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Experimental Discovery of the Phenomenon of Low-Energy Nuclear Transmutation of Isotopes ($Mn^{55} \Rightarrow Fe^{57}$) in Growing Biological Cultures

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Abstract

For the first time the experimental study of cold nuclear transmutation of isotopes was carried out in growing microbiological culture with controlled conditions of growth. With the help of Mossbauer effect the formation of Fe^{57} isotope from Mn^{55} in nutrient medium based on heavy water was observed. The possible mechanism of low-temperature nuclear transmutation is discussed.

1. Introduction

Hypothesis of possibility of nuclear transmutation of elements and isotopes in biological and geological structures has been repeatedly discussed during the last decades. The interest to this topic considerably increased after large-scale researches of the cold nuclear fusion phenomenon on the basis of dd-reactions in solids.

As far as we know, none of the previously conducted researches contains reliable data confirming the possibility of such transmutations.

We have carried out investigations aimed at discovery of nuclear transmutation of elements in microbiological cultures. We believe that this aim can be achieved only if an isotope obtained in the process of transmutation does not have any analogues in the nutrient medium where the culture is growing (along with inevitably present admixtures of this isotope). Therefore all experiments like [1] are hardly convincing because they don't meet this condition.

We have conducted a series of experiments based upon new technology employing the precise methods of Mossbauer spectroscopy. The experiments are based on the expected

$$Mn^{55}+d^{2}=Fe^{57}$$

reactions in growing microbiological culture in heavy-hydrous (D_2O) sugar-salt nutrient medium deficient in Fe but additionally containing Mn. The reaction results is generation of stable rare Fe^{57} isotope, concentration of which in the natural iron (mainly Fe^{55}) is very low.

The Fe^{57} isotope obtained in small quantities can be easily discovered by means of the Mossbauer effect. The Mossbauer effect allows to monitor the isotope contents of all components of the nutrient medium, the initial culture and all samples of initial culture after its growth has finished, taking into account all varieties of experiments.

2. Experimental method and procedures

The researches were carried out on the basis of bacterial cultures ***Deinococcus radiodurans M-1, Bacillus subtilis GSY 228, Escherichia coli K-1*** and yeast culture ***Saccharomyces cerevisiae T-8***, selected according to the possibility of their growth in light and heavy water media. The course of the experiments was as follows.

Previously obtained cultures after centrifuging, washing and post-growth were placed in a flask with sugar-salt nutrient medium containing salts of Mg, Ca, K, ammonium tartrate, sucrose and 10 ml of pure water (D_2O in transmutation experiments, H_2O in control experiments).

The composition of medium is shown in the table.

Components	Concentration in medium (%)	Admixture of Fe (no more) relative (%)	Admixture of Fe (no more) absolute (g)
Sucrose	3	10^{-4}	3.10^{-7}
$(NH_4)_2$ tartrate	1	5.10^{-4}	5.10^{-7}
$MgSO_4 \cdot 7H_2O$	0,25	2.10^{-4}	5.10^{-8}
$CaHPO_4 \cdot 7H_2O$	0,008	$1,5.10^{-3}$	$1,2.10^{-8}$
K_3PO_4	0,5	5.10^{-4}	$2,5.10^{-7}$
$MnSO_4 \cdot 7H_2O$	0,01	5.10^{-4}	5.10^{-9}
Pure water (D_2O or H_2O)	100 (10 ml)	10^{-7}	10^{-8}

In accordance with degree of purification of all nutrient medium ingredients (chemically pure category), the possible content of Fe as an admixture does not exceed $\Delta m \approx 1.1 \times 10^{-6}$g. In accordance with natural content of Fe^{57} isotope (2,2 per cent of the total Fe), its possible quantity as an admixture does not exceed $\delta m \approx 2.5 \times 10^{-8}$g.

