Investigation of ^{3}H capture in ^{7}Li + ^{50}Ti reaction

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Introduction

Reactions involving weakly bound stable nuclei like ^{6,7}Li and ^{9}Be remain an interesting subject in low energy nuclear reaction [1]. In particular, these reactions can produce some of the slightly neutron rich nuclei. The other interest is the reaction dynamics study involving these weakly bound nuclei which can be carried out by comparing the predictions of nuclear reaction models with the experimental cross section measurements. In particular, the presence of $t + \alpha$ cluster structure of ^{7}Li ground state leads to breakup, transfer-breakup, incomplete fusion and cluster transfer channels. The particle-gamma coincidence technique is a powerful tool to study the various reaction mechanisms in this type of reactions[2,3]. Detection of t or α as ejectile in the outgoing channel following the ^{7}Li induced reaction with ^{50}Ti target along with the discrete gamma-rays provide wealth of information about the dynamics. Measurement of the ejectile energies are found to be another controlling parameter for distinguishing various reactions mechanisms. Recently, the population of ^{54}Cr following α-transfer in the ^{7}Li + ^{50}Ti reaction has been studied. Here, we report the population of ^{53}V following the t-transfer in the same reaction.

Possible Reaction channels of ^{7}Li + ^{50}Ti

One of the strongest channels is the complete fusion-evaporation reaction (CF), which exhibits a large cross-section at above-barrier energies. In a complete fusion reaction, the resulting compound nucleus (in our experiment ^{7}Li + ^{50}Ti $\longrightarrow$ ^{57}Mn) is typically highly excited; so it decays and gives various types of residual nuclei. From the yields calculated from PACE4 we can conclude that ^{53} V is not produced by complete fusion channel (its percentage is below 1 percent). Another possibility is breakup fusion, in which ^{7}Li breaks up into triton and α particles, and then one of these fragments fuses with ^{50}Ti, leading to excited states of ^{54}Cr or ^{53}V. The ^{54}Cr nucleus can de-excite to $^{51-53}$Cr through xn-evaporation, as well as to $^{51-53}$V via pxn channels. Similarly, ^{53}V can de-excite to $^{49-52}$V through xn-evaporation, as well as to $^{49-51}$Ti via pxn channels. Lastly, the transfer reaction which occurs when ^{7}Li is in close proximity to ^{50}Ti during scattering, resulting in wavefunction overlap between these nuclei. This overlap facilitates the transfer of nucleons, leading to the formation of either ^{54}Cr or ^{53}V. The remaining triton or alpha particle is then emitted.

Experimental Details

The ^{7}Li + ^{50}Ti reaction, with a 20 MeV ^{7}Li beam (beam current 4 nA) was performed at 14UD Pelletron Linac Facility at TIFR in Mumbai, India. A self-supporting ^{50}Ti target (with enrichment $\approx$ 83%) was used. Seventeen Compton-suppressed clover HPGe detectors were positioned at various angles relative to the beam direction: three at 40°, 115°, 140°, and 157° each, one at 65°, and four at

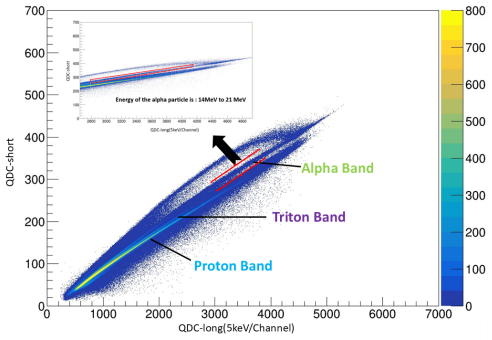

FIG. 1: A two-dimensional spectrum of QDC-short vs QDC-long for CsI(Tl) detectors

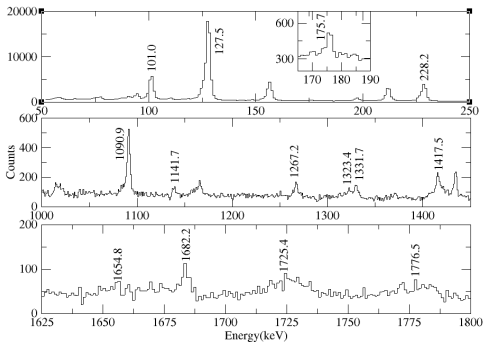

FIG. 2: α-gated γ-spectrum showing most of the known transitions below 1800 keV of ^{53}V as reported in NNDC level scheme.

90° to detect the deexciting γ rays from the present reaction. Ten CsI(Tl) detectors each having dimensions of $1.5 \times 1.5 \times 0.3$ cm^3 were installed inside the target chamber at a distance of 4 cm from the target center of the INGA setup to detect the outgoing charged particles. Among them, four were centered at $\theta = 34°$, five at 56°, and one at 78°.

Experimental Results

The particle-γ coincident data were sorted into a ntuple for further analysis. For the time coincident events, the QDC-short, QDC-long values for CsI(Tl) detectors and the energy of the HPGe clover detectors were recorded in the ntuple. From this ntuple, a 2-D spectrum of QDC-short vs QDC-long for CsI(Tl) detector was extracted (shown in fig 1). We could identify each band separately for different types of particles as shown in the same figure. In our previous work [2] triton band was gated and ^{54}Cr which is coming from fusion with the α-particle was studied. Currently the spectrum is gated in the α-band using ROOT so that we can get the γ-spectrum of ^{53}V. In ROOT each 1-D spectra (which is basically generated after giving gate) coming from different module have been added. The merged α-gated γ-spectrum is shown in fig 2.

Conclusion

An overview of various reaction products of ^{7}Li induced reaction of ^{50}Ti target is presented. The potential of particle-γ coincidence technique to identify different reaction products from this experiment has been discussed in the present work. The configuration of the experimental setup has been described. The measured γ-ray spectrum in coincidence with the α-particle, showed most of known γ-ray transitions from neutron rich ^{53}V isotope which is reported in NNDC level scheme. More work is in progress to identify the different excited states of ^{53}V and the presence of other isotopes in the data.

Acknowledgments

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