Decay spectroscopy of two-quasiparticle K isomers in ^{246,248}Cm via inelastic and transfer reactions

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(Received 11 August 2019; published 12 September 2019)

The decay of K isomers in Cm ($Z = 96$) isotopes has been studied using inelastic and transfer reactions. The half-life of a previously identified 2-quasiparticle (qp) $K^\pi = 8^-$ isomer in ^{246}Cm has been measured. A new 2-qp isomer is observed in ^{248}Cm, its half-life measured and its decay scheme established. The reduced K hindrances extracted for the decay transitions from the isomers in ^{246,248}Cm indicate K to be a robust quantum number and validate axial symmetry in these nuclei. The excitation energies of the 2-qp isomers in ^{246}Cm ($N = 150$) and ^{248}Cm ($N = 152$) support the persistence of a deformed subshell gap at $N = 152$ in the $Z \approx 100$ region down to $Z = 96$ nuclei.

DOI: 10.1103/PhysRevC.100.034309

I. INTRODUCTION

The heaviest known nuclei survive due to quantum shell effects, which lower their ground-state energy and increase the barrier against spontaneous fission from Coulomb forces. The synthesis frontier of the heaviest elements continues to advance, albeit slowly, utilizing fusion reactions with very low cross sections, and scant information has been gleaned on excited states as a result. Not surprisingly, there is considerable disagreement among different models, both macroscopic-microscopic and self-consistent mean field, in predicting the location of the next magic shell gaps beyond the highest established ones at $Z = 82$ and $N = 126$. The spectroscopy frontier of the heaviest nuclei, on the other hand, lies around $Z \approx 100$, where more information can be obtained on excited states. Identification of single- and multiparticle excitations in the $Z \approx 100$ region, therefore, provides a testing ground for models of superheavy nuclei, as well as for understanding the limits of nuclear stability as a function of Z and N.

In the $A \approx 250$ region of heavy actinides, midshell nuclei away from spherical shell gaps exhibit significant deformation, with valence nucleons occupying high-j orbitals near the Fermi surface. These conditions promote the occurrence of K isomers at low excitation energies. Here, the K quantum number denotes the sum of the projections, Ω, of intrinsic angular momenta of the individual valence particles along the symmetry axis [1,2]. Decay studies of K isomers, using pulsed-beam techniques, provide experimental information complementary to that obtained from in-beam studies, since spectroscopy in the beam-off periods typically result in improved signal-to-noise. The underlying configurations of K isomers provide information on single-particle energies. Transition hindrances deduced from the partial half-lives of γ-decay branches from K isomers can be used to assess the robustness of axial symmetry in the nucleus, and $M1/E2$ branching ratios of rotational band transitions built on the isomers enable configuration assignments to the isomeric bandheads.

Significant inroads have been made in recent years in populating 2- and 4-quasiparticle (qp) K isomers in even-even $Z \geqslant 100$ nuclei [3,4]; e.g., in Fm ($Z = 100$) [5], No ($Z = 102$) [6–10], and Rf ($Z = 104$) [11,12] isotopes, using fusion-evaporation reactions. These spectroscopic measurements are challenging due to submicrobarn cross sections. While knowledge of single-particle excitations in the proton domain require pushing the limits of spectroscopy to higher Z, neutron excitations in this region can be accessed through the study of $Z \lesssim 100$ nuclei, where radioactive neutron-rich targets are available and other production mechanisms can be employed.

Experiments at Argonne, GSI, and Jyväskÿla have identified $K^\pi = 8^-$ isomers in the $N = 150$ isotones ^{250}Fm [5] and ^{252}No [6,10]. In ^{246}Cm ($Z = 96$, $N = 150$), a $K^\pi = 8^-$

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isomer had previously been identified in the β^- decay of ^{246}Am [10,13]. While the decay scheme for the isomer had been deduced, the half-life had not been established. More recently, Coulomb excitation reactions at above-barrier incident energies have been used to study prompt rotational structures in $^{246-249}$Cm [14–16] up to spins $\approx 30\hbar$, but no isomer investigations were pursued. Building on successes in populating and studying K isomers in the $A \approx 180$ region using inelastic and transfer reactions with heavy reaction partners [17–19], similar reactions were used in this work to investigate K isomers in the $A \approx 250$ region for the first time, specifically in the relatively neutron-rich ^{246,248}Cm ($N = 150$, 152) nuclei, where the reaction cross sections are in the few to tens of millibarns. Compared to fusion reactions, the resulting few orders of magnitude increase in statistics enables detection of significantly weaker deexcitation branches from the isomeric decays, providing more sensitive tests of K hindrances. These experiments complement the low-cross-section fusion studies of the highest Z nuclei in this region by enabling spectroscopy of the highest N nuclei, and generate a wider palette for testing predictions of superheavy models.

