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Short note

New excitation scheme of ^{139}Cs

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Abstract. Excited levels in ^{139}Cs, populated in spontaneous fission of ^{248}Cm, have been studied by means of prompt gamma spectroscopy, using the EUROGAMM 2 array. New level scheme of ^{139}Cs, different from the one proposed recently, has been established. To confirm the new scheme, additional study of ^{139}Cs has been performed, where γ-rays following β-decay of ^{139}Xe to ^{139}Cs have been measured at the mass separator OSIRIS.

PACS. 23.20.Lv Gamma transitions and level energies – 21.60.Cs Shell model – 25.85.Ca Spontaneous fission – 27.60.+j $90 \leq A \leq 149$

The structure of nuclei surrounding the double-magic ^{132}Sn nucleus provides an important test ground for the shell model. In particular such data can help to find how far extends the region around the ^{132}Sn core, where the shell-model descriptions still apply. Therefore we have undertaken systematic investigation of the the N=84 isotones, from the semi-magic ^{134}Sn towards higher Z. An additional motivation for the present study of ^{139}Cs was a recent work [1], where a medium-spin excitation scheme of this nucleus was proposed. These results do not agree with the systematics based on our previous studies of the odd-N Cs isotopes and our current investigations of the odd-Z, N=84 isotones next to ^{139}Cs.

The systematics of excited levels in these nuclei is shown in Fig. 1. In Fig. 1a, filled circles represent excited levels in the odd-N cesium isotopes [2] and squares represent levels in the odd-Z, N=84 isotones [3]. The open circle represents the 218.6 keV excited level in ^{139}Cs, found in the β-decay study [4], where it was assigned spin and parity $I^{\pi}=5/2^{+}$. Gating on this line the authors of [1] constructed a level scheme of ^{139}Cs, where the the 218.6 keV levels is the first member of the yrast cascade, populated in fission of ^{252}Cf. This implies spin and parity $I^{\pi}=11/2^{+}$ for this level, since the ground state of ^{139}Cs has spin $I^{\pi}=7/2^{+}$ [4]. The systematics shown in Fig. 1a strongly suggests however, that the 218.6 keV level has spin and parity $I^{\pi}=5/2^{+}$, as has been proposed in the β-decay study [4]. For the $11/2^{+}$ yrast level in ^{139}Cs and its decoupled partner $9/2^{+}$, an excitation energy between 400 keV and 600 keV is expected. In Fig. 1b, filled circles represent the $11/2^{+}$ excitations in the discussed odd-Z nuclei (vertical scale) shown versus energies of the 2_1^{+} excitations in their even-Z cores (horizontal scale). The open circle corresponds to the the 218.6 keV level in ^{139}Cs. Again, the systematics suggests that the 218.6 keV level does not correspond to the the $11/2^{+}$, yrast excitation in ^{139}Cs.

In this Note we report on the new yrast structure of ^{139}Cs obtained from our data. The new $11/2^{+}$ excitation is represented by a filled diamond in Fig. 1b.

We used high-fold coincidences between prompt γ-rays following spontaneous fission of ^{248}Cm to search for yrast transitions in ^{139}Cs. The measurement has been performed with the EUROGAM 2 array of anti-Compton spectrometers at Strasbourg (for more experimental details see [5]). Fig. 2 shows the key γ spectra obtained by double gating on our $\gamma\gamma\gamma$ coincidence data.

The yrast cascade in ^{139}Cs proposed in [1] consisted of the 218.6, 408.6, 618.4, 387.5 and 503.0 keV transitions. A spectrum, double-gated on the 408.6 keV and 218.6 keV lines, displayed at the top of Fig. 2, shows the 387.5 keV,

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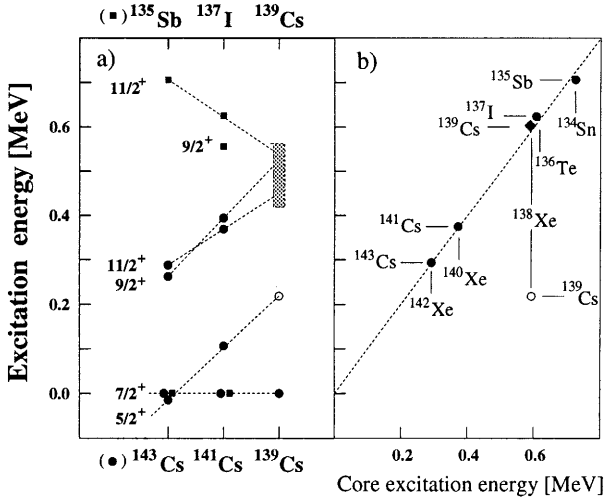

Fig. 1. Excitation energies of levels in odd-A Cs isotopes and odd-Z, N=84 isotones shown a) as a function of N (filled circles) and Z (filled squares) and b) as a function of the 2_1^+ energy in a corresponding core (here only $11/2^+$ levels in odd-A nuclei are displayed). Shaded area in a) represents expected excitation energies of the $9/2^+$ and $11/2^+$ levels ^{139}Cs. Open circles in a) and b) represent the 218 keV level in ^{139}Cs. Dashed lines in a) and b) are drawn to guide the eye.

