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ON HINDERED ELECTRIC TRANSITIONS IN NUCLEI USED FOR OBSERVATION OF P-VIOLATING EFFECTS IN THE WEAK INTERACTIONS OF NUCLEONS

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ON HINDERED ELECTRIC TRANSITIONS IN NUCLEI USED FOR OBSERVATION OF P-VIOLATING EFFECTS IN THE WEAK INTERACTIONS OF NUCLEONS

I. INTRODUCTION

Weak interaction theories predict the existence of parity-violating forces between nucleons. In a number of very precise experiments, see for instance [1], it was shown that the corresponding effects are really seen in the nuclear electromagnetic transitions. There were observed angular asymmetry of the photons emitted by polarized nuclei and circular polarization of the photons emitted by non-polarized nuclei. In both the cases their magnitudes are proportional to the weak interaction constant G.

These effects appear because in the electromagnetic transition of a multipolarity ℓ to a regular transition $M\ell$ due to the weak interaction there admixtures a transition of opposite parity (irregular) $\tilde{E\ell}$, or to the regular transition $E\ell$ - irregular $\tilde{M\ell}$. In the latter case the contribution of $\tilde{M\ell}$ is suppressed both by the weak interaction constant G and by the kinematic factor $R \simeq v/c \simeq 0.1$ [2]. Therefore in such cases experiments are carried out with nuclei in which there are so-called "structural" and "dynamic" mechanisms of enhancement of the P-violating effect [2,3], for instance,

$^{161}Dy(\frac{3}{2}^{-}\frac{3}{2} \to \frac{5}{2}^{+}\frac{5}{2})$ /4/, $^{175}Lu(\frac{9}{2}^{-}\frac{9}{2} \to \frac{7}{2}^{+}\frac{7}{2})$ /1,5/, $^{180}Hf(8^{-}8 \to 8^{+}0)$ /6/. The effect of structural enhancement, in particular, is due to the suppression of $E\ell$-transition because of the structural peculiarities of participating in the transition states, for instance, in the mentioned transition in ^{175}Lu. In this case the contribution from the $M(\ell+1)$ amplitude is essential.

The ratio of the probabilities of regular transition of multipolarity $\ell+1$ and ℓ is usually extracted from analysing the measured coefficients of the internal conversion /7,8/ or angular correlations of photons of a given transitions. Due to suppression of the magnitude of transition charged moments of hindered transitions, the toroid moments in some cases are of very importance /9/, which contribution is not taken into account in the traditional approach to calculation of probabilities of multipole transitions.

In the present paper we consider the effect of toroid moments on the characteristics of the hindered electromagnetic transitions.

II. STATUS OF TOROID MOMENTS

As is known (see, e.g., refs./10,11/), the probability of the $E\ell$-type of transition by a system is determined by transverse electric distributions $E_{\ell m}(\vec{k}^2)$, and that of the $M\ell$ -type of transition by magnetic distributions $M_{\ell m}(\vec{k}^2)$. For calculations of the transition probabilities of atoms and nuclei, the long-wave approximation $\vec{k}^2 \to 0$ is commonly used. In this approximation $M_{\ell m}(\vec{k}^2 \to 0)$ coincides with a standard definition of the magnetic moment, and $E_{\ell m}(\vec{k}^2)$ splits into the sum of two independent multipole moments - the charge and toroid ones /9/:

$$E_{\ell m}(\vec{k}^2)_{\vec{k}^2\to 0} = -i\omega Q_{\ell m}(0) + \vec{k}^2 T_{\ell m}(\vec{k}^2 \to 0), \quad k^2 = \omega^2 - \vec{k}^2 \qquad (1)$$

where

$$T_{\ell m}(0) = -\sqrt{\frac{4\pi\ell}{2(2\ell+1)}} \int r^{\ell+1} \{\vec{Y}^{*}_{\ell\ell-1m}(\vec{n}) + 2\frac{\sqrt{\ell+1}}{2\ell+3}\sqrt{\ell}\,\vec{Y}^{*}_{\ell\ell+1m}(\vec{n})\}\vec{J}(\vec{r})\,d^3r, \qquad (2)$$