II. EXPERIMENT

A ^{209}Bi beam at an energy of 1450 MeV ($\approx$15% above the Coulomb barrier), from the ATLAS superconducting heavy-ion accelerator at Argonne National Laboratory, was incident on a 200-μg/cm^2-thick ^{248}Cm target ($t_{1/2} = 3.48 \times 10^5$ yr), with an activity of 0.23 μCi, deposited on a 50-mg/cm^2 Au backing. The γ rays were detected simultaneously by 101 Compton-suppressed high-purity germanium (HPGe) detectors of the 4π Gammasphere array [20]. Various beam-sweeping ranges, with bursts separated by 1 μs to 8 s, were utilized to search for and measure isomer half-lives. Coincident event-mode data were initially collected within the standard Gammasphere event window of 1 μs, by using every tenth beam pulse from ATLAS; i.e., 1 ns pulses separated by 825 ns. Subsequently, data were collected only in the beam-off periods when the sweeping periods were increased from 1 μs to 8 s, keeping a desired beam ON/OFF ratio via a free-running external clock: (i) 20 μs/80 μs, (ii) 200 μs/800 μs, (iii) 20 ms/80 ms, (iv) 1 s/3 s, (v) 2 s/8 s. The event-mode data were sorted into histograms of varying dimensions, such as 2-dimensional γ-γ or γ-time coincidence matrices, and 3-dimensional γ-γ-γ cubes, and subsequently analyzed using the RADWARE suite of programs [21]. In addition to population via 2-neutron transfer, the cross section for ^{246}Cm was enhanced through inelastic excitation of a 3% impurity of the ^{246}Cm isotope in the ^{248}Cm target. The search for new isomers in the various time regimes revealed more than 20 known isomers in the $A \approx 130$ and $A \approx 100$ regions resulting from fission of target nuclei. This work, however, focuses specifically on isomers in the even-even Cm isotopes [22].

III. ANALYSIS

A. ^{246}Cm

The different beam-off time intervals were inspected in order to converge on the half-life of the known $K^\pi = 8^-$ isomer in ^{246}Cm [13]. The existence of this isomer was confirmed by the observation of out-of-beam coincidence events, specifically in the beam ON/OFF ranges of 1 s/3 s and 2 s/8 s, between the 679-keV γ ray, which directly deexcites the isomeric state, and two ground-state-band (GSB) transitions in ^{246}Cm, viz. the 205-keV ($8^+ \rightarrow 6^+$) and 153-keV ($6^+ \rightarrow 4^+$) γ rays. The half-life of the isomer was determined by fitting summed double-coincidence intensities for the 679-, 153- and 205-keV transitions depopulating the isomer, for six equal time intervals in the 3-s beam-off periods [Fig. 1 (top)]. The extracted value of the isomer half-life is 1.12(24) s.

