Collective gyromagnetic ratios and the structure of odd superdeformed $A=190$ nuclei

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Collective gyromagnetic ratios g_R, microscopically calculated from Hartree-Fock plus BCS calculations using the SkM^* force, are found to be very different from the rough Z/A estimates. It is pointed out that the latter disagree with the spectroscopic data in normally deformed states of even-even nuclei. The consequences of taking into account microscopic values of g_R on the spectroscopic properties of odd superdeformed $A=190$ nuclei are discussed. Quenching factors, for proton and neutron g_s ratios, are tentatively proposed. Single-particle assignments postulated by experimentalists for the available data are confirmed by our consistent approach. [S0556-2813(97)03904-6]

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I. INTRODUCTION

Spectroscopic properties of nuclei in superdeformed (SD) states provide stringent tests for the theoretical description of both collective and single-particle excitations. The first relevant data in this respect have been obtained for SD states in the second well appearing in the fission barriers of actinides. Indeed after the pioneering works on the magnetic properties of rotational states in the odd fission isomers of ^{237}Pu [1] and ^{239}Pu [2] (see also the review of Ref. [3] and the theoretical approaches of Refs. [4,5]), quite detailed spectroscopic studies of SD states have been performed recently in the $A=190$ [6–11] region, thanks to the highly efficient γ-ray multidetector arrays (EUROGAM, GAMMASPHERE, GASP) currently in use. In particular, it has been possible to extract directly $B(M1)/B(E2)$ ratios from cross-talk transitions between pairs of SD bands in the $A=190$ region and also to measure the gyromagnetic g factors of some SD states in other mass region ($A=130$) by the transient field technique.

Within the standard rotor plus one quasiparticle model description of such states, one can extract from magnetic properties [5,12–16] single-particle spectroscopic information [upon knowing, in the $B(M1)/B(E2)$ case, the quadrupole moments by lifetime measurements in stretched $E2$ transitions]. As a starting point, one can infer in such a way the one quasiparticle assignment of the states under study. When that is achieved, one is also able to provide experimental estimates of the so-called g_K value. In order to do so, however, one has to introduce theoretical values of the collective gyromagnetic g_R factors. A first global ansatz, $g_R^0=Z/A$, widely used without much discussion, relies roughly [see below the discussion of Eq. (10) in the paper of Sprung *et al.* [17]] on two assumptions: (i) a rigid body estimate of the moments of inertia $\mathcal{J}$, (ii) a purely isoscalar size dependence of the scaling type in A (according to an $A^{1/3}$ power law), for both the neutron and proton moments of inertia. Using microscopic Hartree-Fock (HF) wave functions, one may improve the former ansatz by considering a rigid body approximation g_R^{RB}, yet taking into account different deformations and radii (N,Z) dependence for protons and neutrons. A more satisfactory microscopic estimate of the collective gyromagnetic ratio, referred to below as g_R^{IC}, relies on the Inglis cranking approach [17–20]. It has been widely used to describe the collective magnetic properties over the whole nucleidic chart in Ref. [17] using the Skyrme $SIII$ effective force [21] whose value for realistic single-particle spectroscopic properties is well established (see also Ref. [22] for a pure Nilsson approach). In Ref. [17], the somewhat poor character of relevant experimental data available at that time precluded the possibility of drawing definite conclusions on the validity of these calculations for well-deformed nuclei. With the far better current experimental knowledge [23], the agreement is much more convincing and rules out in particular the $g_R^0=Z/A$ estimate in most cases (see Table I).

A last theoretical value g_R^{PHF} may be derived [24,25] within a projected HF framework. As shown in Ref. [17] (and examplified in Table I), however, g_R^{PHF} values are systematically closer to g_R^0 than to g_R^{IC}, which thus seems to disqualify them for an accurate description of experimental data in deformed nuclei.

A word of caution should, however, be made concerning the previous approaches which all stem from an intrinsic state. For well-deformed nuclei, such an intrinsic state is, as is well known [26], to be considered as a kind of average over many members of the rotational band associated with it. This average extends over a broad range of spin values as the expectation value of the $\mathbf{J}^2$ operator for the considered intrinsic state is large. Therefore, for SD states in the $A=190$ region, where the very large deformation, and thus the underlying intrinsic state, seems rather constant within the SD bands (as established experimentally by lifetime measurements [27–32]), the previous g_R^{IC} values may be genuinely considered as a band average of the collective gyromagnetic ratio. This is less legitimate in cases where there are slight variations of g_R as a function of the angular momentum as theoretically considered in Ref. [33] and observed for some

TABLE I. Collective gyromagnetic factors for ground-state nuclei. The simple hydrodynamic value $g_R^0 = Z/A$ is compared to the projected HF value $g_R^{\rm PHF}$ and to the microscopic Inglis cranking value $g_R^{\rm IC}$. Experimental data are given with error bars in parentheses.