In transmutation experiments, $MnSO_4$ containing less than $\Delta m_1 \approx 10^{-8}$g of Fe admixture and $\Delta m_0 \approx 2 \times 10^{-4}$g of basis stable Mn^{55} isotope ($N_0 = 1.8 \times 10^{18}$ of Mn^{55} atoms) was added to the sugar-salt nutrient medium.

All initial dry ingredients of the sugar-salt nutrient medium were investigated on Mossbauer spectrometer. The same investigation was held with a part of the inoculum in the nutrient medium of previously dried culture.

A typical series of experiments concerning nuclear transmutation of elements consisted in growing of certain microbiological culture in 3 disks simultaneously (see Fig.1)

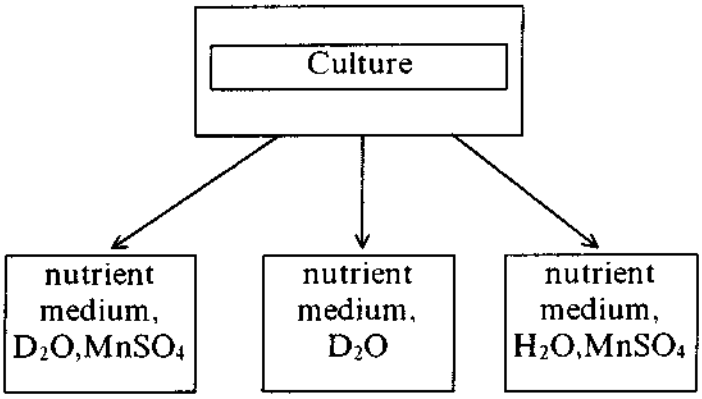

Fig.1 The scheme of experiment.

The first disk contained full-compounded heavy-hydrous (D_2O) nutrient medium with $MnSO_4$, the second one — also heavy-hydrous (D_2O) nutrient medium without $MnSO_4$, and the third one — light-hydrous (H_2O) full-compounded (with $MnSO_4$) nutrient medium.

Such series of experiments was held for different cultures, different time of growth Δt (24, 48 and 72 hours) and different growth modes (in still disks and media and in suspension stirring mode using magnet stirring device). Bacteria and yeast were grown in a thermostat at optimal temperature 32^0 C.

After completing each series, the obtained biological substance was collected using a centrifuge, cleaned in distilled water (H_2O) and dried. The dried substance in the form of a thin film was separated using non-iron containing instrument, ground to a powder and placed in the Mossbauer spectrometer. To increase the possibility of resonant absorption in some of the experiments a sample was cooled to T=78 K.

A Co^{57} isotope with activity of 40 mCi in a chromium matrix was used as a source of Mossbauer radiation. This source has a spectrum in the form of a single line of natural width. The measurements in each of 256 channels of spectrometer were carried out till the required number of counts $N_\infty=3.5\times10^6$ was achieved in channels remote from gamma-resonance line. Calibration of gamma-spectrometer was carried out with standard Fe^{57}-containing absorber.

