α_3 and α_4) to reconstruct ^{12}C excitation. The two excitation energies obtained this way are plotted against each other as shown in Fig. 2. Two strong vertical and horizontal loci seen in this plot correspond to the 7.65 MeV and 9.64 MeV states of ^{12}C. The excitation function of ^{16}O was reconstructed from the events under 7.65 MeV and 9.64 MeV states of ^{12}C as shown in Fig. 3(a) and 3(b) respectively.

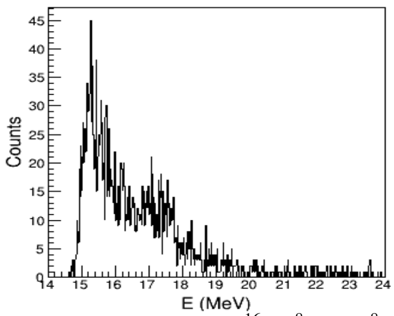

Fig. 4 Excitation function of ^{16}O (^{8}Be$_{g.s.}$+^{8}Be$_{g.s.}$)

Decay through ^{8}Be (g.s.) + ^{8}Be (g.s.):
For this decay channel we must have events for which out of four hits any two pair of hits reconstruct to ^{8}Be$_{g.s.}$. These events are then reconstructed to get ^{16}O excitation function (Fig. 4).

Conclusion

Hoyle analogue state in ^{16}O was probed through inelastic scattering of α on mylar. Preliminary results show a broad peak-like structure around 15.1 MeV (as predicted by the theoretical calculation) for ^{16}O decaying through ^{12}C(7.65MeV)+α and ^{8}Be$_{g.s.}$ + ^{8}Be$_{g.s.}$ channels. The broadness of the peak may be due to the background coming from carbon and population of multiple states in this region. Further analysis is in progress.

References

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