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Short note

Structure of ^{136}Te and the problem of mass of ^{134}Te

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Abstract. Neutron-rich, N=84 nuclei from the ^{132}Sn region, populated in spontaneous fission of ^{248}Cm, have been studied with EUROGAM 2. Excited states and their spins and parities in the ^{136}Te nucleus were established up to $17\hbar$. OXBASH code calculations support the experimental identification of maximum aligned configurations in ^{136}Te. Empirical shell model calculations for the $I^\pi = 14^+$ level in ^{136}Te indicate that the adopted mass of the ^{134}Te nucleus should be lowered by 200(80) keV.

PACS. 21.60.Cs Shell model – 23.20.Lv Gamma transitions and level energies – 27.80.+w $190 \leq A \leq 219$ – 25.70.-z Low and intermediate energy heavy ion reactions

Nuclear masses are a fundamental input for testing nuclear models. Particularly important are masses of nuclei from the doubly-closed shell regions. Due to their simple structure, these nuclei are especially useful for such tests. The masses of nuclei in the ^{132}Sn region were recently reviewed in a discussion [1] of beta-decay end-point measurements. Shortly afterwards, a serious inconsistency in masses of nuclei in this region was pointed out [2], though not resolved, although the mass of ^{134}Te was suspected to be not correct. This suggestion was rejected in a theoretical work [3] which claimed that the good agreement of calculated and measured excited states in ^{134}Te supports the adopted mass [4] of this nucleus. However, the excitation energy of the $d_{3/2}$ proton level has recently been remeasured [5], and the new result can significantly influence the theoretical calculations. Therefore the problem remains unsolved. In this report we present new experimental evidence concerning this problem and suggest a solution.

The data are from the measurement of prompt γ radiation following spontaneous fission of ^{248}Cm, performed with the EUROGAM 2 array (for more experimental details see Ref. [6]). Using these data the N=84 isotones were studied. In this report we focus on the ^{136}Te nucleus. Other isotones will be discussed in a forthcomming paper [7].

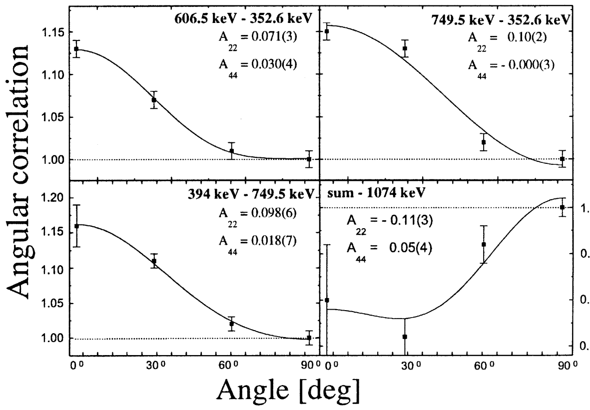

Fig. 1. Examples of angular correlations for gamma transitions in ^{136}Te. Correlation of the 1074 keV line is obtained with a sum of a few strong quadrupole transitions

Yrast excited levels up to 2.8 MeV were known in ^{136}Te prior to this work [8]. We have established the yrast cascade up to 5.6 MeV and were able to assign spins and parities to most of the levels observed using angular correlations and linear polarisation measurements. The quality of the angular correlations is illustrated in Fig. 1. The measured linear polarisations P(γ) obtained

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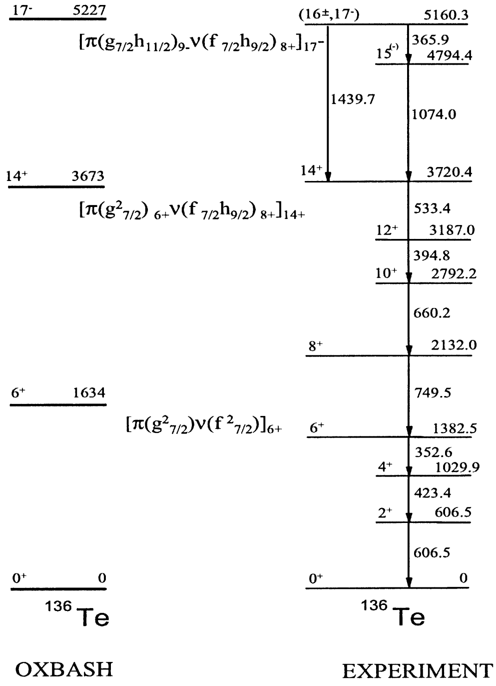

Fig. 2. Partial level scheme of ^{136}Te as obtained in the present work and the OXBASH calculations for ^{136}Te

for certain γ rays are: P(606keV)= +0.12(3), P(423keV)= +0.09(2), P(352keV)= +0.09(3), P(749keV)= +0.09(6) and P(660keV)= +0.19(7).

