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K-hindered decay of a six-quasiparticle isomer in ^{176}Hf

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The structure and decay properties of high-*K* isomers in ^{176}Hf have been studied using beam sweeping techniques and the Gammasphere multidetector array. A new $\Delta K = 8$ decay branch, from a $K^\pi = 22^-$, six-quasiparticle, isomeric ($t_{1/2} = 43\mu$s) state at 4864 keV to the 20^- state of a $K^\pi = 14^-$ band, has been identified. The reduced hindrance factor per degree of *K* forbiddenness for this decay is measured to be unusually low ($f_\nu = 3.2$), which suggests *K* mixing in the states involved. The deduced interaction matrix elements are discussed within the context of relevant *K*-mixing scenarios. The 3266-keV state, previously interpreted as a $K^\pi = 16^+$ intrinsic state, is reassigned as the $J^\pi = 16^+$ member of the band based on the $K^\pi = 15^+$ state at 3080 keV. The systematics of f_ν values as a function of the degree of forbiddenness is discussed in light of this change.

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I. INTRODUCTION

The abundance of high-Ω Nilsson orbitals near the Fermi surface for both protons and neutrons in $A = 170$–180 nuclei leads to a number of multiquasiparticle (multi-qp) high-*K* ($K = \Sigma\Omega_i$, where i is the qp index) states that are often isomeric. To first order, the decays of these *K* isomers follow the selection rule $\Delta K \leqslant \lambda$, where λ is the multipolarity of the γ-ray transition. For observed transitions where this rule is violated, an empirical measure of the retardation is the"reduced hindrance factor per degree of *K* forbiddenness," defined as $f_\nu = (F_W)^{1/\nu}$, where the degree of forbiddenness $\nu = \Delta K - \lambda$, and the hindrance factor F_W is the ratio of partial γ-ray half-life to the Weisskopf single-particle estimate [1,2]. The physics of *K* mixing through observed violations of the *K*-selection rule has spurred considerable interest in recent years [3]. Isotopes of hafnium, in particular, have been studied extensively over a wide range of spin and excitation energies [4]. In ^{176}Hf, two-, four-, and six-qp isomers were reported in the earlier studies of *K* isomerism [5–7]. The highest state (22^-) observed to date in this nucleus is a six-qp isomeric state ($t_{1/2} = 43\mu$s) at 4864 keV which decays to an intrinsic 20^- state by an allowed *E*2 transition [7]. Although a number of decay modes with different reduced hindrance factors have been found in the neighboring isotopes [8] and isotones [9,10], there had been no new experimental information on ^{176}Hf since the early studies. The present experiment was designed to study the structure and properties of the highest observable *K* isomers in ^{176}Hf.

II. EXPERIMENTAL DETAILS

The reaction ^{130}Te(^{48}Ca,2n)^{176}Hf was used to populate high-spin states in ^{176}Hf, with a 194-MeV ^{48}Ca beam from the ATLAS accelerator at Argonne National Laboratory, incident

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on a 1.1 mg/cm^2 ^{130}Te target backed by a 16 mg/cm^2 Au foil. γ rays were detected with the 101 Compton-suppressed Ge detectors of the Gammasphere array [11]. The data presented here utilized two different beam sweeping conditions. In the first, beam pulses $\approx$1 ns wide were incident at 825-ns intervals on the target. Subsequently, to cleanly select decays of high-spin isomeric states with half-lives of a few tens of microseconds, an "on-demand" beam switching system was used in which the beam (with the natural pulse period of 82.5 ns) was switched off for 100 μs following a triple-γ coincidence in a beam pulse. During the beam-off period, the master trigger was switched to singles. The out-of-beam data from the first part were sorted into a γ-γ coincidence matrix as well as into a γ-γ-γ cube where the γ rays were in "prompt" coincidence with respect to each other. Early-delayed γ-γ matrix techniques [12,13] were used to search for isomers above the one with $K^\pi = 22^-$. While no evidence of any higher-lying isomeric state was found, a new $\Delta K = 8$ decay branch of this $K^\pi = 22^-$ isomer to a member of the $K^\pi = 14^-$ rotational band was observed.

