ИНСТИТУТ ЯДЕРНОЙ ФИЗИКИ СО АН СССР

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FIRST OBSERVATION OF NEUTRON EMISSION FROM CHEMICAL REACTIONS

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НОВОСИБИРСК

INTRODUCTION

It has been suggested recently [1, 2] that deuterium in hydrid-forming metals (palladium and titanium) can undergo nuclear fusion at room temperature. In these experiments deuterium was incorporated into metal lattices by electrolytic charging in solutions of heavy water. It is necessary to point out that some years earlier high energy neutrons were also detected during mechanical destruction of LiD-crystals [3].

The most important problem in analyzing the experimental results of this type is to comprehend the mechanism that leads to neutron emission during processes characterized by energy about 1 eV per atom. Motivated by this problem we have performed an experimental study on the neutron detection during chemical reactions of deuterized matters. Here we report about an attempt on the detection of the neutrons emitted from a test-tube during reaction of LiD-crystals with water [4] and exidation-reduction reactions of the complex salts of metals [5].

EXPERIMENTAL DETAILS

The schematic of the neutron detector system used in the experiments, is shown in Fig. 1. The test-tube (*1*) in which chemical reactions occur, is placed in the central part of a polyethylene cube (*2*). Six neutron counters CNM-17 or CNM-18 (*3*) surround the test-

tube. They are placed symmetrically at a radius of 13 cm. For suppression of electromagnetic noises at the input of the amplifiers increasing detector signals from 2 mV up to about 1 V the whole registration system is shielded by a copper screen (*4*). The test-tube is also separated from the slowing-down polyethylene cube by a thin aluminium tube (*5*) connected electrically to the shield. The whole device is embedded in a borated polyethylene shield (*6*). This shield reduces the neutron background signal to the count rate of below $10^{-2}\,s^{-1}$.

The counter signals are analyzed by the pulse amplitude discrimination method. The signals from neutrons are recorded by the CAMAC-ODRA computer system. In addition to the on-line neutron emission measurements the temperature of the test-tube is recorded in every 5 s, which relates the neutron detection to the chemical reaction course. The temperature measurement is carried out by the termocouple fixed on the surface of the lower part of the test-tube.

Tests and calibrations of the neutron registration system were made with the help of radioactive sources. Pu-α-Be-source (source intensity $3.2\cdot10^4$ neutron/s), ^{252}Cf-source (about 8 neutron/s) and ^{137}Cs ($1.5\cdot10^4$ γ-quanta/s). The source were placed in the neutron monitor instead of the test-tube. The measurements showed that the efficiency monitoring 2—3 MeV neutron was about 10% and there were no additional counts above the background when ^{137}Cs-source was placed in the detector.

EXPERIMENTAL PROCEDURE AND RESULTS

Two different chemical reactions were used in our experiments. The first one was the reaction between LiD-crystals and heavy water (this experiment was described in detail in Ref. [4]). The chemical reaction run in a quartz test-tube (see Fig. 1). Some heavy water (about 30 grams) was placed in the test-tube and LiD-crystals were put into it little by little. A size of the crystals could be varied from 0.3 mm up to 4 mm. The intensity of the neutron emission is shown by a histogram of the counts accumulated by six counters in 30 s intervals (see Fig. 2). The histogram in Fig. 2A corresponds to the case when there is the heavy water without LiD in the test-tube. Fig. 2B shows the case when LiD-crystals were poured little by little in this water. The reaction between LiD

and D_2O is exothermic and the temperature of the test-tube increases up to 70—80°C. The decrease of the tube temperature is due to the cooling of the test-tube by an air flow. One can see from Fig. 2B that during the chemical reaction some short time splashes of the neutron emission come up. The duration of a single flashes may be shorter than 5 s (it is the time step of our detection system). The ratio η of the counts N_R recorded during the chemical reaction to the background counts N_B recorded before this reaction in the same time interval averaged over the seven identical experiments is 1.70 ± 0.14.