Nucleus	Z/A	$g_R^{\rm PHF}$ [17]	$g_R^{\rm IC}$ [17]	Expt. [23]
^{152}Sm	0.408	0.431	0.446	0.420(25)
^{158}Gd	0.405	0.402	0.376	0.381(4)
^{162}Dy	0.407	0.399	0.370	0.343(14)
^{166}Er	0.410	0.392	0.338	0.324(5) 0.316(5)
^{174}Yb	0.402	0.378	0.306	0.338(4)
^{178}Hf	0.404	0.367	0.299	0.240(14) 0.300(20)
^{182}W	0.407	0.355	0.267	0.260(8) 0.264(6)
^{184}W	0.402	0.355	0.271	0.289(6) 0.288(7)
^{188}Os	0.404	0.370	0.332	0.292(10) 0.305(15)
^{190}Os	0.400	0.372	0.341	0.350(11)
^{192}Os	0.396	0.385	0.378	0.396(10)
^{194}Pt	0.402	0.356	0.272	0.301(16) 0.203(6)

normally deformed rotational states [23] (where one gets a variation of g_R of up to 10% for spin values from 2 to 10 in even-even Sm and Gd isotopes, of up to 10%).

In this paper, we recall in Sec. II the Inglis cranking approach applied to static Hartree-Fock plus BCS calculations (HFBCS). In Sec. III, we first present and analyze the $g_R^{\rm IC}$ values obtained for twelve even-even mercury and lead isotopes. We also discuss the spectroscopic properties of the known SD states in neighboring odd nuclei and predict them for the whole $A = 190$ mass region.

II. THEORETICAL FORMALISM

The collective gyromagnetic ratio can be expressed within the microscopic Inglis cranking approach as [17,18]

$$g_R^{\rm IC} = \frac{1}{\mathcal{J}_{\rm cr}} \left\{ \sum_{k\ell}{}' \frac{\langle \ell | m_- | k \rangle \langle k | j_+ | \ell \rangle}{E_k + E_\ell} (u_k v_\ell - u_\ell v_k)^2 + \frac{1}{2} \sum_{kl}{}'' \frac{\langle \bar{\ell} | m_- | k \rangle \langle k | j_+ | \bar{\ell} \rangle}{E_k + E_\ell} (u_k v_\ell - u_\ell v_k)^2 \right\}, \quad (1)$$

where Σ' implies a sum over all HF orbitals having a positive z component of the angular momentum operator $\mathbf{J}$ $(K>0)$, while in Σ'', one sums only the contribution of the orbitals having $K = \frac{1}{2}$. It is, of course, assumed that the wave function of the even-even nucleus is time reversal invariant, so that each orbital $|k\rangle$ and its time reversed $|\bar{k}\rangle$ are equally occupied. The quasiparticle energies $E_k = [(\varepsilon_k - \lambda)^2 + \Delta_k^2]^{1/2}$, with usual notation, are obtained by solving coupled HFBCS equations.

In Eq. (1), the Inglis cranking moment of inertia is given [18], with the same notation, as

$$\mathcal{J}_{\rm cr} = \sum_{k\ell}{}' \frac{|\langle k | j_+ | \ell \rangle|^2}{E_k + E_\ell} (u_k v_\ell - u_\ell v_k)^2 + \frac{1}{2} \sum_{k\ell}{}'' \frac{|\langle k | j_+ | \bar{\ell} \rangle|^2}{E_k + E_\ell} (u_k v_\ell - u_\ell v_k)^2 \quad (2)$$

and the operator m_- is the relevant component of the magnetic moment operator

$$\mathbf{m} = \sum_i g_\ell^i \mathbf{j_i} + (g_s^i - g_\ell^i) \mathbf{s_i}, \quad (3)$$

where the sum runs on all single particle states i whose gyromagnetic factors g_ℓ^i and g_s^i depend on the associated charge state $q(i)$.

Assuming now that $g_\ell^n = 0$ and $g_\ell^p = 1$, one may rewrite Eq. (1) as

$$g_R^{\rm IC} = \frac{\mathcal{J}_{\rm cr}^p}{\mathcal{J}_{\rm cr}} + (g_s^p - 1) \frac{W_p}{\mathcal{J}_{\rm cr}} + g_s^n \frac{W_n}{\mathcal{J}_{\rm cr}} \quad (4)$$

with the following expressions for W_q:

$$W_q = \frac{1}{\mathcal{J}_{\rm cr}} \left\{ \sum_{k\ell}{}' \frac{\langle \ell | s_- | k \rangle \langle k | j_+ | \ell \rangle}{E_k + E_\ell} (u_k v_\ell - u_\ell v_k)^2 + \frac{1}{2} \sum_{k\ell}{}'' \frac{\langle \ell | s_- | k \rangle \langle k | j_+ | \ell \rangle}{E_k + E_\ell} (u_k v_\ell - u_\ell v_k)^2 \right\}, \quad (5)$$

q denoting the charge state, i.e., n or p, on which one performs the summation in the above Eq. (2).

