THE THEORY AND DIRECT OBSERVATION OF CONTROLLED (SUPPRESSED) SPONTANEOUS NUCLEAR GAMMA-DECAY

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The theory of controlling and changing the spontaneous nuclear gamma-decay is discussed. The phenomenon of nuclear decay controlling is a result of the interaction of radioactive nuclei with zero-energy electromagnetic modes, which in turn interact with distant controlling and controlled screen. It was shown that the decay parameters greatly depend on the sign and magnitude of the radiation shift (radiation correction) of the resonance level position. In the experiment we have discovered the change (increase) of radiative life-time of excited nucleus Co^{57} (Fe^{57*}) (in relation to resonant Mossbauer gamma-channel of decay) by 10-40% and total life-time (including non-controlled non-Mossbauer radiation and non-controlled electron conversion channel of nucleus decay) by 1%.

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1. INTRODUCTION

The problem of controlled spontaneous gamma-decay of the excited and radioactive nuclei is one of the most interesting in the modern nuclear physics. There are two main models that describe the process of spontaneous decay. The first one considers spontaneous radiative decay as a purely induced process of quasi-laser type directly stimulated by zero oscillations of the electromagnetic field. According to second one it is a process of an excited system relaxation, the phase premises of which are caused by interaction with fluctuating state of the thermostat. But whichever of these models is used, the main point in calculation of probability and dynamics of such process is the consideration of peculiarities of excited quantum system (in our case - nucleus) interaction with the ensemble of vacuum state eigen-modes of the electromagnetic field surrounding the system.

In the case of free space without any material bodies the spontaneous gamma-decay is non-controlled process. Corresponding probability A_{eg} of this decay

$$A_{eg} \equiv 1/\vec{\tau} = (4\pi^2 \omega_{eg} |d_{eg}|^2 / 3\hbar)\rho(\omega_{eg}) = 4\omega_{eg}^3 |d_{eg}|^2 / 3\hbar c^3 \qquad (1)$$

is fully determined by the matrix element d_{eg} of nucleus dipole moment and spectral-volume density $\rho(\omega) = \omega^2/\pi^2 c^3$ of the modes of free quantized electromagnetic field.

Here τ is the radiative life-time in free space (without adjacent material bodies).

The total life-time of this excited nucleus in free space $\tau_{tot} = \tau/(1+\alpha) \equiv 1/\lambda$ is also the constant. Here α is the coefficient of internal electron conversion for the nuclear transition $E_e \to E_g = 0$, $\lambda = 1/\tau_{tot}$ is a constant of nuclear decay.

For the case of radiation transitions of higher multipolarity the expressions for radiative and total life-times also are constants.

The problem becomes very complicated in the important case when material bodies are present in the surrounding space. It is usually stated that in all cases with presence of any material bodies at macroscopic distance $L >> \lambda\!\!\!^{-}_{eg} \equiv 2\pi c/\omega_{eg}$ from the excited nucleus the expression for the life-times τ and τ_{tot} remains the same or changes by unmeasurably small value.

Such supposition is erroneous.

For the first time the idea of spontaneous gamma-decay controlling was suggested in [1]. In work [2] was shown that spontaneous gamma-decay is a process of an excited nucleus relaxation, the phase premises of which are caused by interaction with fluctuating state of the thermostat controlled by the resonant screen situated at the distance $L >> \lambda\!\!\!^{-}_{eg}$ from the nucleus. The phenomenon of controlled nucleus gamma-decay is a result of interaction of the nucleus with zero-energy modes, interaction these modes with the atoms of controlled (and controlling) screen, and interaction of the nucleus with the system of atom electrons.

We have carried out investigation aimed at direct experimental discovery (based on the theory [2] of controlled gamma-decay) of the phenomenon of radioactive nuclei gamma-decay controlling. The experiment was done using decay of excited state of Fe-57 isotope, under conditions where the line width is small on account of the Mossbauer effect. External observations of the decay rate indicate a small, but nonetheless statistically significant modification of the decay rate.

2. THE THEORY OF CONTROLLED SPONTANEOUS NUCLEAR RADIATIVE GAMMA-DECAY

We have considered [2] the general system, which included the excited atom nucleus (described by Hamiltonian operator $\hat{H}_A$), the system of the atom electrons (operator $\hat{H}_E$), the system of zero-energy (in vacuum state) electromagnetic modes (operator $\hat{H}_F$)

and the screen (operator $\hat{H}_R$) — the system of N resonant or non-resonant atoms situated at the distance $L >> \lambda_{eg}$ from the nucleus.