In the second experiment we have measured the neutron emission from complex salts of palladium and platinum reacting with zinc. The neutron emission measured during the oxidation-reduction reactions in the deuterized salts of these metals (β-trans $Pd(ND_3)_2Cl_2$ and $(ND_4)_2[PtCl_6]$), was compared with the one measured during the reaction in the same salts containing only the light hydrogen (trans $Pd(NH_3)_2Cl_2$ and $(NH_4)_2[PtCl_6]$). The zinc grains (of a size about 200 μm) were mixed with the salt and then the mixture was thoroughly grated. 10 grams of this mixture were strewed into the test-tube. The test-tube where the redox reactions were run, was placed inside neutron detector. More detailed description of this experiment has been given in Ref. [5].

It is necessary to point out that for attaining the maximum reliability of the obtained data the experiments were carried out in short series with altering deuterium and hydrogen salts from one experiment to another. Each couple of two alternative experiments started and finished with the measurements of the background and sensitivity. In addition, the background was continuously measured during many houres.

The redox reactions were accompanied by an energy release and the temperature of the test-tube increased up to 250°C (see Fig. 3). The histograms shown in Fig. 3 were obtained by summing up the counts from six identical experiments. The histogram in Fig. 3A corresponds to the case when the hydrogen salt of palladium in the test-tube reacted with zinc and Fig. 3B shows the case of the deuterized salt of Pd reacting with Zn. The strong increase in temperature corresponds to the oxidation-reduction reaction. Then the test-tube is cooled down by the air flow. It is seen from the histogram in Fig. 3A that in case of the hydrogen salt the count rate is practically unchanged in spite of the redox reaction. When the deuterized salt is placed in the test-tube one can see (Fig. 3B) the doubled

count rate during the reaction. As the increase in the temperature does not lead to the increase in the count rate (see Fig. 3A) and the detector counts only neutrons one can conclude that during the oxidation-reduction reaction the nuclear fusion of deuterons takes place.

The increase in the count rate during chemical reactions cannot be explained by the fluctuations of the background. The comparison between the count rate of the background and one in the time interval during the neutron emission effect is shown in Fig. 4. Fig. 4A characterizes the count rate in the case when the background is recorded during a few hours. One can see that the number of the counts in the 50 s time intervals does not exceed 13 and its average value is about 5—7. The number of the counts in the 50 s time intervals when the background is recorded in the course of the chemical reactions, is shown in Fig. 4B by rhombuses as well as in Fig. 4A. It is seen that the number of the counts in this case does not exceed 13 also. As to the number of the counts during the chemical reaction of the deuterium salts it reaches 25 (see crosses in Fig. 4B).

So, the increase in the count rate during the redox reactions is caused by the neutron emission. The ratio η of the counts N_R and N_B is given in the Table. It is seen from the Table that in the case of the chemical reaction of the deuterium salts of Pt and Pd the ratio $\eta = N_R/N_B$ has the values of about 1.5 and 1.9 correspondingly. But in the case of the hydrogen salts the ratio is close to unity.

Platinum		Palladium	
Hydrogen	Deuterium	Hydrogen	Deuterium
0.96 ± 0.09	1.52 ± 0.10	1.06 ± 0.13	1.87 ± 0.08

Taking into account that the dispersion of the ratio is about 0.1, one can say that the effect of the neutron emission during chemical reactions has a considerable statistics. This effect takes place during reactions of the different chemical matters and most probably it is independent on the sizes of their crystals. The number of neutrons emitted during the chemical reactions, is a few tens per gram of the deuterized matter. It is necessary to point out that some recent experiments have shown no statistically significant neutron fluxes

[6] and energetic charged particles [7] from the electrolytic cells during the reduction of deuterium at the palladium and titanium cathodes. On the contrary our experiments clearly show that the neutron flux from the deuterized matters exists during their chemical reactions. As to a plausible explanation of the neutron emission, to obtain the necessary nuclear fusion rate it requires an effective ion energy level of about 150 eV in a lattice [8] which looks unreasonable. Right now, we do not have a clear explanation of the observed phenomena. Further experiments are required to understand the mechanism of enhanced neutron emission.