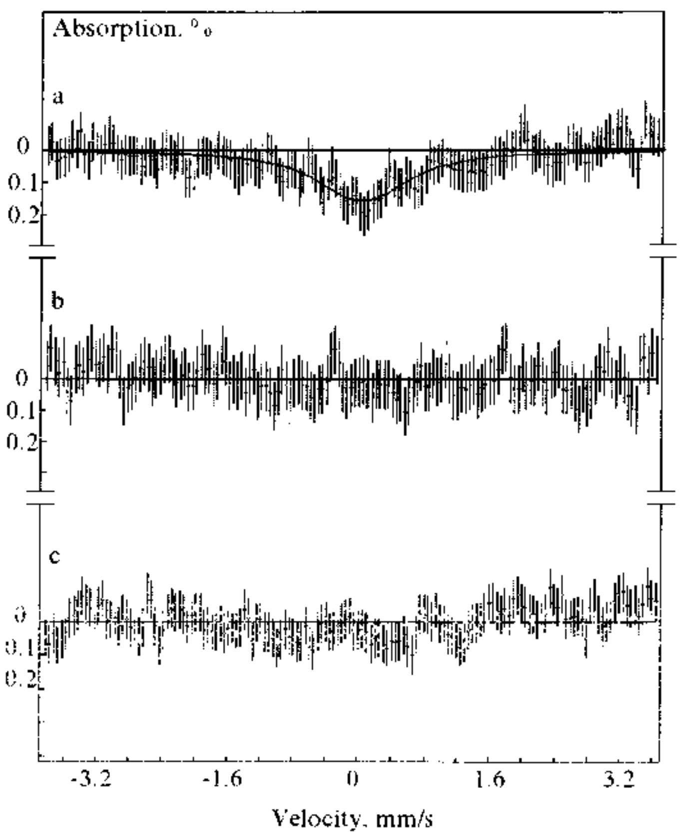

Fig. 2. Mossbauer spectra of grown cultures. Culture *Saccharomyces cerevisiae T-8* grown: a) in D_2O with present Mn^{55}; b) in H_2O with present Mn^{55}; c) in D_2O without Mn^{55}.

3. Results and discussion

The figure 2a presents the Mossbauer spectrum of ***Saccharomyces cerevisiae T-8*** culture grown during Δt = 72 hours in nutrient medium of optimal composition, containing D_2O and $MnSO_4$. The total mass of the culture was 0.28 g. The spectrum 2b corresponds to the same culture grown in the medium containing H_2O and $MnSO_4$, and the spectrum 2c - the medium with D_2O, but without $MnSO_4$. The natural width of Fe^{57} Mossbauer resonance (in Doppler velocity units) equals Γ=0.19 mm/s. In case 2a the gamma resonance line is widened by $p_a=\Delta\omega_a/\Gamma\approx10$ times.

The total number of resonant Fe^{57} atoms for a Lorentz-widened line was calculated by the equation

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$$N = \eta S(1+p)/\sigma_0 f$$

obtained for a thin resonant absorber. Here $\eta = (N_\infty - N_0)/N_0$ - relative depth of absorption resonance, N_∞ and N_0 - number of counts in non-resonant and central resonant channels, $S \approx 0.63$ cm^2 - area of gamma-spectrometer disk, filled with the studied culture, $f \approx 0.6$ - probability of Mossbauer effect in the absorber, σ_0 - cross-section of resonance absorbtion in Fe^{57} isotope.

The full numbers of Fe^{57} atoms and their mass are the following:

$$\eta_a=(1.9\pm0.53).10^{-3},\ N_a=(0.87\pm0.24).10^{16},\ m_a=(1\pm0.28).10^{-6}g.$$

The amount of Fe^{57} isotope in cultures grown in non-optimal conditions, with consideration of measurement , approximately corresponds to the concentration of Fe^{57} admixture in the nutrient medium and water. The significantly larger amount of Fe^{57} in the culture grown at optimal conditions, in the presence of D_2O and Mn^{55} is a result of low-temperature nuclear reaction of Mn^{55} transmutation into Fe^{57} taking place in this culture. The transmutation coeffitient equals