III. RESULTS FOR SUPERDEFORMED NUCLEI

A. Even-even Hg and Pb nuclei

We have calculated the collective gyromagnetic ratios for twelve Hg and Pb isotopes corresponding to all the even-even nuclei with a neutron number N ranging from 108 to 118. For that purpose, static HFBCS wave functions have been obtained on a three-dimensional grid [34–36] using the SkM^* effective force [37] in the particle-hole channel together with a constant strength pairing interaction. The values obtained for $g_R^{\rm IC}$ are listed in Table II and plotted on Fig. 1. They are found to be smaller than the bulk Z/A values by about 30% as it was previously obtained for normally de-

TABLE II. Collective gyromagnetic ratios at the SD minima for even-even Pb and Hg isotopes. The g_R^{IC} value obtained within the Inglis cranking approximation is given for two values of the intrinsic g_s factors. The corresponding moments of inertia $\mathcal{J}_{\mathrm{cr}}$, charge quadrupole moments Q_0, and rigid-body Z/A values are given for comparison.

Nucleus	^{190}Pb	^{192}Pb	^{194}Pb	^{196}Pb	^{198}Pb	^{200}Pb
Z/A	0.432	0.427	0.423	0.418	0.414	0.410
g_R^{PHF}	0.424	0.416	0.411	0.409	0.401	0.402
g_R^{IC} ($g_{s\ \mathrm{free}}$)	0.318	0.338	0.333	0.338	0.323	0.332
g_R^{IC} ($0.7g_{s\ \mathrm{free}}$)	0.323	0.340	0.336	0.340	0.327	0.335
Q_0 (eb)	16.9	18.4	19.5	19.7	19.5	19.7
$\mathcal{J}_{\mathrm{cr}}$ ($\hbar^2$ MeV^{-1})	100.9	105.7	114.3	114.9	117.3	115.9
Nucleus	^{188}Hg	^{190}Hg	^{192}Hg	^{194}Hg	^{196}Hg	^{198}Hg
Z/A	0.425	0.421	0.417	0.412	0.408	0.404
g_R^{PHF}	0.424	0.418	0.414	0.411	0.403	0.407
g_R^{IC} ($g_{s\ \mathrm{free}}$)	0.329	0.356	0.361	0.363	0.350	0.370
g_R^{IC} ($0.7g_{s\ \mathrm{free}}$)	0.334	0.358	0.362	0.364	0.352	0.371
Q_0 (eb)	16.2	17.3	17.9	18.5	18.3	18.5
$\mathcal{J}_{\mathrm{cr}}$ ($\hbar^2$ MeV^{-1})	101.7	105.4	111.9	119.2	121.5	118.4

formed nuclei (see Table I). They are quite independent of the choice of the spin gyromagnetic ratios (free or quenched by 30% for instance).

Let us analyze now the various contributions to g_R^{IC} as resulting from Eq. (4). The contributions proportional to W_n and W_p are much smaller than $\mathcal{J}_{\mathrm{cr}}^p/\mathcal{J}_{\mathrm{cr}}$ and almost totally cancel each other (see Fig. 2). The collective gyromagnetic factor is thus approximated to better than 10% by the ratio $\mathcal{J}_{\mathrm{cr}}^p/\mathcal{J}_{\mathrm{cr}}$. This explains why it is quite independent of the choice of g_s^n and g_s^p. Figure 1 displays also the rigid body estimate of g_R calculated with the same wave functions:

$$g_R^{\mathrm{RB}}=\frac{\mathcal{J}_p}{\mathcal{J}_p+\mathcal{J}_n}=\frac{Z\langle z^2+y^2\rangle_p}{Z\langle z^2+y^2\rangle_p+N\langle z^2+y^2\rangle_n}. \tag{6}$$

While this approximation closely follows the Z/A bulk estimate, it widely differs from the more microscopic g_R^{IC} expression.

As already noted in the introduction for the normal deformation case, the projected HF values g_R^{PHF} are found to be close to Z/A (and to g_R^{RB} as well). For reference the charge quadrupole moments Q_0 and the Inglis cranking moments of inertia $\mathcal{J}_{\mathrm{cr}}$ for the twelve nuclei under consideration are also listed in Table II.

