HALF-LIFE MEASUREMENTS OF EXCITED STATES IN ^{132}Te, ^{134}Xe*

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(Received December 10, 2012)

The ^{7}Li+^{130}Te reaction was used to populate excited states in ^{132}Te and ^{134}Xe. The experiment at the Horia Hulubei National Institute of Physics and Nuclear Engineering, Bucharest, Romania, used an array of high-purity germanium (HPGe) and cerium-doped lanthanum bromide ($LaBr_3$(Ce)) detectors to measure sub-nanosecond half-lives using fast-timing techniques. The half-lives of the yrast 4^+ and 6^+ levels were measured in the $N = 80$ nuclei ^{132}Te and ^{134}Xe, respectively. An upper limit of $T_{1/2} \leq 40$ ps was assigned to the 4^+ level in ^{132}Te and $T_{1/2} = 1075(155)$ ps was assigned to the 6^+ level in ^{134}Xe. The systematics of the $B(E2)$ strengths around the $N = 82$ shell closure are discussed.

DOI:10.5506/APhysPolB.44.403
PACS numbers: 21.10.Re, 21.10.Tg, 23.20.Lv, 27.60.+j

* Presented at the Zakopane Conference on Nuclear Physics “Extremes of the Nuclear Landscape”, Zakopane, Poland, August 27–September 2, 2012.

1. Introduction

The nuclei near the doubly-magic closed shell nucleus ^{132}Sn are of particular interest due to the interplay of single particle and collective degrees of freedom. The energy level systematics of the low-spin states in the $N = 80$ nuclei exhibit an increase as the $Z = 50$ shell closure is approached and all have a long-lived $I^{\pi} = 10^{+}$ isomer based on the $(\nu h_{11/2})^{-2}$ configuration. Prior to this work, the only Te isotopes in which the half-life of the 4^{+} state had been measured were ^{126}Te (2.8(1) ps [1]) and ^{134}Te (1.4(1) ns [2, 3]). Therefore, ^{132}Te has been measured to complete our understanding of the systematics in this region. Similarly, the half-life of the 6^{+} level in ^{134}Xe was also studied in order to understand the trend in the $B(E2; 6^{+} \rightarrow 4^{+})$ systematics across the $N = 80$ isotones.

2. Experimental set-up

A 31.5 MeV ^{7}Li beam delivered by the 9 MV Tandem van der Graaff accelerator at NIPNE, Bucharest impinged on a 1 mg/cm^{2} ^{130}Te target, which was backed with 20 mg/cm^{2} of ^{208}Pb. The energy of the beam (which had an intensity of $\sim 3\,p$nA), was chosen to be close to the Coulomb barrier ($\sim$ 27 MeV) in order to suppress fusion–evaporation reaction channels. Excited levels were populated in ^{132}Te via the ^{130}Te(^{7}Li,$\alpha\, p$) incomplete-fusion transfer reaction, and in ^{134}Xe via the ^{130}Te(^{7}Li,$p2n$) reaction. The γ rays from the de-exciting states were detected by 8 HPGe and 11 LaBr$_3$(Ce) detectors focused on the target position. Gates on transitions feeding and de-exciting the states of interest in the HPGe detectors, were used to produce an E_{γ}–E_{γ}–Δt cube. This was symmetrised so that the two γ-ray energies detected in the LaBr$_3$(Ce) detectors; E_{γ_1} and E_{γ_2}, increment the (E_{γ_1}, E_{γ_2}) and (E_{γ_2}, E_{γ_1}) elements and the time difference between the peaks in the forward and backward time spectra is 2τ [4].

3. Results

3.1. Half-life of the 4^{+} level in ^{132}Te

Excited states up to the $I^{\pi} = 8^{+}$ state in ^{132}Te were populated, and are shown in Fig. 1. The other two low-lying isomeric states at 2723 ($I^{\pi} = 10^{+}$) and 1925 keV ($I^{\pi} = 7^{-}$), were not populated. The $2^{+} \rightarrow 0^{+}$ (974 keV) transition was used as a gate in the HPGe detectors and gates were applied on the $5^{-} \rightarrow 4^{+}$ (383 keV) and $4^{+} \rightarrow 2^{+}$ (697 keV) transitions in the LaBr$_3$(Ce) detectors, to produce the time spectrum in Fig. 1. The 383 keV transition was used as it was more clearly detected than the highly converted [5], yrast 103 keV transition from the 6^{+} isomer. Due to the low statistics in the resulting time spectrum, an upper limit of $T_{1/2} \leq 40$ ps could only be assigned.

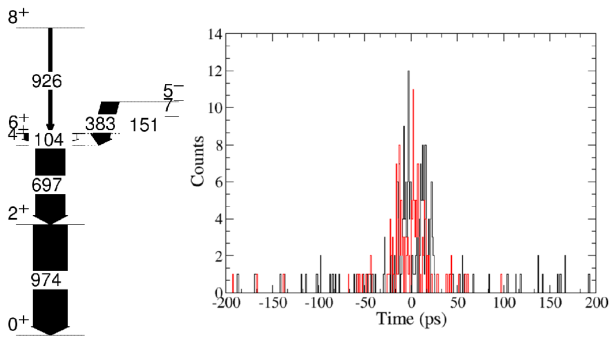

Fig. 1. Left: A partial level scheme for ^{132}Te up to $I^\pi = 8^+$. Right: The forward and backward time spectra for the 383 and 697 keV transitions which show a Gaussian distribution, indicating $T_{1/2} \leq 40$ ps for the 4^+ level in ^{132}Te.