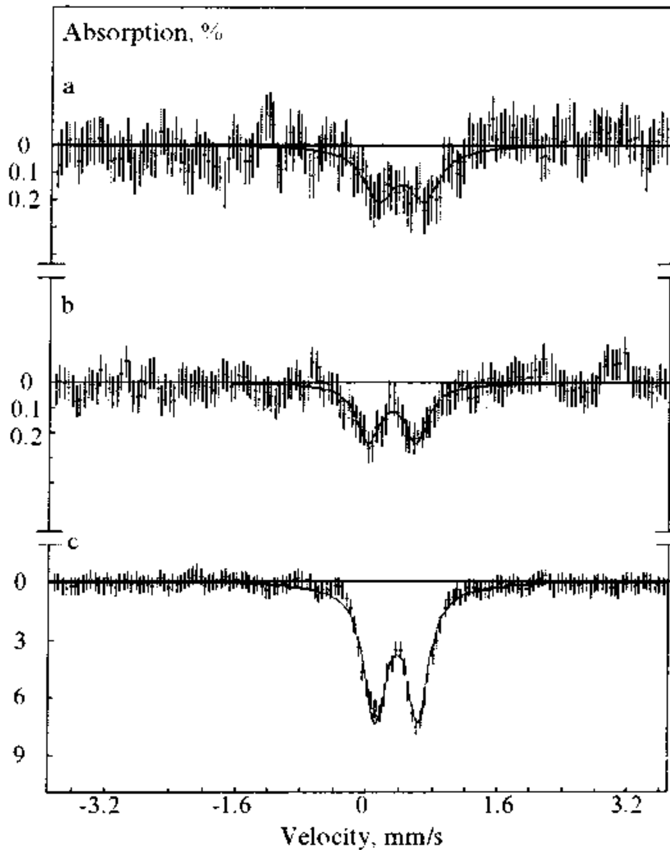

Fig. 3. Mossbauer spectra of grown cultures. Culture *Deinococcus radiodurans* grown: a) and b) in D_2O with present Mn^{55}; c) in H_2O with present Mn^{55} and small quantity of Fe^{57}.

$$\lambda_a = N_a/N_0\Delta t = (1.9\pm0.52).10^{-8}\ Fe^{57} \text{ nuclei per s and per single } Mn^{55} \text{ nucleus.}$$

The similar results were obtained during the growing of other cultures in optimal conditions. In some cases (for example, for ***Deinococcus radiodurans***) the structure of Mossbauer resonanse for created Fe^{57} in grown culture has a form of doublet, what corresponds to spatial or phase structure of the substance. Fig. 3a, 3b presents the results of investigation of Mossbauer spectrum of culture ***Deinococcus radiodurans*** in optimal medium (D_2O with $MnSO_4$). For case 3a

$$N = 2\eta S(1+p)/\sigma_0 f$$

and $p_{3a}\approx3.4$, $\eta_{2a}=(1.53\pm0.57).10^{-3}$, $N_{3a}=(0.59\pm0.21).10^{16}$, $m_{3a}=(0.67\pm0.24).10^{-6}g$,

$$\lambda_{3a} = (1.3\pm0.46).10^{-8}\ s^{-1} \text{ per single } Mn^{55} \text{ atom.}$$

It is necessary to point out that the average power

$$\langle P_a\rangle \approx N_a\,[M(Mn^{55}) + M(d^2) - M(Fe^{57})]\,c^2/\Delta t$$

that is produced in the process of reaction $Mn^{55}+d^2=Fe^{57}$ is small and doesn't exceed 50 mW per total volume V=10cm^3 of nutrient medium with growing culture (here $M(Mn^{55})$, $M(d^2)$, $M(Fe^{57})$ - mass of nucleus Mn^{55}, d^2 and Fe^{57}).

As a result of connecting the main experiments 2a, 3a, 3b and control experiments 2b,2c (nonoptimal nutrient medium ingradients on the basis of H_2O with $MnSO_4$ and on the basis of D_2O without $MnSO_4$) one can say:

1) in D_2O there isn't admixture Fe^{57};

2) in sugar-solt components of nutrient medium there is no Fe^{57};

3) during the growing of cultur Fe^{57} isn't extrated from the glass of flask.

One of the theoretically possible effects causing the appearance of absorption peak in cultures grown in the medium with D_2O and $MnSO_4$ (and absence of this peak in control experiments), could be connected with possible splitting of Mossbauer line due to Fe^{57} admixtures in experiments 2b (H_2O with $MnSO_4$) and 2c (D_2O without $MnSO_4$) and localization (narrowing) of this line (with its increasing) in the main experiments 2a, 3a, 3b (D_2O with $MnSO_4$). To ensure that such effect doesn't take place the additional control experiments were performed, when small amounts of Fe^{57} were added to media 2b and 2c. These experiments (the results presented on fig. 3c) with culture ***Deinococcus radiodurans*** have shown that the appearing resonances of absorption by their width and energy approximately correspond to the cases 3a and 3b. Therefore the appearance of absorption resonance on Fe^{57} in main experiments is not connected with elimination (transformation) of hyperfine splitting and redistribution of resonance line positions, but manifests the appearance of Fe^{57}, which is absent in the control experiments.