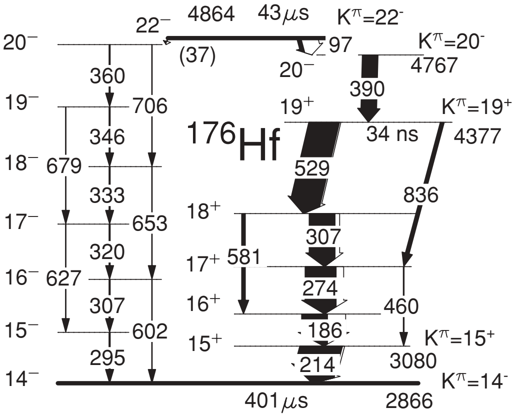

FIG. 1. Partial level scheme of ^{176}Hf showing levels above the $K^\pi = 14^-$ isomer populated in the decay of the $K^\pi = 22^-$ isomer. For a discussion about the unobserved 37-keV transition from the 22^- state to the 20^- level of the $K^\pi = 14^-$ band, see text.

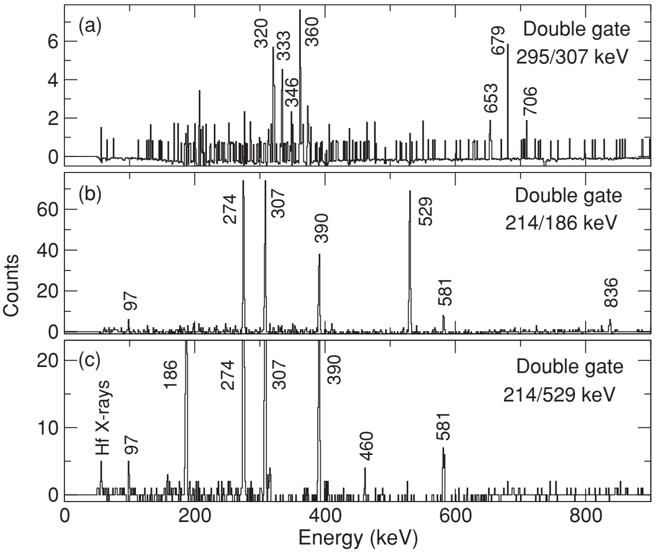

FIG. 2. Double-gated coincidence spectra from out-of-beam data showing γ rays from the decay of the $K^\pi = 22^-$ isomer to (a) the $K^\pi = 14^-$ band via the new K-hindered branch (b) the $K^\pi = 15^+$ band; (c) a new 460-keV γ ray in the $K^\pi = 15^+$ band (see text).

III. RESULTS

Five isomeric states are known in ^{176}Hf with half-lives ranging from 34 ns to 401 μs [5–7]. The present analysis reports on out-of-beam data and transitions above the $K^\pi = 14^-$ isomer ($t_{1/2} = 401 \mu$s) at 2866 keV excitation energy. The partial level scheme of ^{176}Hf above this isomer is given in Fig. 1. All transitions reported earlier were confirmed, but no new transitions below the 401 μs isomer were observed. While a rotational band built on this isomer had been observed in the earlier studies up to a 20^- state [7], this band was not reported to be fed by any isomeric state. Here, we present evidence that this band is being fed by an isomer. In an out-of-beam, double-gated spectrum for this band, shown in Fig. 2(a), obtained from a γ-γ-γ cube from the 825-ns beam-off period, all the γ rays belonging to this band are clearly observed, indicating that it is fed by an isomer. The half-life of the isomer feeding this band was measured as follows. The longer out-of-beam period of 100 μs was divided into six time cuts and a "prompt" γ-γ matrix was constructed for each of these cuts. The intensity of the lowest-energy (295 keV) transition in the $K^\pi = 14^-$ band was obtained from the sum of gates on coincident γ rays in each of these matrices. A half-life of 45 ± 13 μs was obtained from a fit to the intensity variation and is presented in Fig. 3. This is in good agreement with the previously measured half-life of 43 μs for the $K^\pi = 22^-$ isomeric state at 4864 keV excitation [7], and clearly suggests that the rotational band built on the $K^\pi = 14^-$ band is predominantly fed from the $K^\pi = 22^-$ six-qp isomer. As mentioned above, all the transitions up to 20^- in the

