Eur. Phys. J. A **4**, 9–10 (1999)

THE EUROPEAN PHYSICAL JOURNAL A
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Short note

A new high-spin isomer in ^{145}Sm

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Received: 23 October 1998
Communicated by B. Povh

Abstract. A new high-spin isomer in ^{145}Sm was observed by in-beam γ-ray spectroscopy with the reaction ^{122}Sn(^{27}Al,3np) at 127 MeV performed at the NORDBALL multi-detector array in Roskilde. The excitation energy of the isomer was determined to be $E_x = 11147$ keV, and using the generalized centroid-shift method its half-life was found to be $T_{1/2} = (7.4 \pm 1.0)$ ns.

PACS. 21.10.Tg Lifetimes – 25.70.Gh Compound nucleus – 27.60.+j $90 \leq A \leq 149$

In the late seventies, Døssing et al. predicted the existence of yrast isomers in the $A \approx 150$ region [1], and experiments provided first data on excitation energies and half-lives of such isomers. Later on, the accompanying decay schemes were reported. The most prominent of these isomers were observed in $N = 83$ isotones at excitation energies of 8–9 MeV with half-lives of 0.01–1 μs, but isomers at higher energies were also reported, e.g. in ^{149}Tb [2] and ^{151}Er [3]. Recently, Odahara et al. extended the level scheme of ^{145}Sm to the part above the μs isomer [4,5], which made the search for ns isomers at very high spins possible for this nucleus.

In the ^{122}Sn(^{27}Al,3np) reaction, the nucleus ^{145}Sm was produced at a beam energy of 127 MeV at the Niels Bohr Institute's Tandem Accelerator Laboratory in Roskilde. The target consisted of a 1.5 mg/cm^2 tin foil enriched to 95.8% on a 10 mg/cm^2 ^{181}Ta backing. A total of 6.8×10^8 γ–γ-coincidence events were registered with the NORDBALL detector array. The 60-segment BaF_2 inner ball of this spectrometer, surrounded by 20 HPGe detectors, supplies a precise time reference signal given by the BaF_2 element firing first. For any γ–γ-coincidence event, time differences between this reference and the Ge signals were recorded.

The off-line analysis of time-related γ-ray spectra provided evidence for the delay of a 1195 keV line (Fig. 1), that was observed in our data. Setting a gate on this transition in our γ–γ-coincidence matrix revealed a clean spectrum. The observed lines in this spectrum unambigously assign the 1195 keV transition to the ^{145}Sm high-spin level scheme, which lies above the μs isomer at 8786 keV excitation energyas reported by Odahara et al. [5]. A second transition (1188 keV) belonging to this part of the ^{145}Sm level scheme turned out to be prompt and therefore provided evidence for a new high-spin isomer in the ns range.

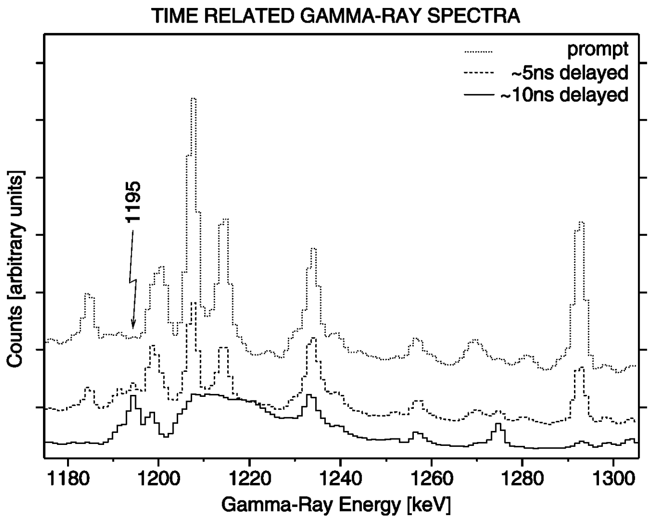

Fig. 1. Cut outs of a prompt and two delayed spectra. The line at 1195 keV becomes more intense for more delayed times of detection. Other delayed lines originate from known isomers

In order to separate the required data from other exit channels well, we sorted three gated energy-time matrices with gates at 270, 1188, and 1195 keV, containing 9.5×10^5, 1.3×10^5, and 1.4×10^5 events, respectively.