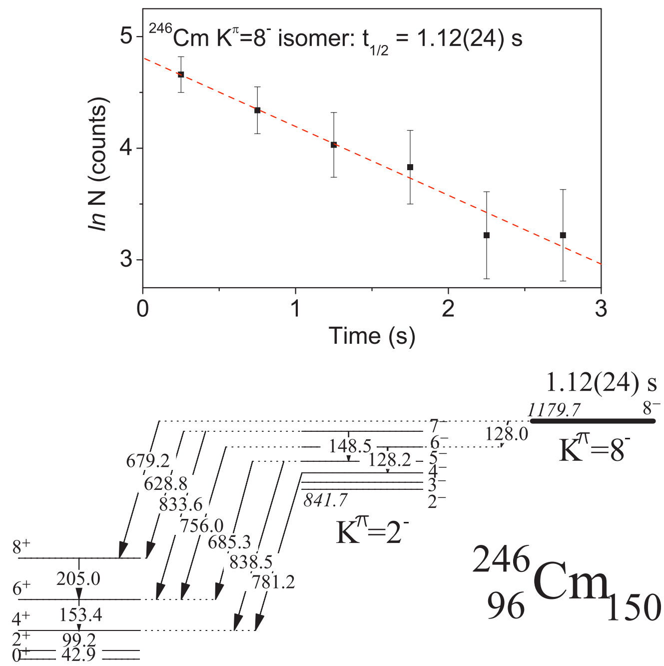

FIG. 1. (Top) Time distribution of γ rays deexciting the previously identified $K^\pi = 8^-$ isomer in ^{246}Cm during the 8 s beam-off periods; (bottom) partial level scheme depicting the decay pattern of the isomer (from Refs. [10,13]).

Three decay branches had been previously established for this long-lived state [10,13]. One is a direct decay to the 8^+ state in the GSB via a 679-keV transition. The other two branches decay to the 7^- and 6^- members of a $K^\pi = 2^-$ octupole vibrational band [Fig. 1 (bottom)]. Similar decay paths through $K^\pi = 2^-$ octupole vibrational bands have been established for the heavier $N = 150$ isotones ^{250}Fm [5] and ^{252}No [6,10].

B. ^{248}Cm

A new isomer is identified in ^{248}Cm in the present work. This isomer is assigned to ^{248}Cm through double-coincidence relationships of the γ rays deexciting the long-lived state with the 208-keV ($8^+ \rightarrow 6^+$) and 155-keV ($6^+ \rightarrow 4^+$) GSB transitions in ^{248}Cm. Two strong γ rays, with almost equal intensities and energies of 954 and 947 keV, are observed in data collected in the 800-μs beam-off period. These two transitions deexciting the isomeric state are not in coincidence

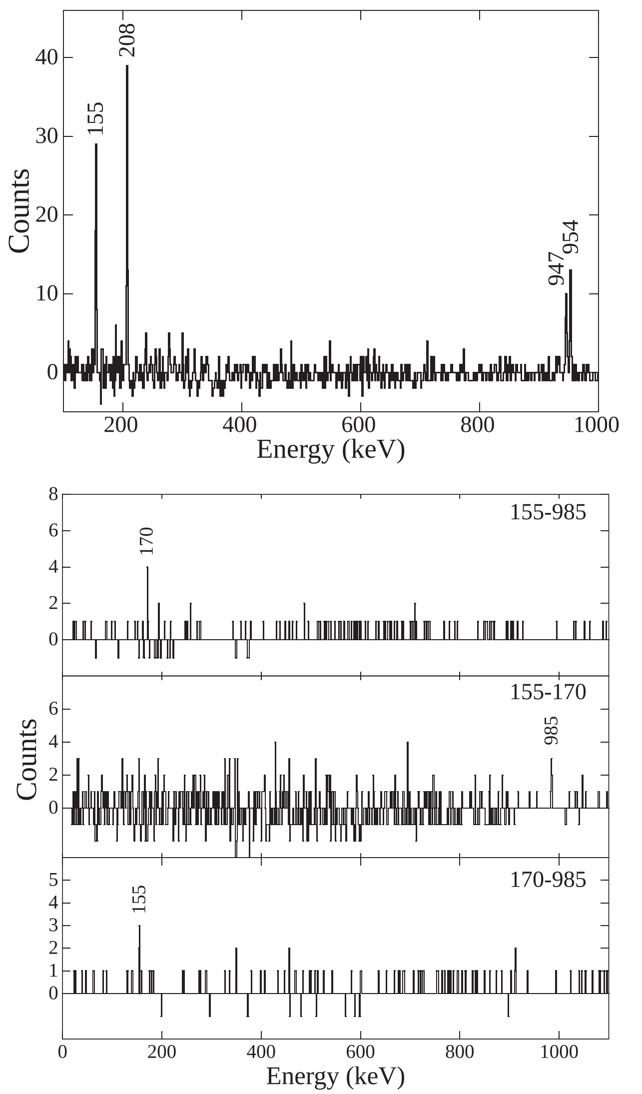

FIG. 2. (Top) Summed, double-gated coincidence spectrum of strong γ rays from the decay of the new ^{248}Cm isomer; (bottom) double-gated γ-ray spectra from a weaker decay branch (see text).