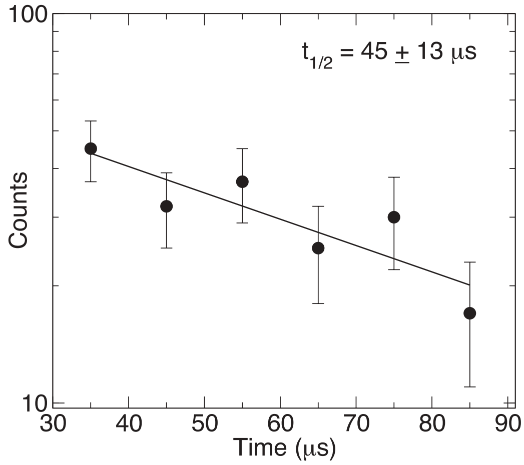

FIG. 3. Half-life of the state feeding the $K^\pi = 14^-$ band, obtained by fitting the time distribution of intensities of the 295-keV ($15^- \to 14^-$) transition, gated by the transitions above it, from six different time slices (see text for details).

TABLE I. Decay branch intensities of the 4864-keV $K^{\pi} = 22^{-}$ isomer.

Branch[a]	Double gate (keV)	E_{γ} (keV)	Raw counts	Relative intensity[b]	%Flow fraction[c]	Branch intensity	%Branch fraction
Strong	186–214	274	172(14)	651(54)	89.9	725(61)	
	186–214	307	146(13)	540(48)	75.7	713(64)	91.7(7.8)
	186–214	529	163(13)	671(55)	83.5	804(66)	
Weak	295–307	320	13(3.9)	39(12)	57.7	67(20)	
	295–307	333	9(3.6)	27(11)	43.2	62(25)	8.3(2.8)
	295–307	360	12(3.7)	36(11)	48.2	74(23)	

[a] "Strong" and "weak" denote the decay branches via the 97-keV and 37-keV transitions, respectively (see Fig. 1).

[b] Corrected for detector efficiency and internal conversion [33]. Pure $M1$ internal conversion coefficients were used for the in-band dipole transitions.

[c] Estimate of the fraction of the branch intensity that flows through this triple-γ combination. For the weak branch, an expected (and experimentally corroborated [7]) g_K of 0.57 for the configuration, with standard values of $g_R = 0.28$ and $Q_0 = 7$ e b (see text), was used to estimate in-band $M1/E2$ branching ratios. For the strong branch, an average $|(g_K - g_R)/Q_0|$ of 0.052 (obtained from $M1/E2$ branching ratios measured in this work) was used.

$K = 14$ band were observed in the spectrum of Fig. 2(a). This indicates that the feeding of these states occurs through an unobserved 37-keV, $E2$ transition depopulating the $K^{\pi} = 22^{-}$ isomer to the 20^{-} state of the $K = 14$ band. Observation of such a low-energy, highly converted (total electron conversion coefficient $\alpha_{\text{tot}} = 310$) transition was beyond the sensitivity of the present experiment.

The relative intensity of this decay path was inferred from the intensities of the observed transitions in the band that it feeds. The stronger decay path of this isomer is, however, to the intrinsic $K^{\pi} = 20^{-}$ state through a 97-keV transition (see Fig. 1). The relative intensity of the newly identified weak branch, as compared to the strong one, is depicted in the double-gated spectra of Figs. 2(a) and 2(b). The 37-keV decay branch is measured to be $(8.3 \pm 2.8)\%$ of the total decay of the $K^{\pi} = 22^{-}$ isomer (see Table I). The reduced hindrance factor (f_{ν}) of 3.2 for this branch was calculated by extracting the γ-ray branching of the 37-keV transition, taking into account its high electron conversion coefficient. Apart from the new decay branch of this isomer, we have also placed a new 706-keV transition in the level scheme as a decay from the 20^{-} to the 18^{-} state in the rotational sequence of the $K^{\pi} = 14^{-}$ band [see Figs. 1 and 2(a)].

The spectrum gated by 214- and 529-keV transitions in the stronger decay path of the 22^{-} isomer is presented in Fig. 2(c). This spectrum clearly indicates the presence of a 460-keV transition along with other transitions in this decay path. This 460-keV γ ray has been placed between the 17^{+} and the 15^{+} states as shown in the level scheme in Fig. 1. The observation of this γ ray is crucial for the configuration assignment of the $J^{\pi} = 15^{+}$ and the 16^{+} states, as discussed in the following section.

