Spectroscopy of ^{128}Te using fusion-fission ^{238}U(^{32}S,f) reaction

L. S. Danu[1],* D. C. Biswas[1], S. Mukhopadhyay[1], B. K. Nayak[1], B. V. John[1], Y. K. Gupta[1], B. N. Joshi[1], G. Prajapati[1], A. Goswami[2], P. K. Joshi[3], S. K. Tandel[4], R. Palit[5], S. Saha[5], J. Sethi[5], R. G. Pillay[5], V. Nanal[5], P. V. Madhusudhana Rao[6], Naveen Kumar[7], and U. Garg[8]

[1]*Nuclear Physics Division, Bhabha Atomic Research Centre, Mumbai - 400085, INDIA*
[2]*Radiochemistry Division, Bhabha Atomic Research Centre, Mumbai 400085, India*
[3]*Homi Bhabha Centre for Science Education, TIFR, Mumbai 400085, India*
[4]*UM-DAE Centre for Excellence in Basic Sciences, Mumbai - 400098, India*
[5]*Department of Nuclear and Atomic Physics, TIFR, Mumbai 400005, India*
[6]*Department of Nuclear Physics, Andhra University, Visakhapatnam 530003, India*
[7]*Department of Physics, Delhi University, Delhi 110007, India and*
[8]*Physics Department, University of Notre Dame, Notre Dame, Indiana 46556, USA*

Introduction

While the doubly magic ^{132}Sn and the nuclei close to this core nucleus clearly exhibit shell-model structures, the nuclei in the transitional region Z$\geq$ 50 and N$\leq$ 82 show a large variety of collective structures. For the even-even $^{114-130}$Te isotopes, the ratio E_{4^+}/E_{2^+} ranges between 1.94 and 2.09, very near to the harmonic vibrational value. The high-spin states of ^{A}Te nuclei with $A \leq 124$ have been studied by fusion-evaporation reactions induced by heavy-ions. On the other hand the spectroscopy of $^{132-138}$Te nuclei have been carried out from the spontanous fission (SF) of ^{248}Cm and ^{252}Cf. However, the high-spin states of $^{126-130}$Te isotopes have not been studied in detail, because of the lack of suitable stable projectile-target combinations and very small yield in the SF of ^{248}Cm and ^{252}Cf. Thus, till now, medium-spin states of the $^{126-130}$Te nuclei were only measured by using deep inelastic ^{130}Te+^{64}Ni reaction [1]. The low-spin states of these nuclei have been studied from the decay measurements (EC and/or β-decay of the parent) and ^{A}Te $(n, n'\gamma)$ reactions [2]. The isotope ^{128}Te is one of the handful of nuclides in which double β-decay has been identified, it is therefore of interest to investigate the high spin excitations in this isotope. In the present work, we report the spectroscopic study of ^{128}Te carried out using fusion-fission reaction.

Experimental details

Excited states in ^{128}Te were populated in fusion-fission reaction by bombarding a ^{238}U target (20mg/cm^2 thick) with the ^{32}S beam at energy, E_{lab}=223 MeV. The beam was provided by the BARC-TIFR pelletron-linac facility, Mumbai. The de-exciting γ-rays were detected in the INGA (Indian National Gamma Array) [3], consisting of 21 Compton-suppressed Clover detectors. The data acquisition was carried out using fast DDAQ (digital data acquisition) system based on Pixie-16 modules of XIA LLC [3]. The time-stamped data were recorded both in singles and coincidence mode, the trigger for the latter was obtained from the condition that at least two clover coincidence events occur within a time window of 1 μs. A total of 1 $\times$ 10^9 coincidence events with fold f $\geq$ 3 were obtained in the present experiment.

Data analysis and results

The time-stamped data were sorted using the program MARCOS (Multi-pARameter time-stamp-based COincidence Search). Each of the clover detectors was used in add-back mode, and the add-back data were used to

*Electronic address: lsdanu@barc.gov.in

generate the singles γ-ray spectra, and the coincidence γ-γ matrices and γ-γ-γ cubes. The time window for sorting the prompt γ-ray coincidence events with fold ≥ 2 was set to 200 ns. Further analysis of the coincidence data was carried out using the RADWARE analysis package [4].

A representative double gated spectrum is shown in Fig. 1, where the 743- and 754 keV γ-rays in the ground state band were gated to 636-, 628-, and 654 keV γ-ray transitions.

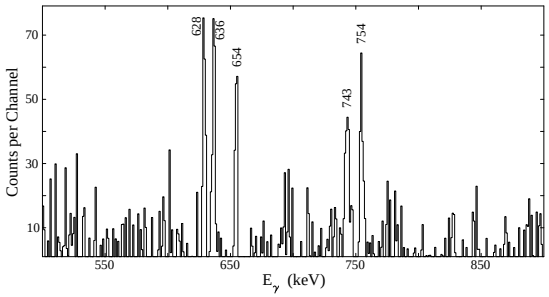

FIG. 1: Representative summed double gated γ-ray coincidence spectrum for ^{128}Te (see text for detail).

On the basis of the analysis of double (γ-γ matrices) and triple (γ-γ-γ cubes) coincidences, three new γ-rays of ^{128}Te with energies 814-, 628-, and 654- keV have been identified in the present work. The level scheme of ^{128}Te (shown in Fig. 2) has been extended by placing these new gamma transitions and three new levels in the existing level scheme [1].

The Directional Correlation of Oriented nuclei (DCO) and polarisation measurements are well established methods for spin parity assignment of the evaporation residue (ER), in the case of heavy-ion induced fusion evaporation reactions. The feasibility of these methods for fission fragments (FF) is being investigated. The spin and parity assignment of the three new levels will be then carried out using DCO ratio and polarisation measurements. Detailed data analysis is in progress.

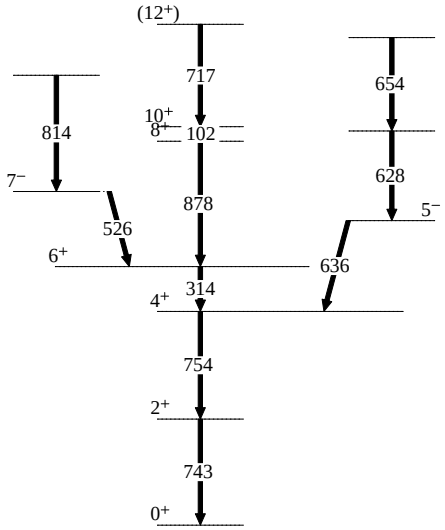

FIG. 2: Partial level scheme of ^{128}Te obtained in this work. The 814-, 628-, and 654- keV γ-rays are new transition.

Acknowledgments

The authors would like to thank L. A. Kinage, A. L. Inkar, R. V Jangle, B. S. Naidu, R. Donthi and S. Jadhav for their support during the experiments. The help and cooperation of Pelletron-Linac staff during the experiment is gratefully acknowledged.

References

[1] C. T. Zhang *et al.*, Nucl. Phys. A **628**, (1998) 386.
[2] S. F. Hicks *et al.*, Phys. Rev. C **86**, (2012) 054308.
[3] R. Palit *et al.*, Nucl. Instrum. Methods A **680**, (2012) 90.
[4] http://radware.phy.ornl.gov/