$$\vec{n} = \frac{\vec{r}}{|\vec{r}|}$$

Due to the factor $\vec{k}^2$ before $T_{\ell m}$ in (1) this term is usually omitted. In this way $E_{\ell m}(0)$ (defined by transverse part of current) is reduced approximately to $Q_{\ell m}(0)$ (given by the longitudinal-scalar part of a current). This approximation in the theory of atomic and nuclear transitions is called the Siegert theorem (see, e.g., ref. /12/). However, since $T_{\ell m}$ is the third (independent of $Q_{\ell m}$ and $M_{\ell m}$) set of moments constituting with them the complete basis for the expansion of an arbitrary current /9/, the Siegert theorem is valid only if the quantitative contribution of $T_{\ell m}$ is really small. At the small $\vec{k}^2$ the contribution of the toroid part usually is much smaller than that of Q_ℓ, because T_ℓ is of the same order of magnitude as $M_{\ell+1}$. However for instance this is not oblige for inelastic electron scattering by the nuclei in the case as $\vec{k}^2$ is large and $\omega \ll |\vec{k}|$. Then the contribution of T_ℓ is significant and for individual measurement of Q_ℓ, T_ℓ and $M_{\ell+1}$ it is necessary to perform a complete experiment [13].

Here we consider the role of T_ℓ in the case of hindered transition moments $Q_\ell(0)$ in the processes of emission of γ-rays in atomic nuclei ($\omega = |\vec{k}|$). Note that in the emission processes the contributions from T_ℓ and Q_ℓ cannot be separated experimentally since the properties of space parity of operators Q_ℓ and T_ℓ are the same and the angular functions for them in the current expansion coincide [9]. Therefore, measurements of the $E\ell$-transition probability always give the sum of contributions $(Q_\ell + T_\ell)^2$.

Remind also, that in nuclei aside from convection currents there are induction currents $\vec{J}^{ind} = \mathrm{rot}\,\vec{M}(\vec{r})$ defined by the nucleon dipole magnetic moment distribution $\vec{M}(\vec{r})$. Inserting $\vec{J}^{ind}$ into (2) we have [13]:

$$T^{ind}_{\ell m} = -i\sqrt{\frac{4\pi\ell}{(2\ell+1)(\ell+1)}}\int r^\ell \vec{Y}^{*}_{\ell\ell m}(\vec{n})\vec{M}(\vec{r})\,d^3r = \frac{1}{\ell+1}\sqrt{\frac{4\pi}{2\ell+1}}\int \vec{M}(\vec{r})\,\mathrm{rot}(\vec{r}\,r^\ell Y_{\ell m})\,d^3r. \qquad (3)$$

This part of toroid moment has been introduced by Blatt and Weisskopf [10] and is called [11] induced electric moments $Q'_{\ell m}$.

III. THE DEFINITION OF MULTIPOLE OPERATORS

In calculating the probability of electromagnetic transitions in nuclei it suffices

to take into account only the contributions from the lowest multipole moments. We write down the definitions of multipole operators normalizing them according to [8]:

$$\hat{\vec{E}}_1 \equiv \left(\frac{\vec{E}_1}{\omega}\right)^+ = \hat{\vec{Q}}_1 + \hat{\vec{T}}_1, \qquad (4)$$

$$\hat{\vec{Q}}_1 \equiv i\vec{Q}_1 = ie_{eff}\vec{r} = ie\left(1-\frac{Z}{A}\right)\vec{r}, \qquad (5)$$

where $\vec{E}_1$ and $\vec{Q}_1$ was defined by (1), and $\hat{\vec{T}}_1$ is expressed via the operator T_1 introduced into (2) as follows: $\hat{\vec{T}}_1 = \omega\vec{T}_1$, and is equal to:

$$\hat{\vec{T}}_1 = -ie\frac{\hbar\omega}{Mc^2}\sqrt{\frac{3}{4\pi}}\left\{\frac{1}{5}r^2\vec{\nabla} - i\frac{1}{2}\left[\vec{r}\times\left(g_\sigma\vec{\sigma}+\frac{2}{5}g_\ell\vec{\ell}\right)\right]\right\}, \qquad (6)$$

$$\hat{M}_{2\mu} = -i\frac{e\hbar}{2Mc}\left(g_\sigma\vec{\sigma}+\frac{2}{3}g_\ell\vec{\ell}\right)\vec{\nabla}\left(r^2 Y_{2\mu}\right), \qquad (7)$$

$$\hat{\tilde{\vec{M}}}_1 \equiv -i[S,\hat{\vec{M}}_1] = iMG''\frac{e\hbar}{2Mc}(2g_\sigma - g_\ell)[i\vec{\sigma}\times\vec{r}]\sqrt{\frac{3}{4\pi}}, \qquad (8)$$

where $S \doteq MG''\vec{\sigma}\vec{r}$,

$\left.\begin{matrix} g_\sigma = 2.79 \\ g_\ell = 1 \end{matrix}\right\}$ for proton and $\left.\begin{matrix} g_\sigma = -1.91 \\ g_\ell = 0 \end{matrix}\right\}$ for neutron.