B. Resulting spectroscopic properties of superdeformed states in neighboring odd nuclei

Clearly, the knowledge of g_R values together with the single-particle level scheme around the Fermi energy are in general the essential ingredients of a correct assignment of valence orbitals in odd nuclei. This is particularly true in SD states. While the first requirement is precisely the topic of the present paper, the second is already rather well documented in the $A=190$ region of SD states after the phenomenological mean-field approach of Ref. [38] and the HFBCS approach of [39] which give qualitatively similar results.

Within the strong-coupling rotor+quasiparticle model, one can define the intrinsic gyromagnetic factor g_K as

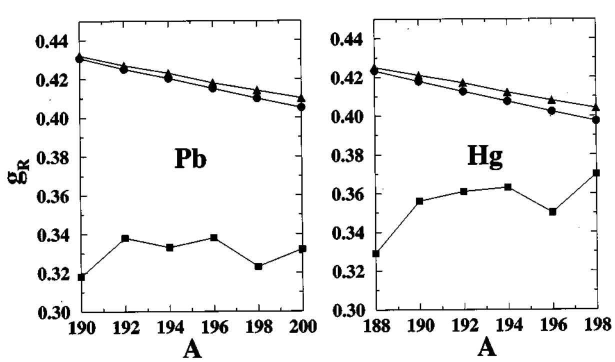

FIG. 1. Collective gyromagnetic ratios g_R, calculated at the SD minimum, as a function of A for Pb (left) and Hg (right) isotopes. Inglis cranking g_R^{IC} (boxes); rigid body g_R^{RB} (circles), and bulk Z/A (triangles).

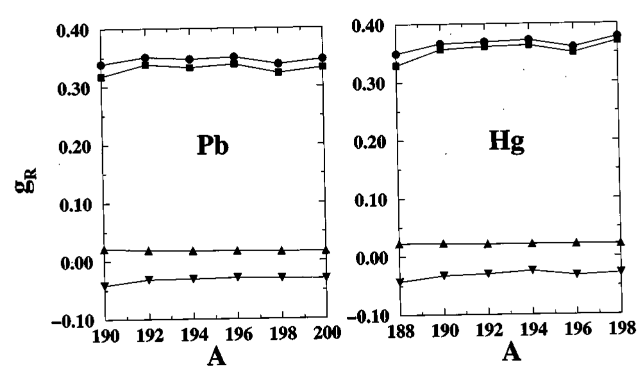

FIG. 2. Contributions (at the SD minimum) of the different terms of Eq. (4) to the Inglis cranking estimate g_R^{IC} (boxes) of the collective gyromagnetic ratio $\mathcal{J}_{\mathrm{cr}}^p/\mathcal{J}_{\mathrm{cr}}$ (circles), $(g_s^p-1)(W_p/\mathcal{J}_{\mathrm{cr}})$ (triangles), and $g_s^n(W_n/\mathcal{J}_{\mathrm{cr}})$ (inverse triangles).

TABLE III. Magnetic properties at the SD minima for odd nuclei. (i) Experimental ratio $R=(g_K-g_R/Q_0)K$ measured in SD bands. (ii) For comparison, the g_K gyromagnetic coefficient is extracted from R with the bulk Z/A estimate and within the microscopic Inglis cranking approximation (this work) for the collective gyromagnetic ratio g_R^{IC}. (iii) With the latter, the semiempirical $\langle s_z\rangle_{\mathrm{exp}}$ is calculated. (iv) With the $\langle s_z\rangle_{\mathrm{th}}$ obtained in HFBCS calculations, the α_q quenched factors are calculated.

Nucleus	^{193}Hg $\nu[512]5/2^-$	^{193}Pb $\nu[624]9/2^+$	^{193}Tl $\pi[642]5/2^+$	^{195}Tl $\pi[642]5/2^+$
R	-0.14 ± 0.01 [6]	-0.245 ± 0.007 [9]	0.138 ± 0.008 [7]	0.14 ± 0.05 [10]
g_K with $g_R=Z/A$	-0.65 ± 0.14 [6]	-0.39 ± 0.12 [9]	1.46 ± 0.17 [7]	1.4 ± 0.4 [10]
g_K with $g_R=g_R^{\mathrm{IC}}$	-0.70 ± 0.14	-0.48 ± 0.12	1.40 ± 0.17	1.34 ± 0.4
$\langle s_z\rangle_{\mathrm{exp}}$	0.46 ± 0.09	0.57 ± 0.14	0.22 ± 0.09	0.19 ± 0.22
$\langle s_z\rangle_{\mathrm{th}}$	0.42	0.46	0.39	0.39
α_q	1.09 ± 0.23	1.2 ± 0.3	0.65 ± 0.08	0.57 ± 0.17