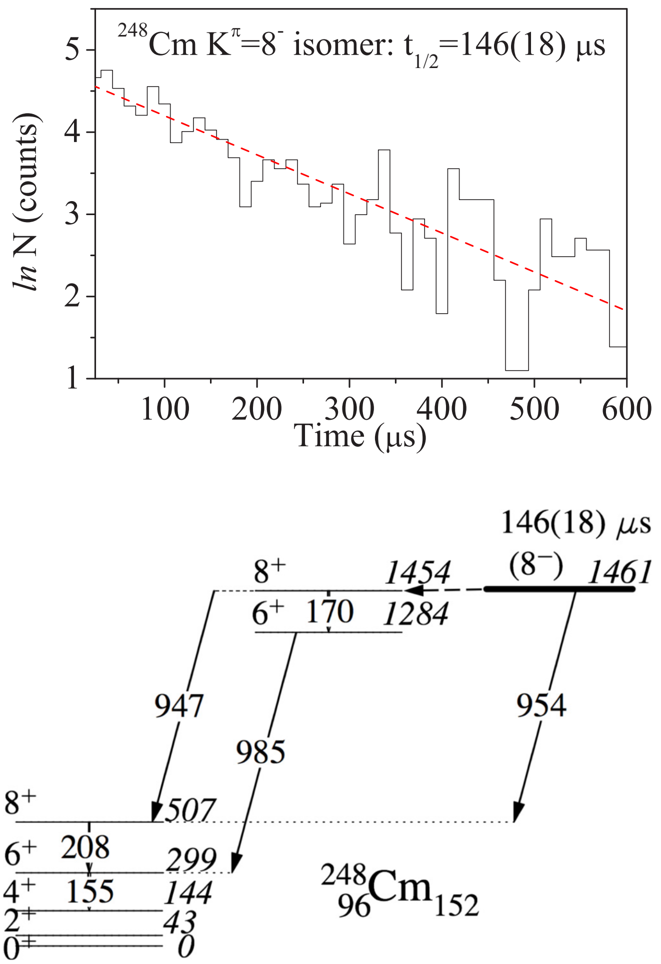

FIG. 3. (Top) Time distribution of γ rays from the decay of the isomer in ^{248}Cm during the 800-μs beam-off period; (bottom) decay scheme of the isomer established from the present work.

with each other, indicating that they represent parallel decay branches. A spectrum of summed double-coincidence gates of the 947- and 954-keV γ rays, together with the 155- and 208-keV transitions, is presented in Fig. 2 (top). A weaker branch, through the sequence of 170-, 985-, and 155-keV γ rays following an unobserved 7-keV transition from the decay of the isomer (discussed below) is shown in Fig. 2 (bottom).

The decay curve for the isomer is obtained by summing all double-coincidence events between the 155-208-947-keV and 155-208-954-keV cascades, and by projecting along the time axis of the external microsecond clock. The half-life of the isomer is determined to be 146(18) μs [Fig. 3 (top)]. The proposed isomeric decay scheme is presented in Fig. 3 (bottom). The 954-keV γ ray decays directly to the 8^+ state of the GSB, placing the isomer at an excitation energy of 1461 keV. The 947-keV γ ray was previously observed through in-beam studies as the $8^+_{\gamma\text{-vib}} \rightarrow 8^+_{\mathrm{GSB}}$ decay [15]. This decay of the new isomer through the γ-vibrational band is further supported by the observation of the 985-keV ($6^+_{\gamma\text{-vib}} \rightarrow 6^+_{\mathrm{GSB}}$) and 170-keV ($8^+_{\gamma\text{-vib}} \rightarrow 6^+_{\gamma\text{-vib}}$) transitions. This implies a decay branch of the isomer to the 8^+ state of the γ-vibrational band via an unobserved, low-energy transition of 7 keV.

Direct decay branches from the isomer are observed to only the 8^+ members of both the GSB and the γ-vibrational band, and no direct decay branches are observed to the 6^+ members of either sequence. This decay pattern strongly suggests a spin-parity assignment of 8^- to this isomer, and argues against spin-parity assignments of 7^+, 7^-, or 8^+. Confidence in this assignment is reinforced both by theoretical expectations and by experimental systematics of *K* isomers in neighboring nuclei, as discussed in the following section.