The results from this study were interpreted using shell model calculations, which used a ^{132}Sn core and a $(\pi g_{7/2})^2$ and $(\nu h_{11/2})^{-2}$ configuration in the model space. Theoretical and experimental $B(E2)$ values are shown in Fig. 2 for some of the even-A Te isotopes. For the 4^+ level in $^{132}_{52}$Te$_{80}$, these calculations estimate a $B(E2; 4^+ \to 2^+)$ of 8.16 W.u., which would infer a $T_{1/2}$ of $\sim$ 10 ps. This is in agreement with the measured value of $T_{1/2} \leq 40$ ps.

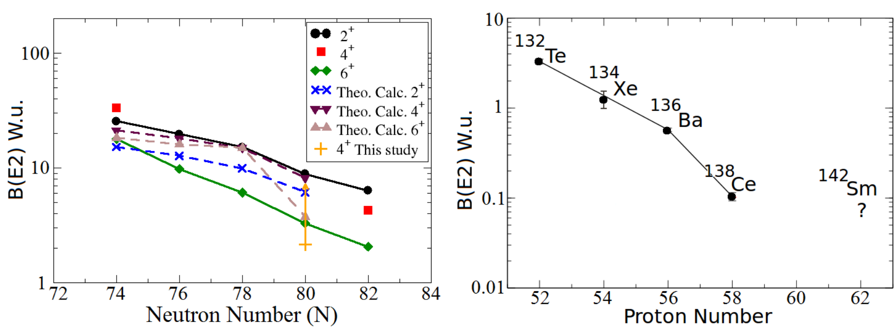

Fig. 2. Left: A comparison of the experimental and theoretical $B(E2)$ values from the 2_1^+, 4_1^+ and 6_1^+ yrast states in some of the even–even $Z = 52$ (Te) isotopes. Right: $B(E2; 6^+ \to 4^+)$ systematics across the $N = 80$ isotones, including the value for the 6^+ in ^{134}Xe measured in this study. The $B(E2; 6^+ \to 4^+)$ value in ^{138}Ce was taken from recent work by Alharbi *et al.* [6].

3.2. Half-life of the 6$^+$ *level in* ^{134}*Xe*

Excited levels up to the tentatively assigned 8^+ were populated in ^{134}Xe as shown in Fig. 3. Gates were made on the $4^+ \to 2^+$ and $2^+ \to 0^+$

transitions (884 and 847 keV, respectively) in the HPGe, and on the $8^+ \to 6^+$ (861 keV) and $6^+ \to 4^+$ (405 keV) transitions in the $LaBr_3$(Ce) detectors. The relative times between these transitions were then projected to give the time spectrum in Fig. 3. Despite the low statistics due to the weak reaction channel, a half-life of 1075(155) ps was obtained by fitting a slope to the exponential tail of the distribution as shown in Fig. 3. This corresponds to a $B(E2; 6^+ \to 4^+)$ of 1.2 ± 0.2 W.u., in good agreement with the downward trend of the $B(E2; 6^+ \to 4^+)$ systematics across the $N = 80$ isotones as shown in Fig. 2.

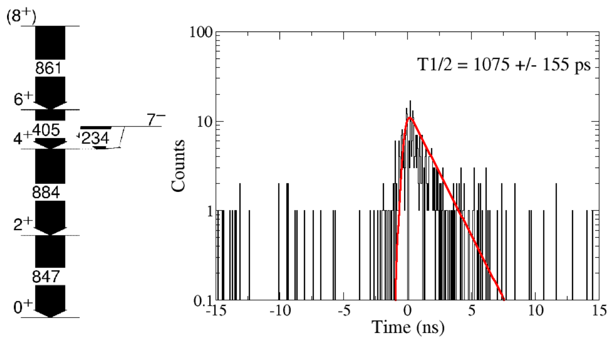

Fig. 3. Left: A partial level scheme for ^{134}Xe. Right: The forward time spectrum of the 6^+ in ^{134}Xe, showing the fit to the exponential tail. It was created using the 861 and 405 keV transitions in the $LaBr_3$(Ce) detectors.

4. Summary and conclusion

A combination of $LaBr_3$(Ce) and HPGe detectors was used to measure the half-life of the 4^+ level in ^{132}Te ($T_{1/2} \leq 40$ ps) and the 6^+ level in ^{134}Xe ($T_{1/2} = 1075(155)$ ps). The latter value corresponds to a value of 1.2 ± 0.2 W.u. for the $B(E2; 6^+ \to 4^+)$, which is in good agreement with the trend of these systematics across the $N = 80$ isotonic region.

REFERENCES

[1] J. Genevey *et al.*, *Nucl. Phys.* **A99**, 507 (1967).

[2] J.P. Omtvedt, *Phys. Rev. Lett.* **75**, 3090 (1995).

[3] K. Kawade *et al.*, *Z. Phys.* **A298**, 187 (1980).

[4] N. Marginean *et al.*, *Eur. Phys. J.* **A46**, 329 (2010).

[5] T. Kibedi *et al.*, *Nucl. Instrum. Methods* **A589**, 202 (2008).

[6] T. Alharbi *et al.*, *J. Phys.: Conf. Ser.* **381**, 012057 (2012).