Concluding the mentioned results and discussion of the experiments, we can state, that creation of Fe^{57} isotope as a result of nuclear transmutation in growing biological medium was observed and verified using precise Mossbauer spectroscopy methods.

4. Theoretical model

In conclusion let's consider briefly the possible mechanisms of nuclei interaction, contributing to effective nuclear transmutation reaction with formation of Fe^{57} isotope.

Obviously, no modification of micro-accelerating mechanisms connected with formation of microcrack, accelerating plasma waves and similar processes can take place in a liquid nutrient medium. It is also evident that tunneling quantum processes can't provide a great probability of nuclear transmutation. We assume that the most effective action in this case would be the one provided by the mechanism suggested in [2] (and in [3]), which is capable of providing a short-term elimination of the Coulomb barrier of the pair reaction in micro-potential hole with the structure that is close to parabolic. In such holes the structure of quantum levels is equidistant and characterized by the spectrum

$$E_n=\hbar\omega_0(n+3/2),\ n=0,\ 1,\ 2,\ldots$$

Let the Mn atom be in the center of such a hole. Due to dissociation processes, high-hydrous compound has a great quantity of free d-deutons (at T = 300 K dissociation probability is $\eta\approx10^{-10}$). When a deuton gets into the hole due to diffusion, a complex Mn+d appears in the hole. In the free space this complex would correspond to quasimolecule $(MnD)^+$. In the

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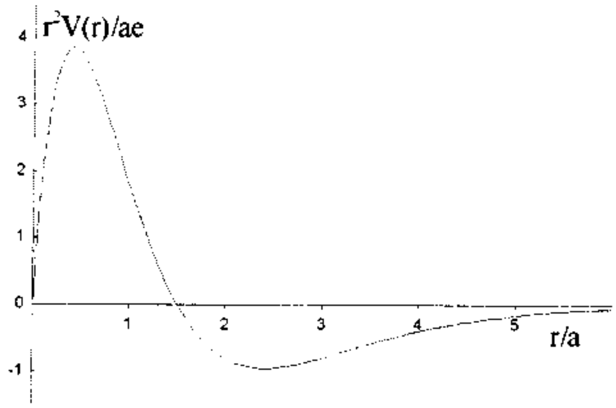

Fig. 4. Structure of interaction energy $r^2V(r)$ in system Mn-d.

quantum system the situation is more complicated.

The matter is that in such a system energy of nucleus interaction V(r) is a sign-variable distance function (see fig. 4 for a plot of function $r^2V(r)$ which is important for calculation of diagonal matrix elements). For distances $r \geq a \equiv \hbar^2/me^2$ this energy V(r) is similar to the energy of p-e-d system and $V(r) < 0$. In the region of intermediate distances $a/Z < r < a$ this energy is defined by the Thomas-Fermi approximation

$$V(r) = \frac{Ze^2}{r}\chi\left(rZ^{1/3}/0.885a\right) \text{ and } V(r) > 0.$$

In the region of small distances $r < a/Z$ nucleus interaction corresponds to pure Coulomb repulsion of bare nuclei and $V(r) = Ze^2/r > 0$.

Can this energy be a small amendment and not influence the character of nuclei movement in quantum system?

For that purpose, the diagonal elements of interaction energy matrix should be small and probability of interlayer transition because of this interaction should also be small.

