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Short note

Simplex s = ±i excitations in ^{141}Xe

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Abstract. Excited levels in ^{141}Xe, populated in spontaneous fission of ^{248}Cm, were studied by means of prompt γ-ray spectroscopy, using the EUROGAMM2 array. Level scheme of ^{141}Xe obtained in this work shows patterns characteristic of simplex symmetry with $s = +i$ and $s = -i$ bands present but low value of D_0 moment indicates that octupole correlations in Xe isotopes are systematically lower than in Ba nuclei.

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

Neutron-rich xenon isotopes are located at the edge of the lanthanide region, where some characteristics of strong octupole correlations are observed. It is still not clear how strong the octupole correlations are in these nuclei. On the one hand, it has been shown [1] that the electric-dipole moment, D_0, is much lower in ^{140}Xe than in its isotone ^{142}Ba. On the other hand, it has been suggested [2] that this low D_0 value is due to a local minimum of the D_0 moment in Xe isotopes at the neutron number $N = 86$, in analogy to a similar minimum in Ba isotopes at $N = 90$ [3,4]. Moreover, it has been claimed [5], that at neutron number $N = 85$ octupole correlations increase when going from ^{141}Ba to ^{139}Xe. It is expected that in ^{141}Xe, octupole correlations should be even stronger than in ^{139}Xe. Therefore, they should be comparable to or stronger than those in ^{143}Ba [6]. If found, a large D_0 moment in ^{141}Xe would confirm the minimum of the D_0 moment in Xe isotopes at $N = 86$.

In this Note we report new data for ^{141}Xe which resolve some of the issues raised above. To study the ^{141}Xe nucleus, we used high-fold coincidences between prompt γ-rays following spontaneous fission of ^{248}Cm. The experiment was performed with the EUROGAM2 array of anti-Compton spectrometers at Strasbourg. For more details on the experiment and data analysis see ref. [7].

Figure 1 shows γ-ray spectra obtained by double gating on γ-γ-γ-coincidence data, which allowed identification of new excited levels in ^{141}Xe. The double gate set on ^{141}Xe lines of energies 112 keV and 370 keV shows γ-rays corresponding to transitions feeding the 481.5 keV level in ^{141}Xe [1] and transitions in ^{104}Mo, which is one of the fission fragments complementary to ^{141}Xe. The 112 keV - 192 keV, double gate, where the 192 keV line corresponds to the $2^+ \rightarrow 0^+$ transition in ^{104}Mo, shows lines feeding the 111.9 keV level in ^{141}Xe. In this spectrum one can see γ-rays of energies 339.4, 440.3, 465.3, 478.5, 547.6 and 602.8 keV not reported previously. The 112 keV−478.5 keV double gate, shown in fig. 1, indicates that these new lines belong to ^{141}Xe, since in this gate lines from both ^{104}Mo and ^{106}Mo can be seen. The coincidence data allowed the construction of the partial level scheme of ^{141}Xe shown in fig. 2.

Spins and parities of levels in ^{141}Xe were determined from angular correlations and directional-polarisation measurements performed with EUROGAM2 [7,8]. The ground state of ^{141}Xe has spin and parity $I^{\pi}=5/2^-$ [9]. The K-conversion coefficient of the 35.6 keV transition was determined using triple coincidences measured by Ge and LEPS detectors of EUROGAM2. A spectrum double gated on the 369.6 keV and 76.3 keV lines observed in Ge detectors and projected on to the LEPS axis shows the 35.6 γ- and corresponding X_K-lines. The conversion coefficient α_K found from this spectrum equals 14(1). This agrees with the previously determined value of 15.0(5) [1]

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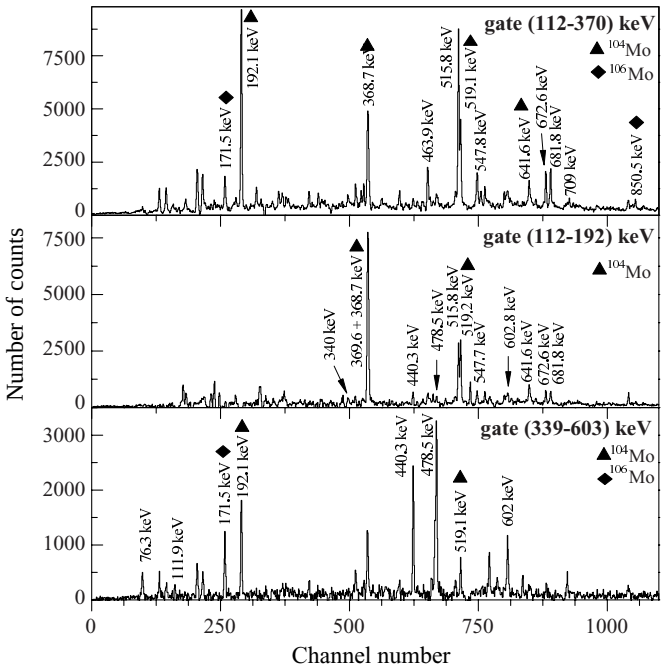

Fig. 1. Double-gated spectra of promt-γ radiation following fission of ^{248}Cm, as obtained in the present work.