The phenomenon of controlled nucleus gamma-decay is a result of interaction $\hat{U}$ of the nucleus with zero-energy electromagnetic modes, interaction $V = \sum_i V^{(i)}$ of these modes with the atoms of controlled (and controlling) screen, interaction $\hat{T}$ of the nucleus with electrons system (see. Fig. 1).

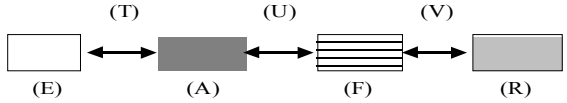

Fig. 1

Fig. 1

Schredinger equation for general system has the form $i\hbar\partial\Psi/\partial t = \hat{H}\Psi$.

Here $\hat{H} = \hat{H}_A + \hat{H}_F + \hat{H}_E + \hat{H}_R + \hat{U} + \hat{T} + \hat{V}$ is total Hamiltonian operator of the general system;

$$\Psi(r,t) = A(t)\Psi_{a000}(r)e^{-iE_a t/\hbar} + \sum_\beta F_\beta(t)\Psi_{0\beta 00}e^{-iE_\beta t} + \sum_e E_e(t)\Psi_{00e0}e^{-iE_e t} + \sum_n R_n(t)\Psi_{000n}e^{-iE_n t}$$

is the total wave function of the general system; ψ_{a000}, $\psi_{0\beta 00}$, ψ_{00e0} and ψ_{000n} are wave functions of the general system for cases of excited nucleus (excitation energy $E_a=\hbar\omega_a$), excited mode {β} (excitation energy $E_\beta=\hbar\omega_\beta$), excited electrons system state {e} (excitation energy $E_t=\hbar\omega_t$), and excited screen state {n} (excitation energy $E_n=\hbar\omega_n$), correspondingly.

The individual states of nucleus, field modes, excited nucleus atom electrons system and screen will be denoted by the indices *a*, β, e, n.

The time-dependence dynamics of spontaneous decay of the excited nucleus is described by unlimited system of equations

$$\begin{aligned} i\hbar e^{-i\omega_a t}dA/dt &= \sum_\beta F_\beta U_{a\beta}e^{-i\omega_\beta t} + \sum_e E_e T_{ae}e^{-i\omega_e t},\\ i\hbar e^{-i\omega_\beta t}dF_\beta/dt &= AU_{\beta a}e^{-i\omega_a t} + \sum_n R_n V_{\beta n}e^{-i\omega_n t},\\ i\hbar e^{-i\omega_n t}dR_n/dt &= \sum_\beta F_\beta V_{n\beta}e^{-i\omega_\beta t},\\ i\hbar e^{-i\omega_e t}dE_{e0}/dt &= AT_{ea}e^{-i\omega_e t} \end{aligned} \qquad (2)$$

Here $U_{a\beta}$, T_{ae} and $V_{n\beta}$ are correspondingly matrix elements of the interaction energy of nucleus (*a*) with field mode (β); interaction energy of nucleus (*a*) with excited nucleus atom electrons system in one of the possible states (e) and interaction energy of the screen in one of the possible states (n) with field mode (β).

We have obtained [2] the general solution of this system for the case of mutually uncorrelated modes of electromagnetic vacuum

$$A(t) = (2\pi i)^{-1}\int_{-\infty-i\delta}^{\infty-i\delta} e^{i\omega t}d\omega/\{\omega - \sum_e \frac{(|T_{ae}|^2/\hbar^2)}{(\omega_e-\omega_a+\omega)} - \sum_\beta \frac{(|U_{a\beta}|^2/\hbar^2)}{(\omega_\beta-\omega_a+\omega-\sum_n \frac{(|V_{n\beta}|^2/\hbar^2)}{(\omega_n-\omega_a+\omega)})}\},\ \delta\to+0;$$

$$|A(t)|^2 = e^{-t/\tau_{tot}^*}. \qquad (3)$$

It was shown for the first time [2] that if the screen made from resonant ($\omega_{n0}\approx\omega_\beta$) atoms acts on the excited nucleus inside solid angle $\Delta\Theta<4\pi$, the result is the change of both the radiative life-time ($\tau\to\tau^*$)