IV. DISCUSSION

The reduced hindrance factors (f_{ν}) calculated for all K-forbidden transitions in ^{176}Hf are given in Table II. The value of $f_{\nu} = 3.2$ for the newly observed K-hindered branch in this work is, clearly, anomalously low. We discuss this result in the context of various current scenarios of K mixing typically invoked in order to reconcile low values of f_{ν} observed in $A \sim 180$ nuclei.

For multi-qp isomers at high excitation energies, reduced K hindrances from possible statistical mixing of an isomer with neighboring levels, due to an increased level density, have been explored earlier [14]. In these calculations, the relevant variable is the excitation energy of the isomer relative to that of a rigid rotor reference at the same spin ($E_K - E_R$). Using a universal reference for the moment of inertia, an exponentially decreasing trend in f_{ν} values of $E2$ and $E3$ decays, from a number of multi-qp isomers with $\Delta K > 5$ in the $A \sim 180$ region, was highlighted by this method [14]. This trend was correlated with the theoretically expected exponential increase in level density with the square root of the energy difference. In specific cases, however, experimental f_{ν} values are significantly lower than predictions of this simple model, underscoring the need to consider additional mechanisms of K mixing. The new $\Delta K = 8$ decay branch of the 22^{-} isomer in ^{176}Hf, with $f_{\nu} = 3.2$, seems to fall in the latter category. In fact, for yrast isomers with small values of $E_K - E_R$ such as the present one, it is doubtful whether a quantitative discussion involving the density of states of similar spin is relevant, as this density is expected to be rather low.

Softness to shape changes, especially to nonaxial deformations, has been proposed as another key parameter for discussing anomalously low reduced hindrances in the Hf-W-Os region. While most of the hafnium nuclei are characterized by stable axial deformation in their ground states, γ softness is known to increase for the W and Os nuclei because of shape driving effects associated with aligning qp's at high spins. In such a situation, the definition of K gets diluted, resulting in K mixing. Small values of reduced hindrances ($f_{\nu} \approx 2$) in the decay of a four-qp $K = 14$ isomer in ^{176}W [15,16] and a six-qp $K = 25$ isomer in ^{182}Os [17,18] were explained by γ-tunneling calculations. A more comprehensive, subsequent survey highlighted the importance of considering nonaxial fluctuations of the nuclear shape in Hf, W, and Os isotopes [19]. Such calculations are, most likely, not very

TABLE II. Intrinsic states and reduced hindrance factors for K-isomer decays in ^{176}Hf.

E_x (KeV)	K^π	$t_{1/2}^{\rm expt}$	Configuration[a]		E_γ (KeV)	$E\lambda$ ($M\lambda$)	I_γ[b] (rel.)	$\alpha_{\rm tot}$[c]	$t_{1/2}^\gamma$ (partial)	ν	f_ν
			Neutron	Proton							
1333	6^+	9.5 μs	7/2,5/2	7/2,5/2	1043	$E2$	45	0.004	26.3 μs	4	42.8
			(40%)	(60%)	736	$E2$	78	0.008	19.2 μs	4	25.6
1559	8^-	9.8 μs		7/2,9/2	53.5	$E1$	53	0.362	20.2 μs	1	1.2×10^7
					226[d]	$M2$	12.1	1.94	85.1 μs	0	[d]
1860	8^-		7/2,**9/2**		301[d]	$M1$				0	[d]
2866	14^-	401 μs	7/2,5/2	7/2,9/2	302	$E2$	44	0.078	1.07 ms	4	23.0
					228	$E2$	9.8	0.187	4.82 ms	4	23.5
					38.7	$M1$	5	10.77	9.45 ms	5	30.1
3080	15^+		**9/2**,5/2	7/2,9/2	214[d]	$E1$				0	[d]
4377	19^+	34 ns	7/2,**9/2**,5/2,1/2	7/2,9/2	836	$E2$	11.4[e]	0.006	310 ns	2[f]	115[f]
					529	$M1$	88.6[e]	0.042	39.8 ns	3[f]	64.5[f]
4767	20^-		7/2,**9/2**,1/2,**7/2**	7/2,9/2	390[d]	$E1$				0	[d]
4864	22^-	43 μs	7/2,**9/2**,5/2,**7/2**	7/2,9/2	97[d]	$E2$	[g]	3.98	234 μs	0	[d]
					(37)[h]	$E2$	[g]	310	161 ms	6	3.2

[a] Neutrons: $7/2^-$[514],$5/2^-$[512],**$9/2^+$**[624],$1/2^-$[521],**$7/2^+$**[633]; protons: $7/2^+$[404], $9/2^-$[514], $5/2^+$[402].