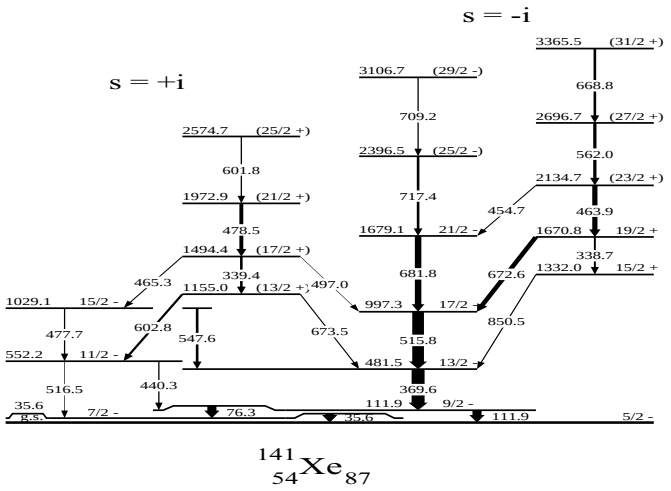

Fig. 2. Partial level scheme of ^{141}Xe as obtained in the present work.

and indicates the $M1 + E2$ character for the 35.6 keV transition (the theoretical α_K values are 2.8, 14.2 and 15.4 keV for $E1, M1$ and $E2$ transitions, respectively). The γ-γ angular correlations of the 369.6 keV transition with the 111.9 keV and 76.3 keV transitions, shown in fig. 3, are consistent with the 111.9 keV transition having stretched quadrupole character and the 76.3 keV transition being a stretched dipole, in agreement with the $M1/E2$ assignment reported previously [1]. The information presented above indicates spin and parity assignments of $7/2^-$ and $9/2^-$ to the 35.6 keV and 111.9 keV levels in ^{141}Xe, respectively.

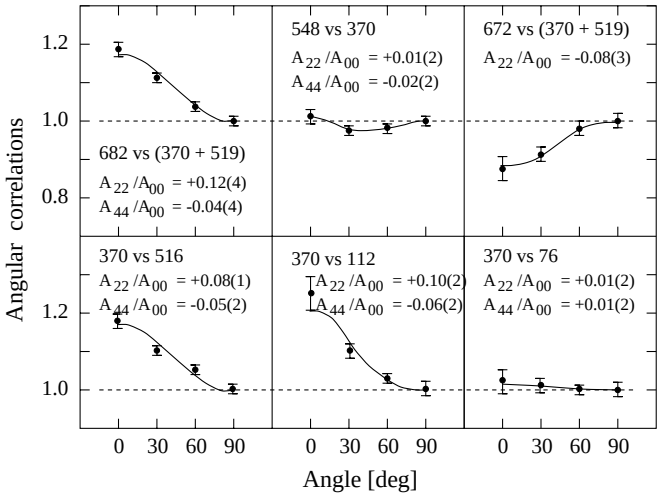

Fig. 3. The γ-γ angular correlations for transitions in ^{141}Xe with coefficients of Legendre polynomial expansions.

The γ-γ angular correlations between the 369.6, 515.8, 681.8, 672.6 and 547.6 keV transitions, shown in fig. 3, are consistent with stretched quadrupole character for the 369.6, 515.8 and 681.8 keV transitions and a spin change $\Delta I = 1$ associated with the 672.6 keV and 547.6 keV transitions. This is consistent with spins of 13/2, 15/2, 17/2, 19/2 and 21/2 for the 481.5, 1029.1, 997.3, 1332.0, 1670.8 and 1679.1 keV levels, respectively. The linear directional-polarisation measurement gave values of $+0.25(9), +0.20(6), +0.20(10), +0.30(12)$ and $-0.30(15)$ for the 369.6 keV, 515.8 keV, 681.8 keV, 672.6 keV and 547.8 keV transitions, respectively, indicating negative parity for the 481.5 keV, 997.3 keV, 1679.1 keV and 1029.1 keV levels and positive parity for the 1670.8 keV level.

The decay of the 1029.1 keV level to the 552.2 keV level and the observed decay of the latter state to the $7/2^-$, 35.6 keV state indicates spin 11/2 and a negative parity for the 552.2 keV level. The 1155.0 keV level can have spin and parity $13/2^+$ or $15/2^-$, in view of its decay pattern. The $13/2^+$ spin assignment is more likely, because of the stronger population of the band which includes the 1155.0 keV level, than that of the band which includes the $15/2^-$ level at 1029.1 keV. Such a population pattern would be hard to understand if the spin of the 1155.0 keV level were $15/2^-$.

The $B(E1)/B(E2)$ branching ratio for the 1670.8 keV level equals $0.09(1) \times 10^{-6}\mathrm{fm}^{-2}$. This is equivalent to an electric dipole moment $D_0 = 0.04(1)$efm, obtained from the formula $D_0 = \sqrt{5B(E1)/16B(E2)} \times Q_0$. An electric quadrupole moment Q_0=2.5(5)b was estimated for ^{141}Xe, based on the Q_0 values for the neighbouring even-even nuclei [10].

The $s = \pm i$, parity-doublet structures, which are proposed in ^{141}Xe in the present work, indicate that octupole correlations play an important role in this nucleus. How-

ever the low value of D_0 here, which is similar to that in ^{140}Xe, suggests that, in general, octupole effects in Xe isotopes are weaker than in the corresponding Ba nuclei.

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