IV. DISCUSSION

From their measured half-lives, reduced *K* hindrances can be calculated for the transitions deexciting the isomers in ^{246,248}Cm, offering a quantitative measure of the associated degree of *K* forbiddenness. A transition is *K* hindered if $\Delta K > \lambda$, where λ is the multipolarity of the transition, and the degree of forbiddenness is defined as $\nu = \Delta K - \lambda$. The reduced hindrance per degree of K forbiddenness, f_ν, is given by the formula $[t_{1/2}^{\text{expt}}/t_{1/2}^{\text{W.u.}}]^{1/\nu}$, where $t_{1/2}^{\text{expt}}$ is the measured partial half-life of the γ-ray transition, and $t_{1/2}^{\text{W.u.}}$ is its corresponding Weisskopf estimate [23]. The f_ν values for the two direct $\Delta K = 8$, $E1$ decay branches connecting the $K^\pi = 8^-$ isomers in ^{246,248}Cm to their respective 8^+ GSB members with ($K^\pi = 0^+$) are extracted and compared. The branching ratios for the decay of the ^{248}Cm isomer were obtained from the intensities of the 947-, 954-, and 985-keV γ rays in coincidence spectra gated on two out of the three 155-, 208-, and 170-keV transitions, after appropriate corrections for detector efficiencies and internal conversion. The branching ratio of the 954-keV, $\Delta K = 8$, $E1$ branch is measured to be 44%, which translates to an f_ν value of 56. The f_ν value for the corresponding strongest 679-keV $E1$ branch in ^{246}Cm is 166, where the half-life measured in the present work was combined with a more precise branching ratio for the transition (60%), compiled in the isomer database from β-decay studies [4]. The f_ν values for similar $\Delta K = 8$, $E1$ transitions from other 2-qp, $K^\pi = 8^-$ isomers in neighboring $N = 150$ isotones are 177, 213, and 178 in ^{244}Pu [24], ^{250}Fm [5], and ^{252}No [6], respectively. These indicate that K is indeed a robust quantum number in this mass region and confirms axial symmetry for the Cm isotopes.

Nevertheless, the comparatively lower f_ν value for the $\Delta K = 8$, $E1$ decay of the $K^\pi = 8^-$ isomer in ^{248}Cm deserves comment. Level density effects have been proposed for K mixing of isomers at higher excitation energies above the yrast line in other mass regions, resulting in decreasing hindrance factors [4,26]. While the lower hindrance factor for the ^{248}Cm isomer is in line with this hypothesis, the limited experimental systematics in this mass region precludes any rigorous analysis. The preferential decay pattern of the ^{248}Cm isomer via γ-vibrational states, rather than the more usual pathway via octupole vibrational states in almost all neighboring $N = 150$ isotones, as discussed later, raises other possibilities. The lower energies of γ-vibrational excitations in ^{248}Cm compared to ^{246}Cm, together with the reduced f_ν value for the 8^- isomer decay, may indicate a softening of the core toward collective excitations involving nonaxial symmetry with increasing neutron number in Cm nuclei.

Energies of 1- and 2-qp states directly reflect the single-particle spectrum and, hence, provide a stringent test of theoretical models. To probe the energies of specific states, the standard method is to vary the location of the Fermi level by changing the number of protons or neutrons. High-K 2-qp isomers occur when high-Ω orbitals are present near the Fermi level. Thus, examination of high-K isomers in nuclei in a local region is a sensitive probe of the location of high-Ω orbitals. Excitation energies of the 2-qp high-K isomers in ^{246,248}Cm are presented in Fig. 4, together with those observed in the $N = 150$ isotones from ^{244}Pu ($Z = 94$) to ^{252}No ($Z = 102$). The experimental energies are compared with theoretical estimates for the lowest $K^\pi = 8^-$ states in these nuclei from multi-qp calculations. The single-particle levels were obtained using a Woods-Saxon potential with so-called universal parameters [27], and with β_2, β_4, and β_6 deformation parameters from the most recent compilation of ground-state masses and deformations [28] (note: both models/potentials