[b] All relative γ-ray intensities other than transitions from the decay of the 22^- isomer are from Ref. [6].

[c] From Ref. [33].

[d] K-allowed transition.

[e] From a 186-214 double gate in the present work, not normalized to the intensities quoted above.

[f] For a $K = 15$ revised assignment for the final state (see text).

[g] Branch intensities derived from subsequent γ rays in cascade (see text and Table I).

[h] γ-ray energy too low for direct observation (see text and Table I).

relevant for ^{176}Hf, since potential energy surface calculations indicate that the nuclear shape remains rigid and without any significant degree of triaxiality, even for the 14^- and the 22^- configurations [20].

A third mechanism that could explain the anomalously low reduced hindrance is the mixing of lower-K components in the 22^- isomer through the Coriolis interaction. The $K^\pi = 22^-$ isomeric state is formed by coupling two $i_{13/2}$ neutrons in the $[633]7/2^+$ and $[624]9/2^+$ orbitals with the $K^\pi = 14^-$ state. These high-j orbitals have been observed to couple to two-qp Fermi-aligned or tilted "t-band" structures in the $A = 180$ region, which interact and mix with the respective zero-qp ground bands in the neighboring W [21,22] and Os [23–25] nuclei. The spin orientation of the t-band configuration is intermediate between the principal cranking axis and the nuclear symmetry axis. Thus, it has characteristics of both high-K and low-K bands. In the present case of ^{176}Hf, the six-qp $K^\pi = 22^-$ isomer can, therefore, be considered to be the "t bandhead" built on the four-qp $K^\pi = 14^-$ configuration. Mixing between the isomeric t bandhead and the 22^- rotational state of the $K^\pi = 14^-$ band may explain the low hindrance factor in ^{176}Hf.

Since our experiment was primarily focused on delayed spectroscopy, we were unable to observe any rotational band built on the 22^- isomer, or the 22^- rotational state of the $K^\pi = 14^-$ band. The mixing amplitude between the two bands can, however, be estimated from the lifetime of the $K^\pi = 22^-$ level. If the wave function of the 22^- isomeric state is expressed as $|22\rangle = \alpha|J = 22, K = 22\rangle + \beta|J = 22, K = 14\rangle$, where $\alpha^2 + \beta^2 = 1$, and that of the 20^- state of the $K = 14$ band as $|20\rangle = |J = 20, K = 14\rangle$, the $E2$ matrix element between these two states involves only the collective contribution, the other being K forbidden. This leads to $\beta = \langle 22|E2|20\rangle/\langle J = 22, K = 14|E2|J = 20, K = 14\rangle$. The mixing amplitude β^2 can, therefore, be obtained from the ratio of the partial half-life of the 37-keV transition to the corresponding collective estimate for an in-band 37-keV $E2$ transition. The observed partial γ-ray half-life of the perturbed $K^\pi = 22^-$ state, for an 8.3% branching and $\alpha_{\rm tot} = 310$, is 161 ms. With a quadrupole moment of $Q_0 = 7$ e b, typical for this mass region [26], assumed for the $K^\pi = 14^-$ band, the collective estimate for the half-life is 1.42 μs. This translates into a mixing amplitude $\beta^2 = 8.8 \times 10^{-6}$. Using this value of β^2 and an energy difference of 723 keV, obtained by extrapolating the $K^\pi = 14^-$ band up to 22^-, the interaction strength between these two bands, with an apparent $\Delta K = 8$, is found to be $|V| = 2.1$ keV. This value is lower than the typical interaction strengths of a few tens of keV extracted from the ground- and t-band crossings in W and Os nuclei [24,25,27], but significantly higher than the values of $\approx$10 eV typically observed [28] for chance degeneracies of states with a nominal ΔK difference of 8.