$$g_K=g_{\ell}+(g_s-g_{\ell})\frac{\langle K|s_z|K\rangle}{K}. \tag{7}$$

The latter enters the expression of the intensity ratio of $\Delta I=1$ and $\Delta I=2$ γ transitions from a same level, in terms of the ratio $B(M1)/B(E2)$:

$$\frac{B(M1;I\rightarrow I-1)}{B(E2;I\rightarrow I-2)}=\frac{(3/4\pi)(e\hbar/2Mc)^2(g_K-g_R)^2K^2\langle IK10|I-1K\rangle^2}{(5/16\pi)e^2Q_0^2\langle IK20|I-2K\rangle^2}. \tag{8}$$

This expression is only valid for $K\neq 1/2$. For $K=1/2$ bands, the numerator of Eq. (8) must be replaced by

$$B(M1;I\rightarrow I-1)=\frac{3}{16\pi}\left(\frac{e\hbar}{2Mc}\right)^2(g_K-g_R)^2\times\left\langle I\frac{1}{2}10\middle|I-1\frac{1}{2}\right\rangle^2\{1+(-)^{I+(1/2)}b\}^2. \tag{9}$$

In Eq. (9) the magnetic decoupling factor b is expressed as

$$b=\frac{1}{g_K-g_R}\left[a(g_R-g_{\ell})+(-)^{\ell}(g_{\ell}-g_s)\left(\tfrac{1}{2}+\left\langle\tfrac{1}{2}\middle|s_z\middle|\tfrac{1}{2}\right\rangle\right)\right] \tag{10}$$

while the usual decoupling factor a is defined as

$$a=-\left\langle\frac{1}{2}\middle|j_+\middle|\overline{\frac{1}{2}}\right\rangle. \tag{11}$$

As a consequence, the experimental data for SD bands with $K\neq 1/2$ yields the ratio

$$\rho=\frac{(g_K-g_R)K}{Q_0}\left|\frac{\langle IK10|I-1K\rangle}{\langle IK20|I-2K\rangle}\right|, \tag{12}$$

whereas for $K=1/2$, the corresponding ratio is

$$\rho=\frac{(g_K-g_R)}{Q_0}\left|\frac{\langle I(1/2)10|I-1(1/2)\rangle}{\langle I(1/2)20|I-2(1/2)\rangle}\right|\frac{1}{2}\{1+(-)^{I+(1/2)}b\}. \tag{13}$$

Now for a given set of data concerning a SD band, one makes two assumptions: (i) the spin I of the considered state, (ii) its single-particle configuration.

It is only through those *a priori* statements that one can deduce from measured $B(M1)/B(E2)$ ratios an ''experimental'' value for the ratio R:

$$R=\frac{(g_K-g_R)}{Q_0}K. \tag{14}$$

These are, so far, only four pieces of relevant data known for SD states in the $A=190$, namely for ^{193}Hg [6], ^{193}Pb [9], ^{193}Tl [7], and ^{195}Tl [10]. The corresponding ''experimental'' R values are listed in Table III (for the quoted assumed configurations). Out of these ratios R, one may extract g_K values upon giving to g_R and Q_0 some specific values. For Q_0, we have used, as done in Refs. [6,7,9,10], the experimental value $Q_0=19\pm2$ eb, deduced from Doppler-shift attenuation method (DSAM) measurements in the neighboring even nuclei, i.e., ^{192}Hg [28], ^{194}Hg [31,32], and ^{194}Pb [29,30].

For g_R now, we have considered two cases: (i) the bulk Z/A estimates, (ii) the microscopic (and physically more relevant) values g_R^{IC} which we have calculated.

The resulting g_K values are listed in the two cases in Table III. From these g_K values, and in the g_R^{IC} case, one can deduce using the Eq. (7) a semiempirical expectation value $\langle s_z\rangle_{\mathrm{exp}}$ with the free values for g_s for instance. Or else, one can extract the quenching factor α_q for g_s when considering the calculated HFBCS $\langle s_z\rangle_{\mathrm{th}}$ expectation value.

The semiempirical $\langle s_z\rangle_{\mathrm{exp}}$ and caculated values $\langle s_z\rangle_{\mathrm{th}}$ are shown to compare reasonably well in Table III. The quenching factors are also displayed in this Table III. It is difficult to draw definite conclusions on the quenching factors in view of the scarcity of experimental data so far. It is encouraging, however, to find that the neutron and proton quenching factor values are consistent for all known cases: $\alpha_n\simeq 1.0$, $\alpha_p\simeq 0.6$.