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REFERENCES

1. *Fleischman M. and Pons S.* Electrochemically Induced Nuclear Fusion of Deuterium.—J. Electroanal. Chem., 261 (1989) 301.
2. *Jones S E., Palmer E.P., Czirr J.B., Decker D.L., Jensen G.L., Thorne J.M., Tayler S.F. and Rafelski J.* Observation of Cold Nuclear Fusion in Condensed Matter.—Nature, 338 (1989) 737.
3. *Klyuev V.A., Lipson A.G., Toporov Yu.P., Derjagin V.V., Lushchikov V.I., Strelkov A.V., Shabalin E.P.*—Sov. Tech. Phys. Lett., 12 (1986) 551.
4. *Arzhannikov A.V., Kezerashvili G.Ja., Muratov V.V., Synitsky S.L.* Neutron Emission during Reaction of Lithium Deuteride with Heavy Water.—Preprint INP 89-144. Novosibirsk, 1989.
5. *Arzhannikov A.V., Kezerashvili G.Ja., Smirnov I.I., Yakimova N.V.* First Observation of Neutron Emission during Oxidation-Reduction Reactions of Metals.—Preprint INP 89-152. Novosibirsk, 1989.
6. *Botter F., Bouchez J., Collot J. et al.* Search for Emission of Neutrons from a Palladium-Deuterium System.—Phys. Lett. B, v.22, N 4 (1989).
7. *Ziegler J.F., Zabel T.H., Cuomo J.J. et al.* Phys. Rev. Lett. 62 (1989) 2929.
8. *Crowley B.J.B.* Nuclear Fusion in High Density Matter.—Nuclear Fusion, v.29, N 12 (1989) 2199.