$$\tau^* = \tau/\{\mathrm{Re}[(1-2i\tau\Delta\omega_0)[1-(f\Delta\theta/4\pi)(1-(1+iG/2-\Delta\Omega)^{-4})]]\} \equiv \tau/\{1-(f\Delta\theta/4\pi)(1-\tau/\tau_{eff}^*)\} \qquad (4)$$

and the total life-time ($\tau_{tot}\to\tau_{tot}^*$) of the nucleus

$$\tau_{tot}^* = \tau/\{\alpha+\mathrm{Re}[(1-2i\tau\Delta\omega_0)[1-(f\Delta\theta/4\pi)(1-(1+iG/2-\Delta\Omega)^{-4})]]\} \equiv \tau/\{\alpha+1-(f\Delta\theta/4\pi)(1-\tau/\tau_{eff}^*)\}. \qquad (5)$$

Here $\Delta\omega = \dot{P}\int_0^\infty \frac{2\omega_\beta^3|d_{eg}|^2 d\omega_\beta}{3\pi\hbar c^3(\omega_\beta-\omega_a)}$

is the radiative shift of excited energy level of the nucleus (radiation correction or nuclear analog of the Lamb shift for atom electrons);

$$G = 2N\pi^2|D_{eg}(\omega_{no})|^2/3\tau^*\hbar v_0[(\omega_{n0}-\omega_a)^2+(1/2\tau^*)^2];\Delta\Omega_{res} = (3\tau^*/\pi)G;$$

v_0 is a quantizing volume of the electromagnetic mode; N is a total number of resonant atoms of the screen in the volume v_0; D_{eg} is a matrix element of screen atom dipole momentum; f is a parameter of recoil-free resonant radiation (parameter of Mossbauer) for the case of Mossbauer nucleus;

$$\tau_{eff}^* \equiv \tau/\{\mathrm{Re}(1-2i\tau\Delta\omega_0)(1+iG/2-\Delta\Omega)^{-4}\}$$

is the effective radiative life-time for Mossbauer component of controlled radiative gamma-decay for gamma-radiation inside solid angle ΔΘ blocked by the resonant screen.

The operator $\dot{P}$ (in the expression for $\Delta\omega_0$) denotes the Cauchy principal value of the integral. The sense of effective radiative life-time τ^*_{eff} is directly following from the subsequent examination.

The equation for changes of the population n_e of excited nuclei during decay (defined by partial probabilities of transformed Mossbauer radiation in blocked angle $P_M^* = f(\Delta\theta/4\pi)/\tau^*$, non-transformed Mossbauer radiation in non-blocked angle $P_M^* = f[1-(\Delta\theta/4\pi)]/\tau$, non-Mossbauer radiation $P_{NM} = (1-f)/\tau$ in the total solid angle $\Delta\Theta=4\pi$ and electron conversion $P_\alpha = \alpha/\tau \equiv 1/\tau_\alpha$) has a form

$$dn_e/dt = \sum_{i>e} n_i/\tau_{ie(tot)} - n_e/\tau_{tot}^* \qquad (6)$$

Here

$$\tau^* = (P_M^* + P_M + P_{NM})^{-1} \equiv$$
$$\tau/\{1 - (f\Delta\Theta/4\pi)(1 - \tau/\tau_{eff}^*),$$
$$\tau_{tot}^* = (P_M^* + P_M + P_{NM} + P_\alpha)^{-1} \equiv$$
$$\tau/\{\alpha + 1 - (f\Delta\Theta/4\pi)(1 - \tau/\tau_{eff}^*),$$

$1/\tau_{ie(tot)}$ is a total probability of transition from upper level $E_{i>e}$ to investigated excited level E_e; τ^*_{tot} is the total life-time of excited nucleus with presence of resonant absorber; $\tau_\alpha = \tau/\alpha$ is electron conversion life-time of excited nucleus. Using these equations we have

$$\tau_{eff}^* = \tau/\{1 - (4\pi/f\Delta\Theta)(1 - \tau/\tau^*).$$

In the case of the ideal resonant screen (at f = 1 and $\Delta\Theta = 4\pi$) we have $\tau^*_{eff} = \tau^*$. In the case without screen (e.g. at $\Delta\Theta \to 0$) we have $\tau^* = \tau$ and $\tau^*_{eff} = \tau$. From this consideration follows that τ^*_{eff} is a changed life-time of radiation decay in the case of presence of an ideal screen.