Here $\hat{Q}_1$ is the operator of the charge dipole moment, $\hat{\vec{T}}_1$ – the operator of the toroid dipole moment, $\hat{M}_1$ is the operator of the magnetic dipole moment, $\hat{M}_{2\mu}$ – the operator of the magnetic quadrupole moment, M – the nucleon mass, and G'' – the constant of parity-violating weak interaction (related linearly to the Fermi constant G [7]). To obtain the values of transition moments one needs to calculate the matrix elements of the corresponding operators, acting on the ket states. The operator $\tilde{\hat{M}}_1$ is represented as the commutator of the usual operator $\hat{M}_1$ with the operator $\vec{\sigma}\vec{r}$. The latter, due to the weak interaction, admixes to the wave function of initial and final states the wave functions of all states of a given nucleus with the same total moments but with the opposite parity. This way of mixing was introduced into /7/ and discussed in /8/.

Let us also write down the definition of a degree of circular polarization of the photons emitted by a non-polarized nucleus /8/:

$$P_\gamma = \frac{2A(\hat{E}_1)A(\tilde{\hat{M}}_1)}{A^2(\hat{E}_1)+A^2(\hat{M}_2)} = 2\frac{1}{1+\delta^2}\frac{A(\tilde{\hat{M}}_1)}{A(\hat{E}_1)}, \qquad (9)$$

where $A(\hat{O})$- are the amplitudes of the multipole operators $\hat{O}$, $\delta = \frac{A(\hat{M}_2)}{A(\hat{E}_1)}$. Within this definition, the angular asymmetry coefficient a_γ in the reaction $A(n,\gamma)A'$ of gamma-ray transition relative to the direction of the neutron polarization is given by the same formula as P_γ.

IV. RESULTS AND DISCUSSIONS

Let us consider the transition $\frac{9^-}{2}\ \frac{9}{2}[514] \to \frac{7^+}{2}\ \frac{7}{2}[404]$ with the energy 396 keV in the nucleus of ^{175}Lu. As is known /14/ its multipole structure is: $E1 + M2 + \tilde{M}1$. The admixture of M2 is 20% /7,15,16/. We calculate the pro-

babilities of the regular E1- and M2 - and irregular $\tilde{M}1$ -transitions in the Nilsson model, considering all the components of wave functions of initial and final states. The obtained results are given in Table 1, where η is the Nilsson parameter, β - the deformation parameter.

Table 1

η	β	$T(\hat{E}_1)_N$	$T(\hat{M}_2)_N$	$T(\tilde{\hat{M}}_1)_N$
6	0.3	2.10×10^{10} sec^{-1}	6.87×10^{6} sec^{-1}	$0.76\cdot F^2\cdot10^{11}$ sec^{-1}
4	0.2	1.58×10^{10} sec^{-1}	7.37×10^{6} sec^{-1}	$0.43\cdot F^2 10^{11}$ sec^{-1}

The quantity F characterizes factor of admixture of the states with the opposite parity ($\psi = \psi^{\pi} + i\,F\,\psi^{-\pi}$) and is equal to $F = MG''R$ /7/, where $R=R_0A^{1/3}$ is the nucleus radius. Here, $T(\hat{E}_1)_N$, $T(\hat{M}_2)_N$ and $T(\tilde{\hat{M}})_{1N}$ - are the calculated in the Nilsson model probabilities of E_1-, M_2- and $\tilde{M}_1$ -transitions, respectively.