618.4 keV and 503.0 keV transitions from this cascade as well as the 127 keV, 159 keV and 162.5 keV lines from the fission partner nuclei ^{103}Nb and ^{105}Nb [6]. There is also the 218.1 keV line, corresponding to a transition in ^{103}Nb [6]. Here we notice the first problem, since the most pronounced fission partners to ^{139}Cs should be ^{105}Nb and ^{107}Nb nuclei, corresponding to the emission of 4 and 2 neutrons, respectively. Observation of lines in ^{103}Nb and ^{105}Nb nuclei suggests therefore that the discussed cascade of cesium lines, belongs to a heavier cesium isotope. The second problem is the presence of a strong line at 96.9 keV. A double gate set on the 96.9 keV line and the 127 keV double line from ^{103,105}Nb is shown in the second pannel of Fig. 2. Apart from the discussed 218.6-408.6-618.4-387.5-503.0 keV cascade, lines at 205.6 keV, 404.7 keV and 544.9 keV are seen in this spectrum. These lines have been assigned to ^{142}Cs isotope in [1], where at the bottom of the level scheme the 97.3 keV transition was placed. Therefor we suggest that the cascade of cesium lines, interpreted as the yrast sequence of ^{139}Cs, forms another band in ^{142}Cs. The 218.6 keV transition is present in both ^{139}Cs [4] and ^{142}Cs isotopes [1].

To identify yrast levels in ^{139}Cs, we gated on strong lines corresponding to transitions in ^{105}Nb and ^{107}Nb nuclei. In this way new lines at 601.5, 595.5, 475.2, 469.0, 428.2 and 740.3 keV have been found. These transitions belong to a cesium isotope since they are in coincidence with lines of at least two niobium isotopes and with Cs X-rays. Of ^{138,139,140}Cs isotopes, the ^{139}Cs is the most likely nucleus to which they belong since the expected production of ^{138}Cs isotopes in fission of ^{248}Cm is to low to observe it in our data and the yrast transitions in ^{140}Cs were already identified [1].

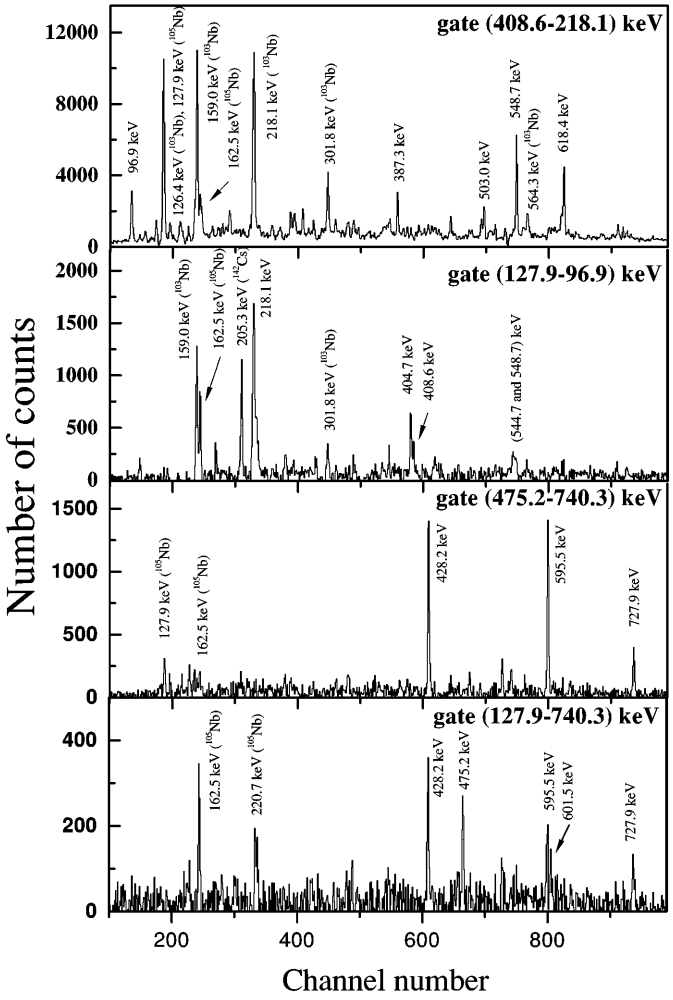

Fig. 2. Double-gated spectra of promt-γ radiation following fission of ^{248}Cm, as obtained in the present work.

The two lower spectra in Fig. 2 are double-gated on the newly identified, 740.3 keV and and 475.2 keV lines and the 127.9 keV line in ^{105}Nd. These and further gates allowed the construction of the new level scheme of ^{139}Cs as shown in Fig. 3.

Spins and parities were assigned based on the angular correlation and linear polarisation analysis [5]. Full description of this analysis will be given in a forthcomming paper [3].