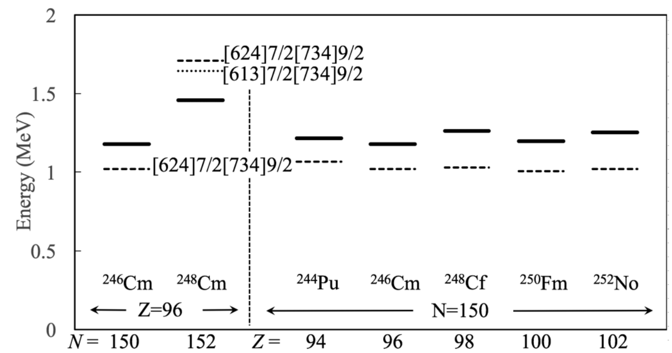

FIG. 4. Experimental excitation energies (thick lines) of $K^\pi = 8^-$ 2-quasineutron isomeric states in ^{246,248}Cm and the $N = 150$ isotones from the $Z = 94$ to $Z = 102$, compared with predicted energies (dashed, dotted lines) of the lowest $K^\pi = 8^-$ states in these nuclei (see text). The references for experimental data are ^{246}Cm [present work, [10]], ^{248}Cm [present work], ^{244}Pu [24], ^{248}Cf [25], ^{250}Fm [5], ^{252}No [6,10].

[27,28] predict similar equilibrium deformations). A truncated space, with orbitals only from the $N = 5$, 6, and 7 shells (for neutrons) and $N = 4$, 5, and 6 shells (for protons), was used. Pairing was treated using the Lipkin-Nogami prescription [29] with blocking taken into account and constant pairing strengths of $G_n = 17.8/A$ (for neutrons) and $G_p = 24.0/A$ (for protons). A first-order correction for residual spin-spin interactions was included, which, for identical nucleon pairs, moves spin-singlet states lower and spin-triplet states higher in energy by $\approx$100 keV in this mass region [5,8,10]. All other $K^\pi = 8^-$ states, including 2-quasiproton excitations, occur at significantly higher energies (above the 2 MeV full scale of the figure) for the nuclei shown. The experimental energies display overall good agreement with predicted values, and these results reinforce the general validity of macroscopic-microscopic models, such as the one used here, in reproducing experimental 2-qp energies in the $Z \approx 100$ region.

A 2-quasineutron, [624]7/2 $\otimes$ [734]9/2 configuration has been proposed for the $K^\pi = 8^-$ isomer in ^{246}Cm, based on β^- decay arguments [10]. The same configuration has also been proposed for the series of $K^\pi = 8^-$ isomers observed in neighboring $N = 150$ isotones, from β-decay and transfer-reaction data, as well as $M1/E2$ branching ratios of transitions between and within the signature partners of strongly coupled, prompt rotational structures built on the isomeric states [5,6,10,24].

For the isomer in ^{248}Cm with $N = 152$, calculations predict two different 2-quasineutron $K^\pi = 8^-$ configurations that lie close in excitation energy. These are the spin-singlet [624]7/2 $\otimes$ [734]9/2, and the spin-triplet [613]7/2 $\otimes$ [734]9/2 configurations, which are calculated to lie at 1711 and 1643 keV, respectively, after residual spin-spin interactions of $\pm$100 keV are included. This separation is well within the $\approx$300 keV uncertainties of such calculations [10]. The lowest 2-quasiproton $K^\pi = 8^-$ configurations are again predicted to be located at much higher energies (>2.5 MeV). In order to experimentally distinguish between the two neutron configurations for the isomeric state in ^{248}Cm would require more spectroscopic information, as is the case, for example, in the $N = 150$ isotones. No rotational structures could be identified with any confidence following a comprehensive band search in the prompt coincidence data.

In addition to direct decays to the GSB, the decay of the $K^\pi = 8^-$ isomers in the $N = 150$ isotones, including ^{246}Cm, proceeds through the $K^\pi = 2^-$ octupole vibrational band [5,10,13]. Both experiment and calculations identify the $\nu^2([622]5/2 \otimes [734]9/2)$ configuration as the principal 2-qp component in the $K^\pi = 2^-$ octupole vibrational state in ^{246}Cm [10,30,31]. The presence of the common [734]9/2 neutron orbital in the configurations of both the $K^\pi = 8^-$ isomer and the $K^\pi = 2^-$ octupole vibrational states provides a consistent explanation for the decay of the 2-quasineutron isomer via the octupole vibrational band in ^{246}Cm.