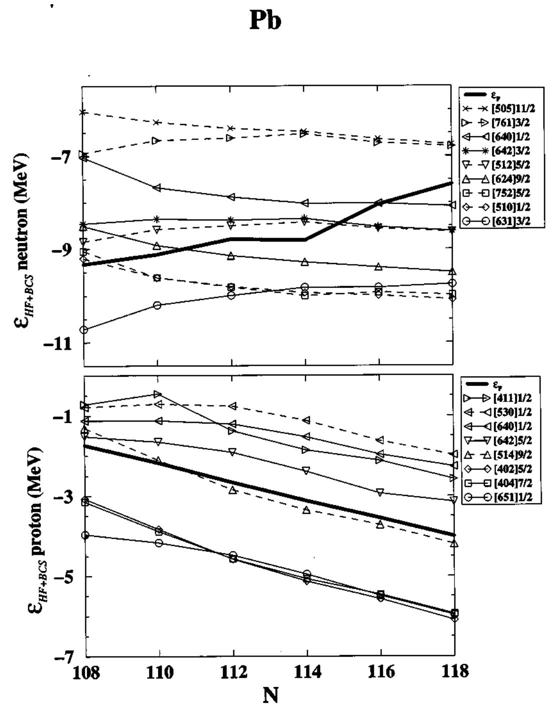

FIG. 3. HFBCS single particle spectra near the Fermi level as a function of the neutron number in Pb isotopes.

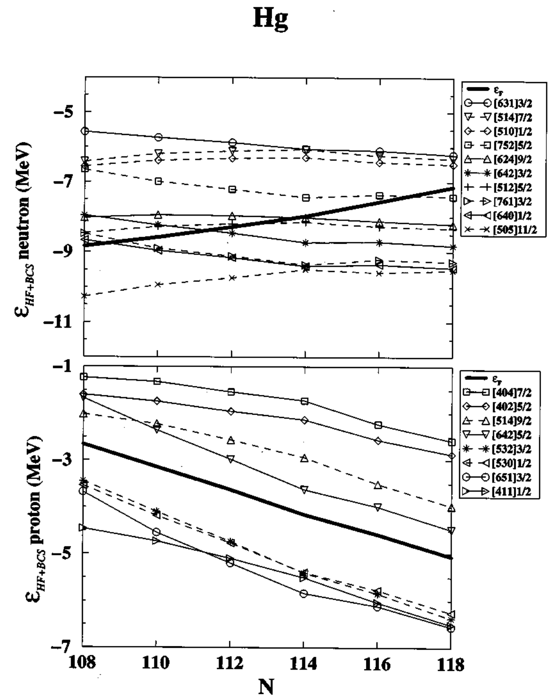

FIG. 4. Same as Fig. 3 for Hg isotopes.

The value obtained here for ^{193}Tl, i.e., $\alpha_p \simeq 0.65 \pm 0.03$ is in agreement with the one proposed in [7] (0.70 ± 0.2) even though in the latter case it stems from a somewhat crude mixture of simple model estimates for $\langle s_z \rangle$ and g_R (taken as Z/A) with the Q_0 value deduced from DSAM lifetime measurements.

C. Spectroscopic assignments

Let us discuss the relevance of the two assigments made on the total angular momentum I and the single particle configuration. First, let us notice that using or not using the exact values of I affect the Clebsh-Gordan coefficients ratio occurring in Eqs. (12),(13). For instance in the experimental case of ^{193} Tl [7] the variation of I from $I = 21/2$ to $I = 43/2$ results in a variation of R of the order of 5%.

The assignment of single-particle configuration is, *a priori*, a far more delicate matter. It relies, obviously, on some model calculations. To check the consistency of our assignments, we will concentrate here only on the agreement between experimental and theoretical R values. We have selected for each experimental band all single-particle configurations whose quasiparticle energies are less than 3 MeV. As a matter of fact, for a given odd nucleus we have considered the two adjacent even ''core'' nuclei, namely, ^{192}Hg and ^{194}Hg, ^{192}Pb and ^{194}Pb for the neutron states, ^{192}Hg and ^{194}Pb, ^{194}Hg and ^{196}Pb for the proton states. The relevant single-particle configurations are displayed on Figs. 3 and 4 where they are plotted for each of the twelve calculated nuclei in their SD equilibrum states. The corresponding theoretical ratios are presented in Tables IV and V with the estimated quenching ratios obtained, i.e., $\alpha_n \simeq 1.0$ and $\alpha_p \simeq 0.6$. For each of the four experimentally studied SD bands, we are able to assign the configurations and we may confirm the previous assignments by merely considering the theoretical ratio $R = [(g_K - g_R)/Q_0]K$.