Probability of interlayer transition in the regarded parabolic potential becomes equal to zero automatically at the moment $\tau = 2s\pi/\omega_0, s = 1,2,3\ldots$, when frequencies of all possible interlayer transitions $\omega_{nk} = (n-k)\omega_0$ will correspond to zeroes of spectral density of perturbation energy (see fig. 5)

$$|V(\omega)|^2 = \left|\int_0^\tau V_{nk}(t)\exp(i\omega t)\,dt\right|^2 = V_{nk}[\sin(\omega\tau/2)/(\omega/2)]^2$$

Here nucleus interaction completely disappears and deuton wave function is determined only

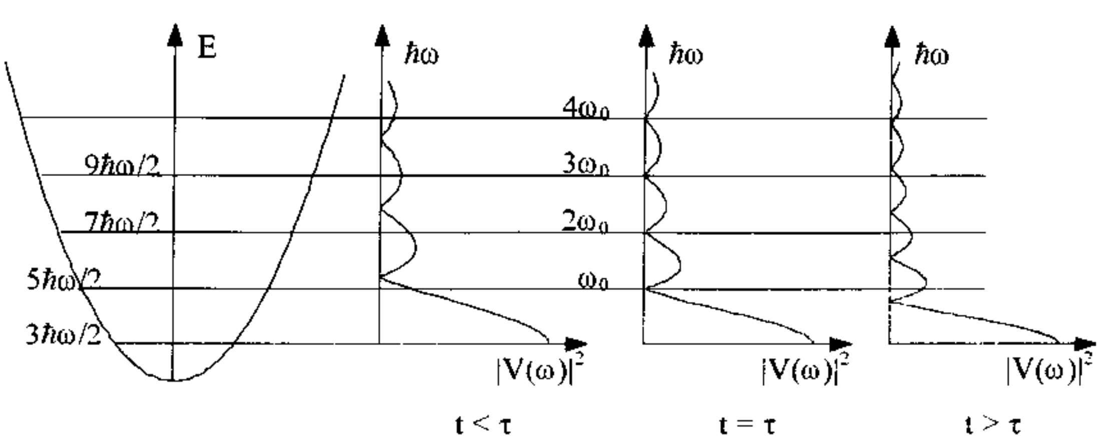

Fig. 5. Correlation between energy spectrum of quantum levels E_n and spectral density $|V(\omega)|^2$ of perturbation energy V(t) for $t < \tau$, $t = \tau$, $t > \tau$.

by quantum potential field properties.

For zeroing of diagonal matrix elements of interaction energy (which is a sign-variable function of inter-nucleus distance)

$$V_{nn} = \int 4\pi \, |\psi_n(r)|^2 \, V(r) \, r^2 \, dr$$

it is essential that the size of the hole be optimal. In the paper [2] it is shown that in case of d-e-d system this size corresponds to $2R \approx 3A$ and the optimal slope of the walls of the hole is $U_{max}/R^2 \approx 0.1 eV/A^2$. For the system Mn-d this size is $2R \approx 8A$.

If all the above-mentioned conditions are met, the independent from Mn quantizing of the deuton in the hole takes place. In this case the wave function of deuton $\psi_n(0)$ in all even states will be different from zero in the center of the hole, where the Mn nucleus is located. This leads to a high probability of nuclear fusion, $\lambda = C|\psi_n(0)|^2$, C - constant of purely nuclear Mn^{55}-d^2 interaction.

As it can be seen from the given scenario of the process, quantizing structures of optimal size and shape are necessary for such non-barrier nucleus interaction [4]. The exact parameters of these structures are very hard to calculate. The situation substantially improves when the hole parameters are slowly changing inevitably passing through optimal value. This situation is realized in growing microbiological cultures. In the growth process the replication of DNA and other biomolecules takes place. In this case in the field of growth inter-atomic potential holes with slowly changing sizes are consistently appearing. If a Mn atom and a deuton are in such a changing hole, conditions for a new Fe^{57} isotope fusion will be created.

We believe that the given mechanism completely describes the basic properties of the process of nuclear transmutation, which is observed in experimental course.

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