It is known, that the probabilities of the transition moments Q_1 calculated in the Nilsson model are much higher than the experimental ones. Indeed for the considered transition in the nucleus of ^{175}Lu it is known /15/ that $T(\hat{E}_1) = 1.1\cdot10^8$ sec^{-1}, and $\frac{T(\hat{E}_1)}{T(\hat{M}_2)} = 4$, i.e., $T(\hat{M}_2) = 2.75\cdot10^7$ sec^{-1} and consequently,

$$\frac{T(\hat{E}_1)_N}{T(\hat{E}_1)} \approx \begin{cases} 191 \text{ for } \eta = 6 \\ 143 \text{ for } \eta = 4 \end{cases} \qquad \frac{T(\hat{M}_2)_N}{T(\hat{M}_2)} \approx \begin{cases} 0.25 \text{ for } \eta = 6 \\ 0.27 \text{ for } \eta = 4 \end{cases}$$

Thus, the calculation in the Nilsson model gives satisfactory agreement with an experiment for the M2-transition and the exceeding by two orders of magnitude for the E1-transition. Therefore, to evaluate the contribution of the T_1 moment, we present the results in a rather different form.

Table 2

η	β	$\frac{A(\hat{Q}_1)}{A(\hat{M}_2)}$	$\frac{A(\hat{T}_1)}{A(\hat{M}_2)}$	$\frac{A(\hat{M}_2)_N}{A(\hat{M}_2)}$	$\frac{A(\hat{E}_1)}{A(\hat{M}_2)}$	$\frac{A(\hat{\tilde{M}}_1)_N}{A(\hat{M}_2)}$
6	0.3	2.47	-0.47	0.5	2	$4.19\cdot10^{-5}$
4	0.2	2.35	-0.35	0.5	2	$3.16\cdot10^{-5}$

where $A(\hat{O})_N$ are the amplitudes of the multipole operators $\hat{O}$, calculated in the Nilsson model, and $A(O)$ are the experimental values of the same amplitudes.

The ratio of the amplitude of $\hat{T}_1$ operator to that of $\hat{M}_2$ operator given in the fourth colomn of Table 2 is also calculated in the Nilsson model. We believe, however, that the theory gives right value of this ratio,

i.e., $\frac{A(\hat{T}_1)_N}{A(\hat{M}_2)_N} \approx \frac{A(\hat{T}_1)}{A(\hat{M}_2)}$.

Such an assumption can be explained in the following way. The wave function of the excited state has the form:

$$\frac{9^-}{2}\ \frac{9}{2}[514] = 0.980\cdot|554+> + 0.198\cdot|555-> ,$$

the function of the ground state /17/:

$$\frac{7^+}{2}\ \frac{7}{2}[404] = 0.204\cdot|443+> -0.979\cdot|444->, \quad (\eta=6).$$

Therefore, if one takes only the main components of the functions, it is evident, that Q_1 between such states gives no contribution. But if one takes into account small components then they provide the destructive interference (close values with different phases), that finally causes so strong suppression of the Q_1 contribution.

Thus, one may assert that since the main contribution to E1 comes from the transition between small components, then discrepancies and unavoidable and dependent on the choice of a nuclear model. The situation changes essentially in calculating the moments M_2 and T_1. The operators $\hat{T}_1$ and $\hat{M}_2$ have the similar structure (see formulae (6) and (7)), and the main contribution to the transitions due to them comes from the leading components of wave functions. Therefore, the theoretical value of amplitude of the M2-transition $A(\hat{M}_2)_N$ approaches the experimental one $A(\hat{M}_2)$ (the fifth column of Table 2). For the same reason it may be expected that the theoretical value of $A(\hat{T}_1)_N$ is close to the experimental one. Under these assumptions one can find the amplitude of the Q_1-transition from the relation

$$[A(\hat{Q}_1) + A(\hat{T}_1)]^2 = T(\hat{E}_1). \qquad (10)$$

The results are given in the third column of Table 2. Now the ratio between the charge and toroid components of the E1 -transition is as follows:

$$\left|\frac{T(\hat{E}_1)-T(\hat{Q}_1)}{T(\hat{Q}_1)}\right| \simeq 2\,\frac{A(\hat{T}_1)\,A(\hat{Q}_1)}{[A(\hat{Q}_1)]^2}=0.33 \qquad (11)$$

(we neglect the ratio $\left[\frac{A(\hat{T}_1)}{A(\hat{Q}_1)}\right]^2$, which is a much higher order of smallness by magnitude).

It is seen thus that the contribution from the transition toroid moments turns out to be rather large due to the structural suppression of Q_1-transition.