Let us first discuss the neutron states. In ^{193}Pb, only two configurations have large absolute values of R ratios, around -0.20, the $\nu[505]11/2$ and the $\nu[624]9/2$, but the former is excluded since it lies at about 2.5 MeV above the Fermi level (see Fig. 3). We have to note that the 1/2 configurations (for instance, the $\nu[510]1/2$) are excluded because, as demonstrated by cranked calculations [40], these orbitals are immediately split even at low frequency so that cross talk is forbidden.

Similarly, in the case of ^{193}Hg, with an experimental R ratio equal to -0.14, the configurations $\nu[512]5/2$ and $\nu[752]5/2$ are, *a priori*, both possible with values ranging between -0.140 and -0.120. The $\nu[512]5/2$ configuration is closer to the Fermi level and is then preferred. The $\nu[631]3/2$ and $\nu[731]3/2$ configurations presented as possible candidates by [41] are rejected in our calculation (respectively with $R = -0.075$ and $R = -0.090$).

For the two proton cases, the $\pi[642]5/2$ orbital is the unique possibility to obtain a R value around $+0.14$, since the $\pi[530]1/2$ and $\pi[402]5/2$ configurations are ruled out by energy considerations (see Fig. 4).

As a result, we may conclude that, in all four cases, the single-particle assignments made by the experimentalists (albeit grounded on non-self-consistent or bulk theorerical quantities) are confirmed by our microscopic analysis. Our predicted values of the R ratios combined with the single-particle spectra around the Fermi level could be compared with the experimental data under analysis, for instance in $^{195-197}$Pb, or odd Thallium and Bismuth SD nuclei.

D. On the influence of the effective Hamiltonian in use

As discussed for instance in [35], the better surface tension properties of the SkM^* force yields a description of the total energy of SD solutions which is better than what could

TABLE IV. Prediction for the $R=(g_K-g_R/Q_0)K$ ratio at the SD minimum using HFBCS calculations for different neutron (ν) and proton (π) valence orbitals in the $^{190-200}$Pb isotopes with $\alpha_n=1.0$ and $\alpha_p=0.6$.

Nucleus	^{190}Pb	^{192}Pb	^{194}Pb	^{196}Pb	^{198}Pb	^{200}Pb
ν[505]11/2	−0.217	−0.205	−0.192	−0.191	−0.189	−0.190
ν[761]3/2	−0.089	−0.086	−0.081	−0.080	−0.080	−0.080
ν[640]1/2	0.036	0.030	0.028	0.028	0.029	0.029
	−0.110	−0.115	−0.112	−0.111	−0.109	−0.109
ν[642]3/2	−0.010	−0.003	−0.002	0.001	0.001	0.002
ν[512]5/2	−0.140	−0.135	−0.129	−0.128	−0.128	−0.126
ν[624]9/2	−0.189	−0.178	−0.167	−0.168	−0.165	−0.167
ν[752]5/2	−0.124	−0.117	−0.109	−0.109	−0.108	−0.110
ν[510]1/2	0.003	0.000	0.001	0.001	0.000	0.000
	−0.250	−0.201	−0.193	−0.191	−0.189	−0.184
ν[631]3/2	−0.071	−0.075	−0.075	−0.074	−0.072	−0.072
π[411]1/2	−0.030	−0.029	−0.029	−0.029	−0.027	−0.027
	−0.058	−0.053	−0.050	−0.050	−0.050	−0.049
π[530]1/2	0.145	0.136	0.130	0.129	0.131	0.130
	−0.013	−0.0010	−0.009	−0.009	−0.010	−0.010
π[532]3/2	0.019	0.013	0.012	0.011	0.012	0.011
π[642]5/2	0.157	0.140	0.133	0.131	0.134	0.131
π[514]9/2	0.248	0.223	0.212	0.210	0.215	0.211
π[402]5/2	0.166	0.153	0.145	0.143	0.146	0.143
π[404]7/2	0.074	0.065	0.062	0.060	0.064	0.065
π[651]1/2	0.077	0.065	0.061	0.061	0.066	0.067
	−0.037	−0.039	−0.039	−0.040	−0.041	−0.040

TABLE V. Same as Table IV for $^{188-198}$Hg isotopes.