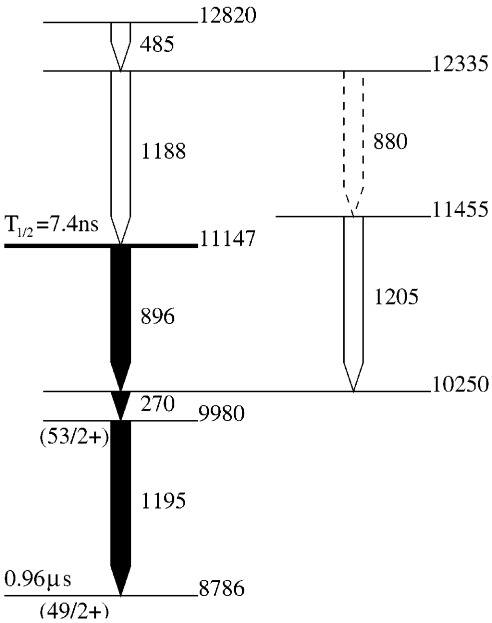

Fig. 2. Partial high-spin level scheme of ^{145}Sm observed in this work. The dashed arrow denotes the transition that could not be examined due to contaminations and low statistics

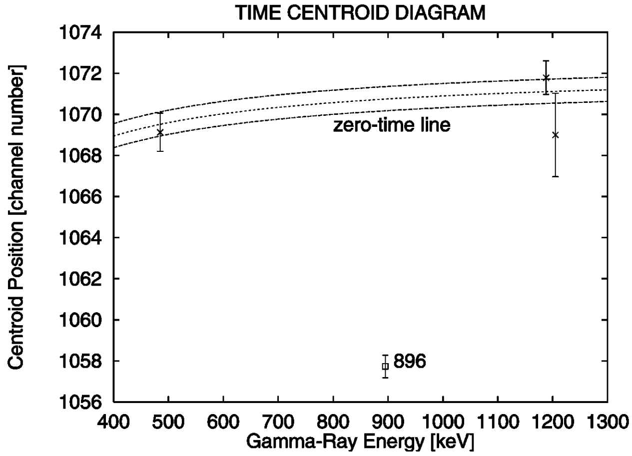

Fig. 3. Centroid positions of the time distributions for ^{144}Sm transitions above 10 MeV excitation energy. Crosses (×) denote positions belonging to prompt transitions, which give the zero-time line, and a quad (□) denotes the delayed one deexciting the isomeric level

For the γ-ray transitions of interest, cuts on the energy axis of our gated matrices were made, and the resulting background-subtracted time spectra were analysed by means of the generalized centroid-shift method [6]. With the use of the E_γ–E_γ coincidence matrix we constructed a partial level scheme (Fig. 2), which confirms the corresponding part of the ^{145}Sm level scheme by Odahara et al. [5]. The time centroids obtained from our energy-time matrices revealed the following results (Fig. 3).

Above an excitation energy of 11147 keV the 1188 and 485 keV transitions turned out to be prompt. In addition, the 1205 keV transition is prompt, so that these three transition gave the zero-time line. On the other hand, the cascade of the 896, 270, and 1195 keV transitions turned out to be delayed.

For a quantitative analysis of each centroid shift, we had to find its relationship to a corresponding half-life $T_{1/2}$. For that reason, we created a time-calibration by making use of well-known low-spin isomers belonging to by-products of our reaction (see [7] for details). Finally, the shift observed for the 896 keV transition, which is directly below the prompt one of 1188 keV, gave a half-life of

$$T_{1/2}(11147 \text{ keV}) = (7.4 \pm 1.0) \text{ ns}.$$

Unfortunately, there is no spin assignment available for the isomeric level, but its spin should be in the range from $J = 57/2$ to $61/2$. So Odahara et al. had proposed a value of (57/2) in their earlier work [4]. Very likely, the configuration of this isomer involves multiple quasiproton × quasineutron excitations, what is typical for this mass region. Such isomers are known to coincide with an onset of sizable oblate shape towards higher spins. In this spin range, a 4 ns isomer is known in ^{149}Tb with a spin-parity of $J^\pi = 61/2^+$ [2].

Considering possible multipolarities for the depopulation of the new isomer, the 896 keV transition strength in W.u. would be: 4.1×10^{-6} ($M1$), 4.6×10^{-8} ($E1$), 3.0×10^{-3} ($E2$), and 0.26 ($M2$). Apparently, only for multipolarity $M2$ the transition strength is in the normal range of non-hindered transitions [8]. Thus, we can only exclude M2 character. In the case of another multipolarity of the 896 keV transition, the isomeric character points at specific structural properties of the 11147 keV level, e.g. shape isomerism cannot be excluded.

Therefore, a further investigation of the level structure around the isomer, in particular of spins and parities, is of high interest.

The authors from Cologne are grateful to all the members of the NBI for their kind hospitality. W. A. wishes to thank the Bulgarian NRF for support (contract no. PH511). This work was partially supported by the BMBF under project number 06 OK 862 I(0) and the Danish Natural Science Research Council.

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