In contrast to the situation in ^{246}Cm, the *K* isomer in ^{248}Cm is observed to decay preferentially to the γ-vibrational band, rather than to the octupole vibrational one, in addition to direct decay to the GSB. To understand the different decay patterns of these two isomers in ^{246}Cm ($N = 150$) and ^{248}Cm ($N = 152$), the progression of both octupole and γ-vibrational excitation modes are analyzed in these nuclei. In moving from $N = 150$ to $N = 152$ in Cm nuclei, the octupole bandhead increases in excitation energy from 842 to 1050 keV, while the γ-vibrational bandhead decreases from 1124 keV to 1049 keV, the two becoming nearly degenerate in energy in ^{248}Cm. In fact, in inelastic deuteron scattering experiments on ^{248}Cm, the $J^\pi = 1^-$ member of the octupole band is obscured by the more intense excitation of the 2^+ level in the γ-vibrational band [31]. Given the observed decay branch of the ^{248}Cm isomer through the γ-vibrational band, the 2-qp contributions to the wave functions calculated for the γ-vibrational state in ^{248}Cm are inspected, and the dominant contribution is seen to come from the $\nu^2([622]3/2 \otimes [624]7/2)$ configuration [32]. The spin-singlet $[624]7/2 \otimes [734]9/2$ configuration choice for the 2-quasineutron $K^\pi = 8^-$ isomer in ^{248}Cm could provide a common [624]7/2 neutron orbital in the configurations of both the isomer and the γ-vibrational states, while the spin-triplet $\nu^2([613]7/2 \otimes [734]9/2)$ configuration would not. While this could be used to argue for the $\nu^2([624]7/2 \otimes [734]9/2)$ configuration as the preferred one for the $K^\pi = 8^-$ isomer in ^{248}Cm, no firm assignment is possible from purely experimental considerations. Furthermore, if the two configurations lie as close in energy as the calculations suggest, there is also the possibility of mixing, which obviates the need to distinguish between the two.

For nuclei in the heavy-actinide region with $Z \approx 100$, establishing the contours of a deformed subshell gap around $N \approx 152$ is a topic of current interest. For even No ($Z = 102$) down to Cm ($Z = 96$) isotopes, a measure of the gap is demonstrated through a local increase at $N = 152$ in δ_{2N}, the *difference* in 2-neutron separation energies between neighboring even-even isotopes [34,35] (Fig. 5). The increase of the $N = 152$ gap with Z is also demonstrated by the rise in energy of the $[620]1/2^+$ quasineutron orbital, which lies above the gap, in $N = 151$ isotones [35,36]. This gap has also been discussed in the context of the energies of the first-excited 2^+ states in even-even nuclei in this region [37,38]. These analyses suggest that the gap grows from Pu ($Z = 94$) to No ($Z = 102$)

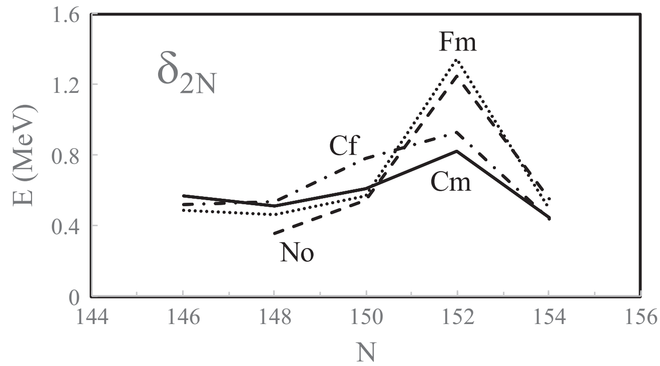

FIG. 5. Differences of 2-neutron separation energies in even-even nuclei in the $Z \approx 100$ region (from Ref. [41]), highlighting the persistence of a $N = 152$ shell gap down to $Z = 96$ (see text).