Nucleus	^{188}Hg	^{190}Hg	^{192}Hg	^{194}Hg	^{196}Hg	^{198}Hg
ν[505]11/2	−0.230	−0.224	−0.218	−0.211	−0.210	−0.213
ν[640]1/2	0.040	0.033	0.032	0.032	0.032	0.031
	−0.107	−0.116	−0.116	−0.109	−0.110	−0.109
ν[761]3/2	−0.094	−0.093	−0.090	−0.087	−0.085	−0.086
ν[512]5/2	−0.145	−0.142	−0.140	−0.138	−0.138	−0.139
ν[642]3/2	−0.016	−0.009	−0.007	−0.005	−0.006	−0.007
ν[624]9/2	−0.200	−0.194	−0.189	−0.183	−0.182	−0.185
ν[752]5/2	−0.131	−0.127	−0.123	−0.119	−0.119	−0.120
ν[510]1/2	0.000	0.000	0.001	0.000	0.000	0.001
	−0.224	−0.211	−0.207	−0.201	−0.202	−0.201
ν[514]7/2	0.023	0.016	0.017	0.014	0.017	0.013
ν[631]3/2	−0.068	−0.075	−0.075	−0.075	−0.074	−0.073
π[411]1/2	−0.031	−0.031	−0.030	−0.030	−0.030	−0.030
	−0.059	−0.057	−0.055	−0.053	−0.053	−0.053
π[651]3/2	0.107	0.099	0.096	0.094	0.094	0.092
π[530]1/2	0.150	0.141	0.138	0.134	0.137	0.134
	−0.013	−0.012	−0.011	−0.011	−0.011	−0.011
π[532]3/2	0.019	0.014	0.012	0.011	0.012	0.010
π[642]5/2	0.165	0.145	0.140	0.136	0.138	0.133
π[514]9/2	0.256	0.233	0.224	0.216	0.223	0.216
π[402]5/2	0.167	0.160	0.154	0.148	0.152	0.147
π[404]7/2	0.075	0.065	0.062	0.059	0.063	0.059

TABLE VI. Collective gyromagnetic factors $g_R^{\rm IC}$ calculated for four nuclei using the $SIII$ and SkM^* Skyrme effective forces. The free g_s values are used here.

	^{190}Hg	^{194}Hg	^{192}Pb	^{196}Pb
$g_R^{\rm IC}$ ($SIII$ force)	0.330	0.343	0.305	0.319
$g_R^{\rm IC}$ (SkM^* force)	0.356	0363	0.338	0.338

be obtained with the Skyrme $SIII$ interaction. Even though the latter is known *a priori* to give better results for spectroscopic properties, it has been checked that the quantities entering the evaluation of R, namely Q_0, g_K, via the $\langle s_z \rangle$ value and $g_R^{\rm IC}$ are very much the same with both forces. Indeed no significant discrepancy is observed on the quadrupole moment Q_0 and on the g_K value with $K>5/2$ for which cross-talk transitions can be observable. For the collective gyromagnetic ration $g_R^{\rm IC}$, we present in Table VI the theoretical values obtained with SkM^* and $SIII$ effective forces respectively in four cases, i.e., ^{190}Hg, ^{194}Hg, ^{192}Pb, and ^{196}Pb. A slight difference between 5 and 10 % can be noted when the $SIII$ is used. Moreover, as seen in [39], the corresponding single-particle spectra are also very similar qualitatively for both forces in these SD nuclei.

It is well known that the moments of inertia are strongly influenced by the global strength of the pairing interaction. We have used a constant pairing matrix element approximation (namely with $G_n = 16.5$ MeV and $G_p = 17.5$ MeV) acting on all states below an energy cutoff at 5 MeV above the Fermi level. This choice of strength has been *a posteriori* assessed by a good agreement between the theoretical and the recent experimental SD excitation energy values in ^{194}Pb [42] and ^{194}Hg [43]. However, one might improve our approach by using a more sophisticated pairing interaction with a density-dependent form factor as, e.g., in Ref. [44,45].

IV. CONCLUSIONS

In this paper we have demonstrated in a microscopic treatment that the collective gyromagnetic ratio g_R differs for superdeformed nuclei around $A = 190$ significantly from the Z/A value. From available data related to the cross-talk transitions, we have been able to deduce, in the framework of the strong-coupling model, the quenching factors for the $\pi[642]5/2$ SD proton and the $\nu[512]5/2$ and $\nu[624]9/2$ SD neutron configurations. The predicting power of our Inglis cranking microscopic calculations, checked on normal deformation data, has allowed us to give the theoretical values of the ratio $(g_R - g_K/Q_0)K$ for many odd superdeformed nuclei of the $A = 190$ mass region.

A possible explanation for the existence of a quenching factor α_q can be found in the presence of a tensor term in the effective magnetic operator. An extensive study taking into account this extra term within the rotor+quasiparticle model using our lattice microscopic HFBCS wave functions is currently in progress. It should be finally noted that a more sophisticated treatment of the rotational degree of fredom for large values of frequencies and diabatical motion [45,46] still remains to be performed for the collective gyromagnetic factor.

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