The expressions (4) and (5) were obtained in [2] under the condition that all electromagnetic modes are quantized at the same (or approximately the same) values of relation N/v_0. If the resonant atoms of the screen are identical to the researched atom (containing the excited nucleus) than we have $D_{eg} = d_{eg}$ and

$$|D_{eg}|^2 = 3\hbar c^3/4\pi\omega_a^3.$$

For the case when the excited nucleus is a Mossbauer one, the screen is made from Mossbauer resonant atoms and the usual condition of small modification of a electromagnetic modes spectrum $G \ll 1$ holds, at exactly resonant state $\omega_{n0} = \omega_\beta$ we have

$$\tau_{tot}^* \approx \tau/\{\alpha + 1 - (f\tau\Delta\omega_0 G\Delta\Theta/\pi)\} \approx$$
$$\tau_{tot}\{1 + 2f\tau\Delta\omega_0\Delta\Theta\pi c^3 N/v_0(\alpha+1)^2\omega_{n0}^3\}, \qquad (7)$$
$$\tau^* \approx \tau/\{1 - (f\tau\Delta\omega_0 G\Delta\Theta/\pi)\} \approx$$
$$\tau_{tot}\{1 + 2f\tau\Delta\omega_0\Delta\Theta\pi c^3 N/v_0(\alpha+1)\omega_{n0}^3\}. \qquad (8)$$

From formulas for τ^*_{tot} and τ^* follows that the decay parameters for the case when resonant screen is present greatly depend on the sign and magnitude of radiation shift $\Delta\omega_0$ of the resonance energy level position. E.g., at absent of radiation shift (at $\Delta\omega_0 = 0$) we have $\tau^*_{tot} = \tau_{tot}$, $\tau^* = \tau$. At positive sign of this shift (at $\Delta\omega_0 > 0$) we have the braked (partially suppressed) nuclear decay and $\tau^*_{tot} > \tau_{tot}$, $\tau^* > \tau$. For an opposite case of negative sign (at $\Delta\omega_0 < 0$) we have the accelerated decay and $\tau^*_{tot} < \tau_{tot}$, $\tau^* < \tau$. However, it is well known that the sign and magnitude of the radiation shift $\Delta\omega_0$ for nuclei are unknown.

For the case of non-resonant screen (at $\omega_{ns} \neq \omega_\beta$, $|\omega_{ns} - \omega_\beta| \gg 1/\tau^*$) we have other results

$$\tau_{tot}^* = \tau/\{\alpha + 1 - (\Delta\Theta/4\pi)[1 - (1 - \Delta\Omega_{nres})^{-4}]\} \approx$$
$$\tau_{tot}\{1 - \Delta\Omega_{nres}\Delta\Theta/\pi(\alpha+1)\}, \qquad (9)$$

$$\tau^* = \tau/\{1 - (\Delta\Theta/4\pi)[1 - (1 - \Delta\Omega_{nres})^{-4}]\} \approx$$
$$\tau\{1 - \Delta\Omega_{nres}\Delta\Theta/\pi\}. \qquad (10)$$

Here

$$\Delta\Omega_{nres} = 2N\pi\sum_s \frac{|D_{eg}(\omega_{ns})|^2(\omega_{ns} - \omega_a)}{3\hbar v_0[(\omega_{ns} - \omega_a)^2 + (1/2\tau^*)^2]} \approx$$
$$\approx 2N\pi\int f(\omega_{ns})\frac{|D_{eg}(\omega_{ns})|^2(\omega_{ns} - \omega_a)}{3\hbar v_0[(\omega_{ns} - \omega_a)^2 + (1/2\tau^*)^2]}d\omega_{ns}; \qquad (11)$$

$f(\omega_{ns})$ is a function of distribution of frequences ω_{ns} of absorbtion in the screen.

It was shown [2] that resonant screen effect in all cases appears to be more significant than nonresonant one. This result also follows from (9-11): in the case of ideal nonresonant screen we have $f(\omega_{ns}) = \text{const}$ and $\Delta\Omega_{nres} \to 0$ because of an oddness of the intergrand function in 11). In result from (9) and (10) we have $\tau^*_{tot} \to \tau/(\alpha+1)$, $\tau^* \to \tau$.