Let us consider another transition, between the first excited $J^\pi=1/2^-$ and ground $J^\pi=1/2^+$ states in ^{19}F with the energy 110 keV. This transition differs from the above one as here only the E1 -type of emission occurs and the M2 -transition is forbidden by the selection rules. The calculation with the wave functions as given in paper /18/ has shown that the contribution of T_1 is small in this case ($\lesssim$ 0.1%). Meanwhile, from the analysis of the transition $\frac{9^-}{2}\frac{9}{2} \to \frac{7^+}{2}\frac{7}{2}$ in ^{175}Lu it follows that even in the case when the M2 contribution in this transition were equal not to 20% but to about 1%, the T_1 -contribution would be nevertheless significant:

$$2\left|\frac{A(\hat{T}_1)}{A(\hat{Q}_1)}\right| \simeq 0.10-0.15$$

(of the order 10-15%) due to the interference with Q_1. This may be an indication

that at least in those transitions where M2 is not very small (M2 $\gtrsim$ 1%) the T_1 contribution cannot be neglected.

In papers /3/ and /14/ the experimental data are compiled on measurements of asymmetry and circular polarization of the gamma-ray transition. In Table 3 we give the transitions with a noticeable contribution from T_1. This holds in odd deformed nuclei where the effect of structural suppression of $E\ell$ -transitions (the effect of suppression due to the structural properties of nuclear states in the transitions) is of much importance. Table 3 presents the hindered E1 -transitions (with considerable admixture of M2) where one may expect the transitional toroid moments T_1.

V. ON CALCULATION OF P_γ IN THE TRANSITION $\frac{9^-}{2}\frac{9}{2} \to \frac{7^+}{2}\frac{7}{2}$ (^{175}Lu)

On the basis of the previous estimates we calculate the circular polarization of the gamma-ray transition (with energy 396 keV) in nucleus of ^{175}Lu in the Nilsson model with taking into account all components of wave functions. The obtained value $P_\gamma = 3.4\cdot 10^{-5}$ is consistent with experiment $P_\gamma = (4\pm1)\cdot 10^{-5}$ /1/. (The same calculation has been made by /23/ for the irregular $\tilde{M}1$ -transition. It turns out that the application of the Saxon-Woods, instead of Nilsson, potential slightly influences the value of P_γ). However, in Table VII of ref./24/ where the results of various calculations are shown they differ from obtained

Table 3

Nucleus	Transition energy, Kev	Transition	Types of regular transitions and their relative contribution (experiment)	Irregular transition	Results of measurement of gamma-ray asymmetry, a_γ and circular polarization, P_γ.
^{75}As	401	$\frac{5}{2}^{+} \rightarrow \frac{3}{2}^{-}$	E1+(~3%)$M2$ /19/	$\tilde{M1}$	$P_\gamma = -(6.0 \pm 2.0) \cdot 10^{-5}$ /20/
^{161}Dy	75	$\frac{3}{2}^{-}\ \frac{3}{2}[521] \rightarrow \frac{5}{2}^{+}\ \frac{5}{2}[642]$	E1+($M2$) /19,21/	$\tilde{M1}$	$a_\gamma = -(2.0 \pm 2.0) \cdot 10^{-5}$ /4/
^{175}Lu	396	$\frac{9}{2}^{-}\ \frac{9}{2}[514] \rightarrow \frac{7}{2}^{+}\ \frac{7}{2}[404]$	E1+(20%)$M2$ /15,16/	$\tilde{M1}$	$P_\gamma = (4.0 \pm 1.0) \cdot 10^{-5}$ /1/ $P_\gamma = (4.5 \pm 1.0) \cdot 10^{-5}$ /5/
^{177}Hf	208	$\frac{9}{2}^{+}\ \frac{9}{2}[642] \rightarrow \frac{9}{2}^{-}\ \frac{7}{2}[514]$	E1+(~0.1%)$M2$ /19,21/	$\tilde{M1}$	$P_\gamma = (3.0 \pm 13.0) \cdot 10^{-4}$ /22/

both in magnitude and in sign of the circular polarization. In particular, all the data of ref. /25/ shown in that table have the negative sign. The sign minus is due to including of ρ -exchange terms in the nucleon-nucleon potential /26/. Besides, all data of ref. /25/ should be lowered since they are based on calculations /7/ which do not consider small components of wave functions and therefore are 2.6 times overestimated. It should be noted that experimentalists identify Q_1 with E_1 in formula (9) and therefore in interpretation of measurement results for P_γ no errors do arise.