The resulting partial level scheme of ^{136}Te obtained in this work is shown in the right-hand part of Fig. 2. Identification of levels is further supported by the systematics of levels in even-even, N=84 isotones [7], part of which is shown in Fig. 3.

To gain insight into the level structure of ^{136}Te, we perfomed shell model calculations using the OXBASH code [9]. The results are shown on the left-hand side of Fig. 2. The 14^+ and 17^- excited states, for which the calculated energies agree remarkably well with experiment, are the so called maximum-aligned configurations. A characteristic feature of maximum-aligned configurations is that their structure is often dominated by one configuration only. This allows the shell model reduction technique [13] to be used in a consistency check of the data from ^{136}Te and its neighbours. The 3720.4 keV, 14^+ level in ^{136}Te is interpreted in terms of the maximum-aligned $[\pi(g^2_{7/2}\nu(f_{7/2}h_{9/2}]_{14^+}$ configuration. The excitation energy of this state can be calculated in the following way:

$$\begin{aligned} E(14^+;^{136}\mathrm{Te}) = {} & E(\frac{19}{2}^-;^{135}\mathrm{Te}) + E(\frac{21}{2}^-;^{135}\mathrm{Te}) \qquad (1)\\ & +E(8^+;^{134}\mathrm{Sn}) - E(\frac{7}{2}^-;^{133}\mathrm{Sn}) \\ & -E(6^+;^{134}\mathrm{Te}) - E(\frac{9}{2}^-;^{133}\mathrm{Sn}) + W \end{aligned}$$

where W is the mass window composed of ground state masses of nuclides which appear in equation (1) and the mass of the ^{132}Sn core nucleus:

$$\begin{aligned} W = {} & M(^{132}\mathrm{Sn}) + 2M(^{135}\mathrm{Te}) + M(^{134}\mathrm{Sn}) - 2M(^{133}\mathrm{Sn}) \\ & -M(^{134}\mathrm{Te}) - M(^{136}\mathrm{Te}) \qquad (2) \end{aligned}$$

This calculation predicts that the excitation energy of the 14^+ state is 3293(208) keV. The error in this value results from errors in the masses in the mass window. The discrepancy between calculated and measured values is rather large. It appears that the value of mass window is 430(208) keV *toolow*. This result questions the nuclear masses which appear in (2), if one assumes that the identification of excited levels in (1) is correct.

An analogous discrepancy has been noted in [2]. There, the mass window was expressed as:

$$W = M(^{132}\mathrm{Sn}) + 3M(^{134}\mathrm{Te}) - 3M(^{133}\mathrm{Sb}) - M(^{136}\mathrm{I}) \quad (3)$$

and was 490(150) keV *toohigh*. We note that only the mass of the ^{134}Te nucleus contributes to both mass windows with *thesame* sign as the observed discrepancy. It is therefore probable that the mass of ^{134}Te is lower than the adopted value [4]. The results of this work suggest that the correction to the mass of ^{134}Te is -430(208) keV, and the results of ref. [2] suggest that it is -163(88) keV. The weighted average of -200(80) keV represents the proposed correction to the accepted mass of ^{134}Te.

While preparing this report, we learned that in a new mass measurement for the A=134 chain [14] the mass of ^{134}Te has been changed by an amount close to our correction.

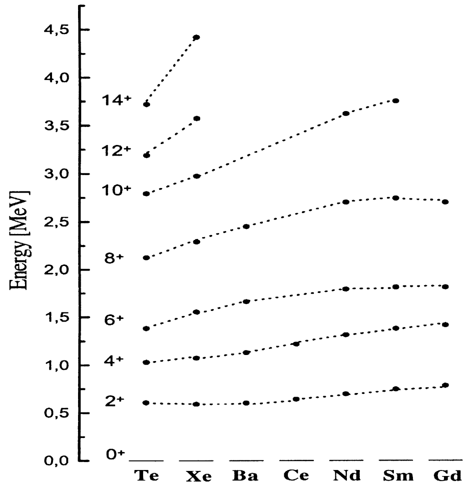

Fig. 3. Systematics of levels in the N=84 isotones. Data are from this work and [7,10–12]

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