3. DIRECT OBSERVATION OF CONTROLLED NUCLEAR GAMMA-DECAY

In our previous experiments the phenomenon of controlled decay was studied indirectly by investigating two related phenomena: increase of the spontaneous gamma-radiation intensity in the solid angle that wasn't blocked by the resonant screen [3], and the change of spectral width of the emitted gamma-radiation at presence of the resonant screen [4]. The aim of the present experiment [5] was to observe directly and examine the law of the controlled gamma-decay of the second quantum of gamma-cascade (see Fig. 2) of radioactive $Co^{57}(Fe^{57*})$ nucleus at resonant screen presence by the delayed gamma-gamma coincidence method (see Fig 3).

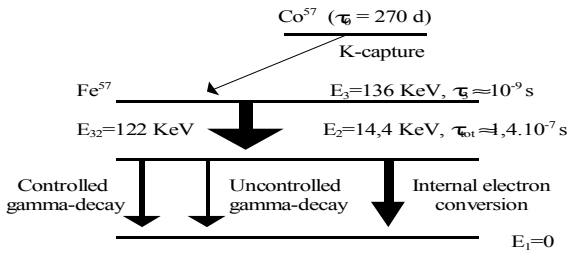

Fig. 2

Fig. 2

The $Co^{57}(Fe^{57*})$ radioactive isotope with energy $E_{21} \approx 14.4$ keV of controlled nuclear gamma-transition $2 \to 1$, internal electron conversion coefficient $\alpha \approx 8.2$, total life-time $\tau_{tot} = ln2\ T_{1/2} \approx 1{,}4.10^{-7}$ s and decay period $T_{1/2} \approx 0{,}98.10^{-7}$ s for this nuclear transition and with very small activity Q=10 μKu was used as a source of controlled Mossbauer radiation 1.

This source had the spectrum in the form of a single line of natural width. The source had thickness about 5 μm, was fixed on the surface of Plexiglas disc with thickness 2 mm and put in the center of the resonant absorber 2, having a form of cylinder with

diameter 2R ≈ 0.8 cm and length L ≈ 2.5 cm, made of stable Fe^{57} isotope in stainless steel. The thickness (surface density) of this Fe^{57} absorber was $\sigma_m \approx 7$ mg/cm^2. For the case of pure resonant Mossbauer radiation, the transparency coefficient of this absorber was $K \approx 10^{-4}$. For the case of non-resonant radiation, we had almost full transparency with $K \geq 0.8$. The total number of Fe^{57} nuclei on the length of resonant absorbtion of gamma-quanta with energy 14.4 keV on the internal surface $S_0 \approx 2\pi RL$ of the quantization volume $v_0 \approx \pi R^2 L$ equals about $N \approx 10^{19}$. For this absorber we had $N/v_0 \approx 10^{19}$ cm^{-3} and $\Delta\Theta \approx 3\pi$.

Behind the diaphragm 3 there was an amplitude detector 4 (thick NaJ(Tl) crystal with thickness about 4 cm) for detection of the first quantum of decay gamma-cascade with high energy $E_{32} \approx 122$ keV. Behind the diaphragm 5 there was another amplitude detector 6 (thin NaJ(Tl) crystal with thickness about 0.1 mm) for detection of the second quantum of decay cascade with energy $E_{21} \approx 14.4$ keV. The signal processing system picked out the part of amplitude spectrum close to the gamma-line with $E_\gamma \approx E_{21}$.

The law of gamma-decay

$$|A(t)|^2 = e^{-t/\tau_{tot}^*} = e^{-\lambda^* t}$$

of the second transition of the cascade from the excited state with energy $E_2 \approx 14.4$ keV to the final ground state $E_2 = 0$ of Fe^{57} nucleus was the object of our investigation. Two signals from the detectors 4 and 6 were used in the processing system 7 to obtain the law of gamma-decay. The measurements of the delay of the second quantum of gamma-cascade were performed in two regimes.

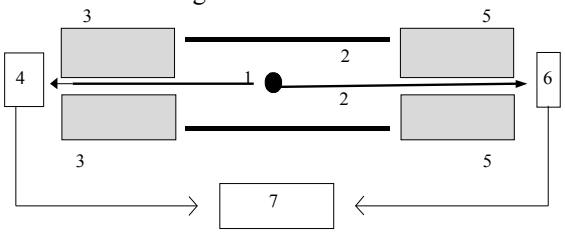

Fig. 3a

Fig. 3a

In the first regime (see Fig. 3a) the measurements corresponded to presence of the resonant absorber cylinder 2 (resonant screen) only. For this regime the total and radiative life-time were equal (see (6), (7))

$$\tau_{tot(res)}^* \equiv \tau_{tot}^* \approx \tau_{tot} / \{1 + \frac{2f\tau\Delta\omega_0\Delta\Theta\pi c^3 N}{v_0(\alpha+1)^2\omega_{n0}^3}\},$$

$$\tau_{(res)}^* \equiv \tau_t^* \approx \tau / \{1 + \frac{2f\tau\Delta\omega_0\Delta\Theta\pi c^3 N}{v_0(\alpha+1)\omega_{n0}^3}\}$$