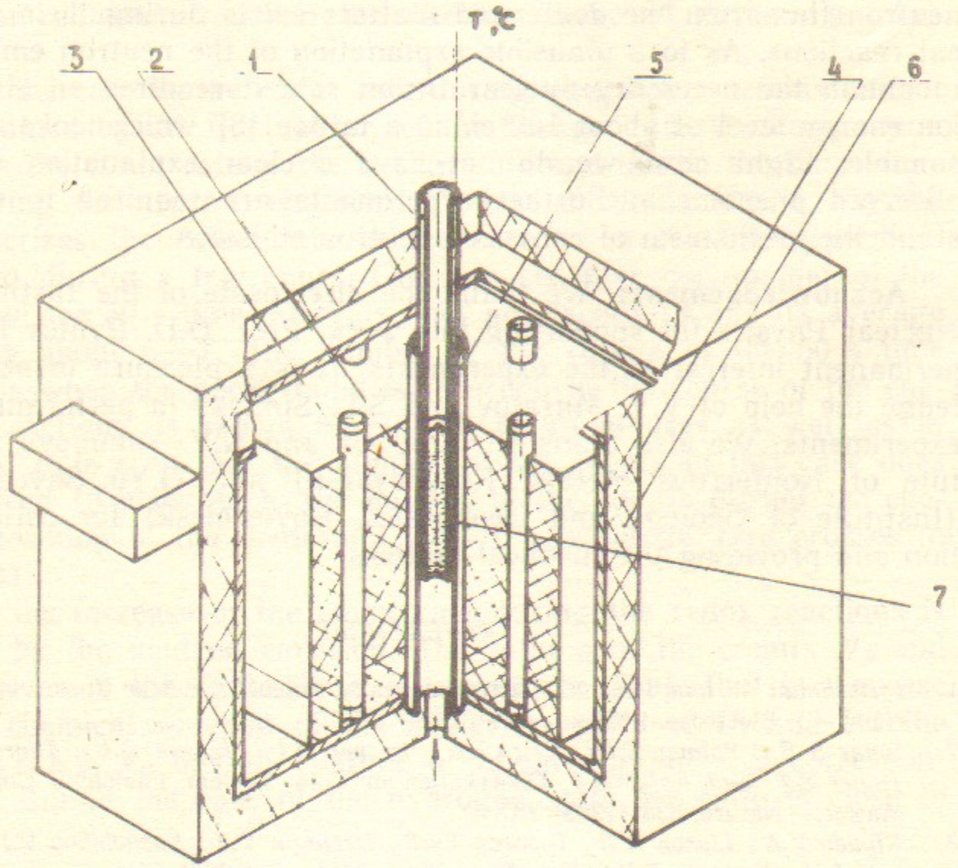

Fig. 1. The schematic of the neutron detector:

1 — test-tube; *2* — slowing-down polyethylene; *3* — neutron counter; *4* — cooper screen; *5* — aluminium tube; *6* — polyethylene shield.

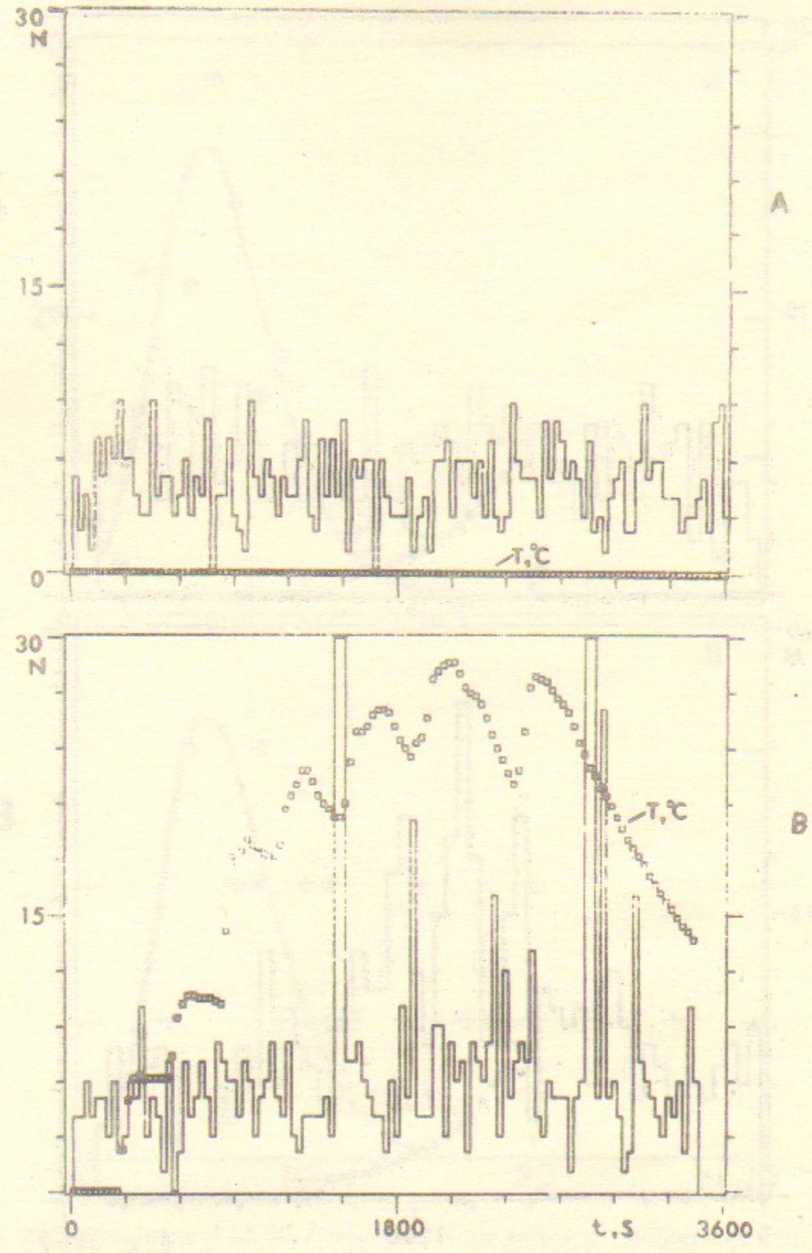

Fig. 2. The count histograms obtained by six counters CNM-17 for the LiD-D_2O reaction experiment:

A — pure heavy water in the test-tube. Tempreture $T \simeq 20°$ C. B — LiD-crystals strew into this water. Minimum temperature $T_m \simeq 20°$C, maximum temperature $T_M \simeq 80°$C.

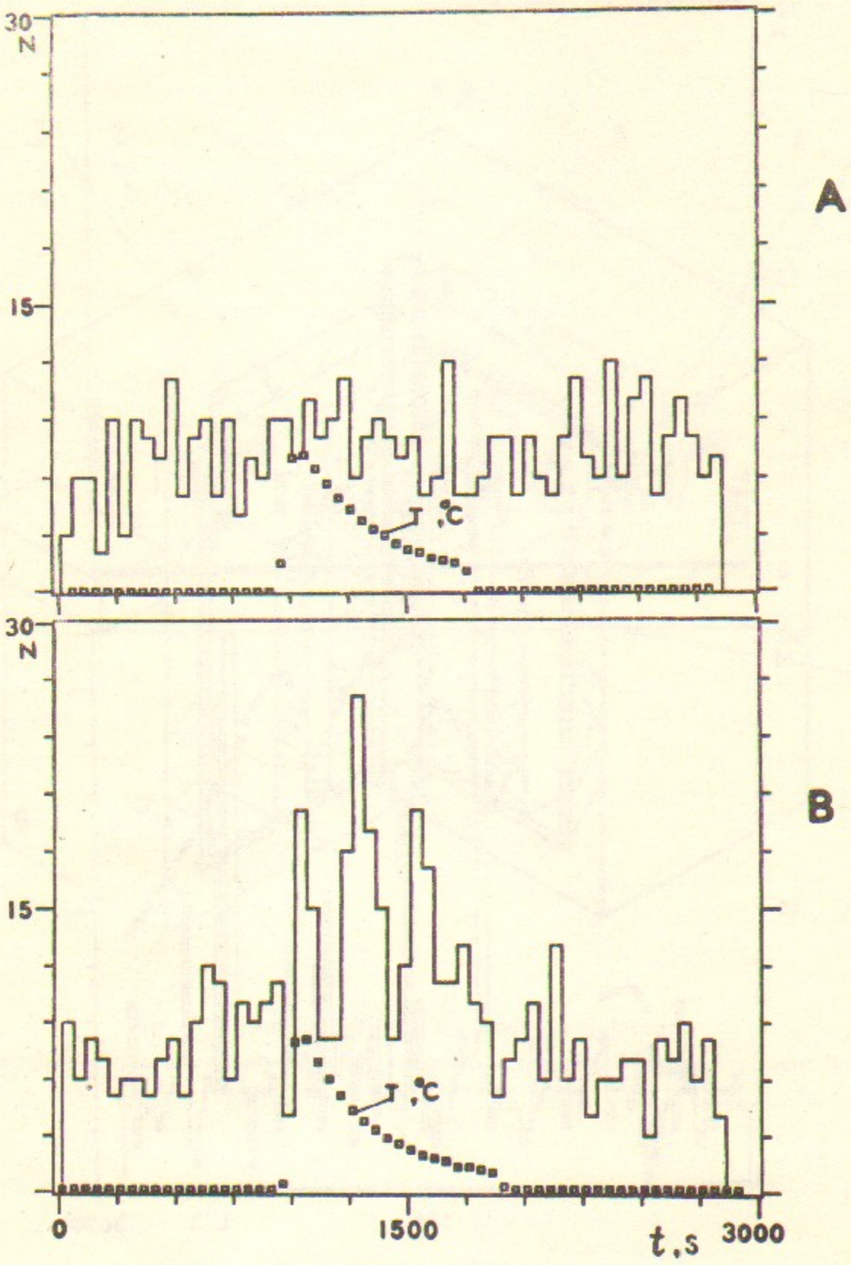

Fig. 3. The count histograms obtained by six counters CNM-18 for the reaction of the Pd-salts with Zn. Minimum temperature $T_m \simeq 20°C$, maximum temperature $T_M \simeq 250°C$.