Another possible mixing that could lead to the anomalously low reduced hindrance is a mixing between the 20^- rotational state of the $K^\pi = 14^-$ band and the intrinsic $K^\pi = 20^-$ level, which lies 60 keV lower and receives 91.7% of the decay strength from the 22^- isomer. Since the 97-keV $E2$ transition from the 22^- isomer to the intrinsic 20^- state is K allowed, the long half-life requires a brief discussion. Each of the initial and final 6-qp states involves four protons and two neutrons, differing only by one neutron orbital. The half-life of 43 μs stems from a configurational hindrance between the differing

[512]5/2$^-$ and [521]1/2$^-$ neutron orbitals in the respective configurations [7]. This particular configurational hindrance between these specific orbitals is also observed in neighboring nuclei. In ^{175}Hf, for example, a 126-keV transition from a [521]1/2$^-$ level to the [512]5/2$^-$ ground state is isomeric with a 53.7 μs half-life [29]. This translates into a $B(E2)$ value of 2.3×10^{-3} W.u.. Similarly, in ^{177}Ta, a proton [402]5/2$^+$ orbital couples to the identical 22$^-$ and 20$^-$ configurations in ^{176}Hf, and exhibits an 86-keV transition between the resulting 49/2$^-$ and 45/2$^-$ states with a 133 μs half-life [30], which translates into a $B(E2)$ value of 2.0×10^{-3} W.u.. The corresponding $B(E2)$ probability for the 97-keV decay branch from the 22$^-$ isomer in ^{176}Hf is 4.8×10^{-3} W.u., in good agreement with the systematics of this particular configurational hindrance. Using this $B(E2)$ value as the *K*-allowed value, an estimate of the mixing amplitudes for the 20$^-$ states can be made, along the same lines as the mixing calculations for the 22$^-$ levels above, where the decay of the 22$^-$ isomer proceeds along both branches through the $K = 20$ admixtures in the final states. Since the stronger branch involving the 97-keV *E*2 transition, with a measured partial γ-ray half-life of $t^{97}_{1/2} = 233.5$ μs, is essentially unperturbed, the "unperturbed" partial γ-ray half-life for the weaker branch involving the 37-keV *E*2 transition would be $t^{37}_{1/2} = (97/37)^5 \times 233.5$ μs $= 28.9$ ms. In this scenario, a small $K = 20$ mixing amplitude, β, in the 20$^-$ final state, which has primarily $K = 14$, leads to the experimental partial γ-ray half-life of 161 ms. Thus, $\beta^2 = 28.9/161 = 0.18$, and $\alpha^2 = 0.82$. Using this α^2 value, one can generate a new "unperturbed" half-life for the stronger branch and recalculate new values of β^2 and α^2. A couple of iteration steps leads to final values of $\beta^2 = 0.15$, and $\alpha^2 = 0.85$, or $\beta = 0.39$ and $\alpha = 0.92$. The energy difference ΔE of 60 keV between the two 20$^-$ states leads to an interaction strength $|V| = \beta\alpha\Delta E = 22$ keV. This is two to three orders of magnitude larger than the values of ≈10–100 eV extracted for chance degeneracies of states in this mass region [28] with a nominal ΔK value of 6. Whether this can be termed a discrepancy is unclear, since the available database for such mixings has sparse statistics to date, and typically has one rotational $B(E2)$ transition probability in the mix, and may not provide a reliable benchmark for this special case involving a configurational hindrance.

We now turn to the discussion of the configuration assignments for the 15$^+$ and the 16$^+$ states following the placement of a new 460-keV γ ray between the 17$^+$ and the 15$^+$ levels, and new intensities measured in the present work. The originally proposed quasiparticle configurations of the $K^\pi = 15^+$ and the $K^\pi = 16^+$ states [7] were $\pi^2\{[404]7/2^+, [514]9/2^-\} \otimes \nu^2\{[512]5/2^-, [624]9/2^+\}$ and $\pi^2\{[404]7/2^+, [514]9/2^-\} \otimes \nu^2\{[514]7/2^-, [624]9/2^+\}$, respectively, i.e., the coupling of two different two-neutron qp configurations with the $\pi^2[8^-]$ state. Subsequent authors have argued [31] that the 16$^+$ state is not a pure one but is, in fact, mixed with a collective excitation of the $K^\pi = 15^+$ state. They have also suggested a new configuration for this $K^\pi = 15^+$ level as $\pi^2\{[404]7/2^+, [514]9/2^-\}\otimes \nu^2\{[514]7/2^-] \otimes [633]7/2^+\}$ [31]. An expected requirement for the new suggestion is a 460-keV *E*2 transition from the 17$^+$ level to the 15$^+$ bandhead. This 460-keV crossover transition is clearly observed in our new data [see Fig. 2(c)].