In the second regime (see Fig. 3b) another cylinder 8 made of lead with diameter $D_1 \approx 1.4$ cm, length $L_1 \approx 5$ cm and thickness of the wall $\Delta D_1 \approx 0{,}5$ cm was put around the resonant absorber cylinder. It totally absorbed both the resonant and the non-resonant radiation in the range of energies close to $E_{21} \approx$ 14,4 keV. This corresponded to completely non-selective (non-resonant) absorber ("black" screen). For this regime

$$\tau_{tot(nres)}^* \equiv \tau_{tot} \approx \tau/(\alpha+1), \tau_{(nres)}^* \approx \tau$$

The same results $\tau_{tot} = \tau/\alpha$ and $\tau^* = \tau$ take place in the case of free space without a screen.

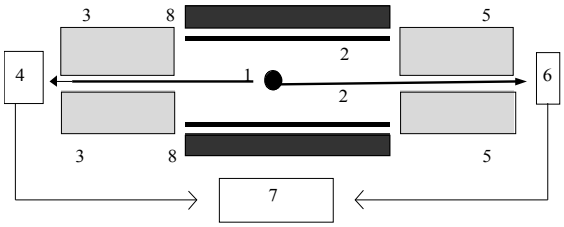

Fig. 3 b

Fig. 3b

Such method of investigation excludes the uncontrolled influence of reverse scattering of the resonant gamma-quanta after change from the pure resonant absorption (case 3a) to the non-resonant one (case 3b) (such influence would occur if the resonant absorber cylinder were simply taken off the source).

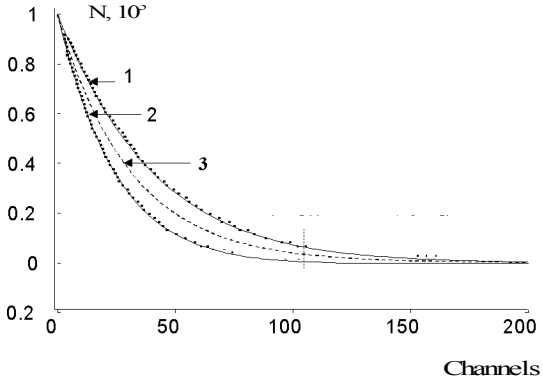

Fig. 4. *Controlled gamma-decay of excited level. Curve 1(presence of Fe^{57} screen): $N_1(t) = \langle N\rangle + 25(N_1 - \langle N\rangle)$, $\lambda^* = (0.03232 \pm 0.00003)$ per channel; Curve 2 (presence of Fe^{57} and Pb screens): $N_2(t) = \langle N\rangle + 25(N_2 - \langle N\rangle)$, $\lambda = (0.03266 \pm 0.00003)$ per channel; Curve 3(averaged decay): $N_3(t) = \langle N\rangle = (N_1 + N_2)/2$*

Each series of experiments in both regimes lasted $\Delta t = 10$ hours. The measured law of gamma-decay of the second transition $2 \rightarrow 1$ of the cascade $3 \rightarrow 2 \rightarrow 1$ in the final ground state of Fe^{57} nucleus (after three series of experiments) is presented on Fig. 4. In the experimental arrangement shown on Fig. 4 (time calibration is about $\delta t \approx 4.7$ ns per channel and time resolution of the coincidence spectrometer is about 5 ns) the contribution of the Mossbauer scattering was the same in both types of measurements – with and without the "black" lead screen surrounding the Mossbauer screen. It is known that the resonantly scattered radiation is delayed with respect to the primary beam. In the case of a strict resonance between the source and the (thick) scatterer, which takes place here, this delay is equal to τ_{tot}, and the time distribution of the scattered radiation is characterized by the decay constant $\lambda_s = 1/2\tau_{tot}$. Formulas for total intensities of registered both direct and scattered

resonant gamma-quanta of nuclear decay with energy $E_{21} \approx 14.4$ keV in both regimes are the following:

$$J_1(t) = J(0)[(1-g)e^{-\lambda_s^* t} + ge^{-\lambda_s^* t},$$
$$J_2(t) = J(0)[(1-g)e^{-\lambda t} + ge^{-\lambda_s t}.$$