Calculations of the effect of circular polarization based on the model of single-particle parity violating potential without taking into account V_π potential (e.g., paper /7/ with allowing for the correction factor 2.6, paper /23/ and this one) produce the results consistent with experiment. Calculations with V_π, V_ρ and also with the pairing and short-range correlations /26/ have resulted in decreasing the magnitude of P_γ by an order and, consequently, made inconsistent theory and experiment.

In conclusion we discuss the question of whether the $\hat{\tilde{T}}_1$ contribution can be essential when $\hat{M}_1$ interferes with $\hat{\tilde{Q}}_1$. At the first view the exact answer is "not" since the coefficients for operators $\hat{Q}_1$ and $\hat{T}_1$ (formulas (5) and (6)) show that $\frac{\langle \hat{T}_1 \rangle}{\langle \hat{Q}_1 \rangle} \sim 10^{-4}$. This estimate, however, is very rough, as it is seen from the example of transitions

$$^{181}\mathrm{Ta}\,(482\ \mathrm{KeV})\ \frac{5}{2}^+ \frac{5}{2} \to \frac{7}{2}^+ \frac{7}{2}$$

and

$$^{175}\mathrm{Lu}(343\,\mathrm{KeV})\ \frac{5^+}{2}\frac{5}{2} \rightarrow \frac{7^+}{2}\frac{7}{2}$$

analysed in ref. /18/.

It is shown /8/ that the $\hat{\tilde{Q}}_l$ -contribution in both the transitions is strongly suppressed as

$$\hat{\tilde{Q}}_1 \sim G''[\vec{r}, \vec{\sigma}\vec{p}\ ] \sim -im\omega[\vec{r}, \vec{\sigma}\vec{r}] \rightarrow 0. \qquad (12)$$

$\hat{\tilde{Q}}_1$ will differ from zero if one takes into account that the shell model Hamiltonian contains a small admixture of the spin-orbital interaction $-\kappa(\vec{l}\vec{s})$ forbidding the substitution $\vec{p} \rightarrow -im\,\omega\,\vec{r}$. Therefore the $\tilde{Q}_1$ contribution appears to be proportional to $\kappa \sim 10^{-1} \div 10^{-2}$. The contribution from $\vec{\tilde{Q}}_1 \sim \vec{\sigma}$ is suppressed also structurally since the contribution of $\vec{M}_l \sim g_\ell \vec{l} + g_\sigma \vec{\sigma}$ for the transition in ^{181}Ta is suppressed in $10^5 \div 10^6$ times, in ^{175}Lu in 600 times /8/.

Now we give the formula for $\tilde{T}_1$:

$$\tilde{T}_{1\nu} = \tilde{E}_{1\nu} - \tilde{Q}_{1\nu} = \tilde{E}_{1\nu} + \sqrt{\frac{3}{4\pi}}\, G''\sigma_\nu = \qquad (13)$$

$$= \frac{1}{\sqrt{3\pi}}\left(\frac{g_\ell}{5} - g_\sigma\right)\frac{\omega r^2}{M}\,\sigma_\nu - \sqrt{2}\sum_{\mu m}(1\mu 1\nu|2m)\frac{\omega r^2}{M} Y_{2m}\,\sigma_\mu .$$

It is seen, first, that $\tilde{T}_1 \neq 0$ even at $\kappa = 0$ in the nuclear Hamiltonian and, second, that the selection rules for $\tilde{T}_1$ differ from those for $\tilde{Q}_1$ in the orbital quantum number, that should intensify the $\langle\tilde{T}_1\rangle$ contribution. (The latter is quite analogous to the situation in conversion (ref. /8/, formulae (33) and references therein), where $\hat{M}_e$ contains the additional to $\hat{M}_\gamma$ term of the form $\vec{r}(\vec{\sigma}\vec{r})$). Concrete estimates by formula (6) show that

in the considered transitions in ^{181}Ta and ^{175}Lu the $\langle\tilde{T}_1\rangle$ contributions are of several per cents, i.e., there occurs the enhancement of about two orders. Though in this case the $\langle\tilde{T}_1\rangle$ contribution appears to be small relative to that from $\langle\tilde{Q}_1\rangle$, it is required to estimate its contribution in each special case just because of its possible enhancements.

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