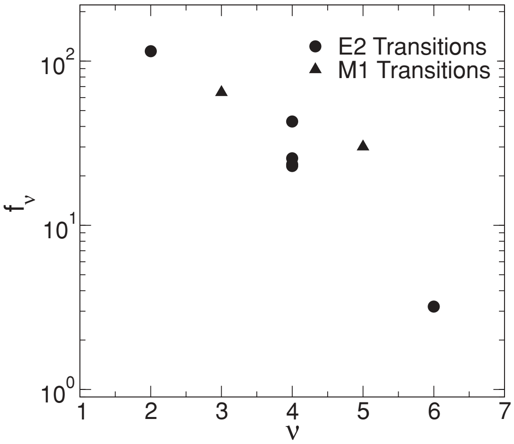

FIG. 4. Reduced hindrance factors (f_ν) as a function of the degree of forbiddenness ν for *E*2 (circle) and *M*1 (triangle) transitions in ^{176}Hf.

A more stringent test for configuration assignments is provided by the experimental $|(g_K - g_R)/Q_0|$ ratios deduced from the measured branching ratios. In the present work, the measured value of this ratio from the decay of the 18$^+$ state (which deexcites by the 307- and 581-keV γ rays) is 0.052(7) for a $K = 15$ band. Using the branching ratio between the 274-keV and the new 460-keV γ rays from the decay of the 17$^+$ state (the $K = 15$ interpretation is the only one allowed for this case), the value extracted for $|(g_K - g_R)/Q_0|$ is 0.053(24). The agreement of the extracted ratios within experimental uncertainties represents a strong validation of the $K = 15$ interpretation. The compression of the first transition in the band is a typical consequence of Coriolis mixing between the different members of the $i_{13/2}$ neutron orbital involved, and depends on the position of the Fermi level within the $i_{13/2}$ set [32]. Note that the configuration of the $K^\pi = 15^+$ state in ^{176}Hf is related to that of the $K^\pi = 23/2^-$ level in ^{175}Hf discussed in Ref. [32] by the simple addition of a spectator [514]7/2$^-$ neutron.

A $K = 15$ interpretation also resolves discrepancies for the f_ν values extracted for the decay of the $K = 19$ isomer with a half-life of 34 ns. In Fig. 4, the f_ν values are plotted as a function of ν for *E*2 and *M*1 transitions from all isomeric states in ^{176}Hf. The 529-keV *M*1 branch and the 836-keV *E*2 branch would now have f_ν values of 65 and 115, as opposed to 518 and 13174, respectively. The new values are more in line with a much larger body of systematics available on f_ν values in this mass region, and support the $K = 15$ interpretation. A gradual decrease in f_ν values is observed with increasing ν, with a sharper drop to the unusually low value for the new 37-keV decay branch observed from the 22$^-$ isomer.

V. CONCLUSIONS

A new weak decay branch of the six-qp 22$^-$ isomer ($t_{1/2} = 43$ μs) in ^{176}Hf has been identified in the present work. This new $E2$ transition to the 20^- state of the rotational band built on a $K^\pi = 14^-$ intrinsic state has a very small reduced hindrance factor ($f_\nu = 3.2$) compared to the other K-hindered $E2$ decays in ^{176}Hf. Different K-mixing scenarios, involving Coriolis interactions as well as chance degeneracies, have been explored. A systematic trend of decreasing f_ν as a function of ν is observed for $E2$ and $M1$ transitions from all multi-qp isomers in ^{176}Hf. An earlier controversy about the configuration and K assignment of a rotational band built on either a 15^+ or a 16^+ bandhead is reconsidered. The $K = 15$ interpretation is supported by the new observation of a 460-keV crossover transition between the 17^+ state and the 15^+ bandhead, together with its measured branching ratio, as well as revised f_ν values for the decay of the $K = 19$ isomer to this band.

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