The exact contribution of the resonance scattering was difficult to estimate *a priori*. However, considering the geometry, the recoilless fraction, and the internal conversion of the 14.4 keV transition, it could not be large enough to be resolved directly in the measured time spectra. Thus, we compared the effective decay constants of the time spectra measured with and without the Pb screen. The experimental points were fitted in the time range of the order of 900 ns**,** i.e. about 6.5 total life-times τ_{tot} of the 14.4 keV level.

It is seen that the experimental points in the apex of the curve lie lower than the fitting curve, which evidences a contribution of the delayed scattered radiation.

The computer simulation showed that the observed discrepancy could be attributed to $g \approx 0.1$ contribution of the components with

$$\lambda_s = 1/2\tau_{tot} \equiv \lambda/2 \text{ and } \lambda^*_s = 1/2\tau^*_{tot} \equiv \lambda^*/2.$$

So any difference in the decay constants for the spectra measured with and without the Pb screen should be attributed to the influence of the latter.

The decay constants, obtained from the fits are the following:

$\lambda^*=(0.03232\pm0.00003)$ per channel $\approx$

$(0.6877\pm0.0006)\cdot10^7\ s^{-1}$

with presence of Fe^{57} screen;

$\lambda=(0.03266\pm0.00003)$ per channel $\approx$

$(0.6950\pm0.0006)\cdot10^7\ s^{-1}$

with presence of Fe^{57} and Pb screens.

It is seen that in the second case the decay is slower, and the difference is well beyond the statistical uncertainty. The relative difference $\Delta\lambda/\lambda = (\lambda - \lambda^*)/\lambda = (0.0106\pm0.0018)$ may be ascribed to the retarding effect of the "black" lead screen. The averaged results (for three series of experiments) for changed total life-time τ_{tot}, radiative life-time τ and effective radiative life-time τ_{ef} equal

$$\Delta\tau_{tot}/\tau_{tot} \equiv \frac{\tau_{tot(res)}^* - \tau_{tot(nres)}^*}{\tau_{tot(nres)}^*} \approx (0.92\pm0.17).10^{-2},$$
$$\Delta\tau/\tau \equiv \frac{\tau_{(res)}^* - \tau_{(nres)}^*}{\tau_{(nres)}^*} \approx (0.092\pm0.017), \qquad (12)$$
$$\tau_{eff}^*/\tau = 1/\{1-(4\pi/f\Delta\theta)(1-\tau/\tau^*) \approx 1.32\pm0.05.$$

It follows from these results and equation (6) that the magnitude of the radiative shift of excited nucleus level Fe^{57} equals $\Delta\omega_0 \approx 10^{13}\ s^{-1}$ and the sign of the shift is positive.

CONCLUSION

The results of the presented experiments prove the main conclusion of the theoretical analysis about the possibility of controlled influence of a thin resonant screen on the temporal, amplitude and space characteristics of spontaneous decay and excited nuclei radiation. By optimization of decay controlling system parameters (using the nuclei without the electron conversion decay channel $\alpha \to 0$, the resonance absorbers with a maximum solid angle screening $\Delta\Theta \to 4\pi$, with maximum weight part of the gamma-radiative resonance channel $f \to 1$) it is possible to achieve significantly higher influence upon the spontaneous decay characteristics and, respectively, sharp increase of total life-time $\tau_{tot}^* >> \tau_{tot}$.

Among other conclusions, the obtained results in fact prove the existence of a peculiar macroscopic "distance effect" predicted above, namely the dependence of the effectiveness of quantum spontaneous decay process of the excited nuclei on macroscopically remote position $L>>\lambda_{eg}$ (e.g. about several cm) from the excited nucleus of a resonant absorbing screen (unlike, for example, Kazimir's effect manifesting itself only at microscopic distances).

In conclusion we would like to note that the effect of influence upon the spontaneous radiation characteristics of excited (radioactive) nuclei may manifest itself not only for Mossbauer nuclei and transitions but also for other excited states and nucleus types provided the existence for them of an obviously expressed resonance absorbtion.

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