A — the salt contains hydrogen; B — the salt contains deuterium.

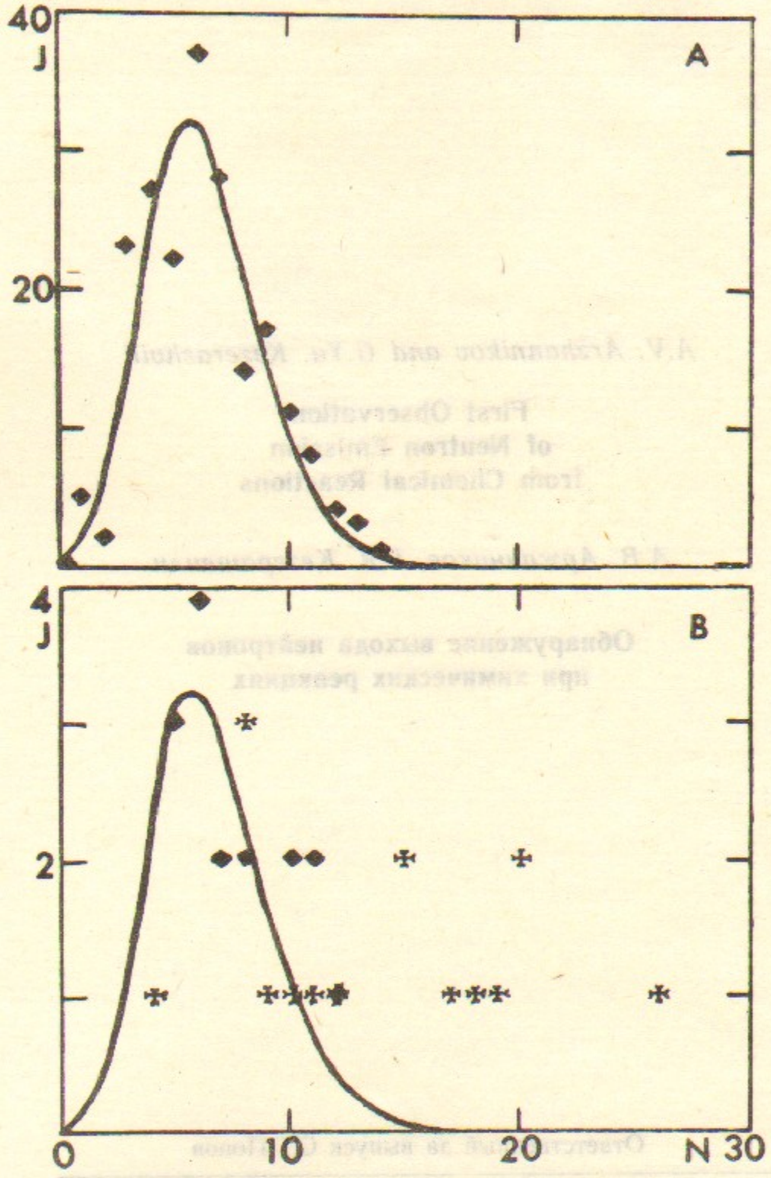

Fig. 4. The number J of 50 s intervals with selected numbers of counts N:

A — long time background measurements. B — measurements at the time intervals equal to the reaction duration. Rhombuses — background counts, crosses — counts during the chemical reaction. The solid lines show the Poisson distribution function. The only parameter of this function ($\mu = 6.3$) is chosen to fit the experimental points given in Fig. 4A.

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