To obtain additional arguments supporting the new level scheme we performed at the mass separator OSIRIS in Studsvika a coincidence measurement of γ-rays following β-decay of ^{139}Xe to ^{139}Cs . In a similar measurement, reported in [4], a 595.5 keV transition was observed, which was placed on top of the 1508.1 keV level. No coincidence data was reported in favour of this placement. Such a position of the 595.5 keV transition implies that it should be in coincidence with transitions depopulating this level. In particular coincidences with the 1289.5 keV transition and with the 218.6 keV ground-state transition should be seen. Fig. 4 shows fragments of spectra gated on the 218.6 keV and 595.5 keV lines, respectively. The coincidence of

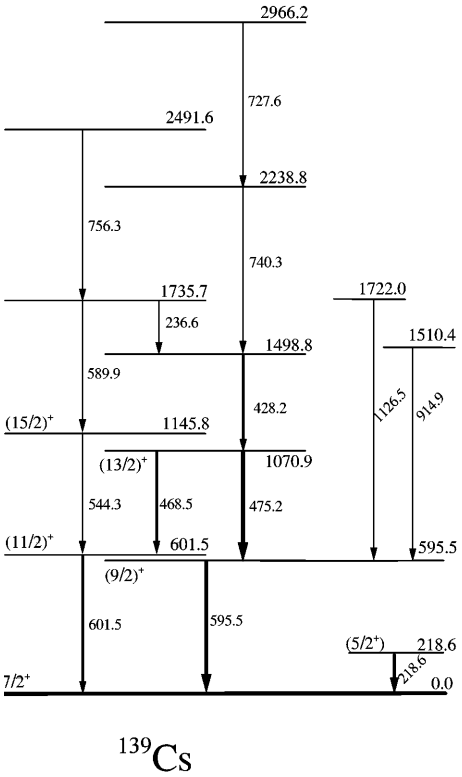

Fig. 3. Partial level scheme of ^{139}Cs as obtained in the present work. The 218.6 keV and 1721.8 keV levels were observed in our new β-decay measurement of ^{139}Xe (see text).

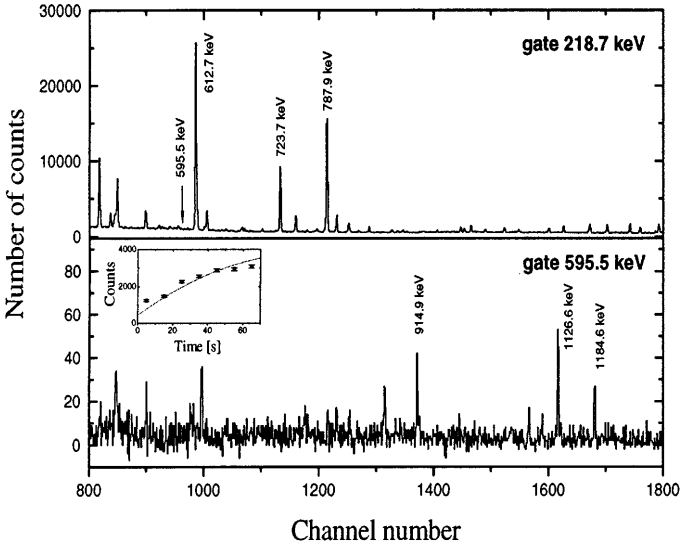

Fig. 4. Gated spectra of γ radiation following β-decay of ^{139}Xe to ^{139}Cs, obtained in the present work.

the 595.5 keV with 218.6 keV or 1289.5 keV transitions is not observed. Instead, the 595.5 keV transition is in coincidence with the 914.9 keV and 1126.6(2) keV transitions, not reported previously. This lines are not observed in the spectrum gated on the 218.6 keV line. Therefore we conclude that the 595.5 keV line observed in β-decay of ^{139}Xe corresponds to the 595.5 keV, ground-state transition seen in the spontaneous fission of ^{248}Cm. The 914.9 keV and 1126.5 keV transitions define new levels in ^{139}Cs at 1510.4 keV and 1722.0 keV.

The assignment of the 595.5 keV line to ^{139}Cs is supported by its population characteristics. In our measurement, the activity was collected on a movable tape at the focal plane of the OSIRIS mass separator, where it was measured with Ge detectors. The collection and measurement were done for a period of 120 seconds, after which the tape was moved and a new portion of activity was collected and measured. Within each 120 seconds period the activity was collected and measured in 15 seconds intervals. The insert in the lower pannel of Fig. 4 shows a variation of the activity corresponding to the 595.5 keV line in comparison with the variation corresponding to the known, 218.6 keV line in ^{139}Cs (dashed line). The data for both lines are consistent with the 39.7 seconds half-life of ^{139}Xe.

We could not see in the β-decay data any line at 97 keV. This fact supports our earlier conclusion that the 218.6-408.6-618.4-387.5-503.0 keV cascade belongs to ^{142}Cs isotope.

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