nuclei. An experimental study of *K* isomers in ^{250}Fm indicates the presence of a deformed subshell gap at $Z = 100$ and $N = 152$ [5]. Theoretical predictions, however, differ on the exact location of the gaps. While macroscopic-microscopic models predict deformed subshell gaps at $Z = 100$ and $N = 152$ [40], Hartree-Fock-Bogoliubov calculations, using the Skyrme interaction SLy4, place these at $Z = 98$ and 104, and at $N = 150$ [39]. The 1461-keV excitation energy of the 2-quasineutron isomer in ^{248}Cm ($N = 152$), established in the present work, can be compared to the 1180-keV energy of the isomer in ^{246}Cm ($N = 150$). The configurations require promotion of two particles above the $N = 152$ gap in ^{248}Cm, but not in ^{246}Cm. The measured 281-keV increase in excitation energy in ^{248}Cm compared to that in ^{246}Cm is consistent with that expected from the δ_{2N} systematics (Fig. 5), and reinforces the presence of a subshell gap at $N = 152$ for $Z = 96$ nuclei.

The notable increase in the excitation energy of the 8^- isomer in ^{248}Cm also provides clarity for the configuration assignment of the $K^\pi = 8^-$ isomer in the isotone ^{254}No. As a consequence of the $N = 152$ subshell gap, 2-quasiproton states lie lower in ^{254}No, with $K^\pi = 3^+$ ($[514]7/2 \otimes [521]1/2$) and $K^\pi = 8^-$ ($[514]7/2 \otimes [624]9/2$) states at $E = 988$ and 1296 keV, respectively [7–9]. An alternative 2-quasineutron configuration assignment ($[624]7/2 \otimes [734]9/2$ or $[613]7/2 \otimes [734]9/2$) has been proposed for the 8^- isomer in ^{254}No [33]. The fact that the excitation energy of the 8^- isomer in ^{254}No is 185 keV *lower* than that in ^{248}Cm argues against the 2-quasineutron assignment [33], and favors the 2-quasiproton one [7–9]. Usually, 2-quasineutron isomers should have nearly constant energy in isotones, as illustrated by the narrow energy spread of 62 keV of 8^- isomers in $N = 150$ isotones with $94 \leqslant Z \leqslant 102$. The proposed 8^- 2-quasineutron configurations in ^{254}No are, therefore, expected to lie significantly *higher* in energy than the 1461-keV value in ^{248}Cm because of the increase in magnitude of the $N = 152$ gap from Pu to No [35] (Fig. 5), as discussed above.

V. CONCLUSIONS

In summary, *K* isomers have been studied in ^{246}Cm and ^{248}Cm by using inelastic excitations and transfer reactions.

The half-life of a previously identified $K^\pi = 8^-$ isomer in ^{246}Cm has been measured to be 1.12(24) s. A new isomer has been observed in ^{248}Cm with $K^\pi = 8^-$, and its decay scheme has been established. Its half-life is determined to be $t_{1/2} = 146(18)\,\mu$s, and a 2-quasineutron configuration assignment of either ([624]7/2 ⊗ [734]9/2) or ([613]7/2 ⊗ [734]9/2) discussed. The observed excitation energies for the high-K isomers are in good agreement with expectations for 2-quasineutron states calculated using the Woods-Saxon potential with standard parameters and Lipkin-Nogami pairing. Reduced K hindrances extracted from the half-lives and decay intensities for the strong transitions deexciting the isomers in ^{246}Cm and ^{248}Cm confirm K to be a robust quantum number and indicate axial symmetry for these Cm isotopes. A possible softening of the core toward collective excitations involving nonaxial symmetry might be present with increasing neutron number. The significant increase in the excitation energy of the $K^\pi = 8^-$ isomer, from ^{246}Cm ($N = 150$) to ^{248}Cm ($N = 152$), supports the persistence of a deformed subshell gap at $N = 152$ in the $Z \approx 100$ region down to $Z = 96$ nuclei.

ACKNOWLEDGMENTS

This research is supported by the U.S. Department of Energy, Office of Science, Office of Nuclear Physics, under Grants No. DE-FG02-94ER40848, No. DE-FG02-97ER41033, and No. DE-FG02-97ER41041, and Contract No. DE-AC02-06CH11357. This research used resources of the ATLAS facility at ANL, which is a DOE Office of Science user facility. The authors are also indebted for the use of ^{248}Cm to the Office of Nuclear Physics, U. S. Department of Energy, through the trans-plutonium element production facilities at Oak Ridge National Laboratory.

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