INVESTIGATIONS OF NEUTRON EMISSION IN A COLD FUSION EXPERIMENT IN PALLADIUM

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1. INTRODUCTION

The experiments dealing with performance of nuclear fusion at room temperature actually create a great sensation and are carried out in various laboratories [1,2]. This interest arises from the results achieved by Fleischmann and Pons, and it results from their paper [1] that there exists a possibility of obtaining an ignition owing to nuclear fusion reactions during "usual" electrochemical process - namely the electrolysis of D O with use of the system of Pd-Pt electrodes. These fusion reactions of the type of

$$D + D \rightarrow \begin{cases} ^3He(0.82\ MeV) + n(2.45\ MeV) \\ T(1.01\ MeV) + p(3.02\ MeV) \end{cases}$$

are connected with neutron emission. From this reason the measurements of the yield and behaviour of neutron emission give the information about processes of interest.

At the IPPLM the cold fusion experiments have been conducted from the beginning of April 1989. In the first experiment the reliable evidence of neutron emission was obtained. A number of irregularly repeated neutron pulses of the level of 10^5 per pulse was recorded. The measurements of the neutron emission, in this experiment, were performed with the use of three independent methods employing the 2.5 MeV neutron spectrometer, the scintillation neutron detector as well as the nuclear track detector. Neutron emission had been first recorded after 106 hours of the electrolysis process of D_2O.

The correlation between the neutron emission and measured temperature effects has not been observed. The recorded electrode temperature changes were clearly connected with the polarization current density.

In the next our experiments, besides diagnostic methodes listed above, the silver activation neutron detectors and the triple coincidence system have been employed. In these experiments a disagreement, between results obtained by means of the nuclear track detectors and other diagnostic systems, appeared. This disagreement will be discused in the next sections.

2. EXPERIMENTAL ARRANGEMENT

2.1. Experimental conditions

The scheme of the experimental arrangement used in the first experiment is shown in Fig. 1. The glass vessel, in which the electrolysis had been driven, was in cylinder shape 90 mm in diameter and 200 mm in height. The 0.5N NaOD solution in D_2O (99.8% enhancement) as an electrolyte was used. Palladium electrode (a massive cylindrical rod cathode) was 10 mm in diameter and 124 mm in height, while the platinum grid of the 35 mm in diameter and 100 mm in height was used as an anode. During the first experiment the palladium electrode temperature was being continuously checked by means of a thermocouple.

During the first experiment the current density was changed from 12.5 to 105 mA/cm^2.

In the next experiments similsr geometry of electrodes and current densities were employed with one exception in which electrodes in the form of cylinders were used. In the last experiment the solution of ^{6}LiOD in D_2O was used as the electrolyte.

2.2. Neutron emission measurement

A detailed scheme of the neutron measurement systems used scintillation probes in the first experiment is shown in Fig. 2.

The probe named NS consisted of the NE-213liquid scintillator and PM tube This probe was connected to the pulses counter via n-γ discriminator, so only pulses from the neutron recoil protons could be counted. The overall efficiency of the NS probe (including measurement geometry) was equal to 0.3%.

The probe named NC consisted of the NE-102A plastic scintillator and PM tube and was connected to the pulses counter via amplitude discriminator only, so this probe was able to count pulses from neutron recoil protons pulses as well as the γ-rays from a reaction

$$n + p \rightarrow D + \gamma(2.5 \text{ MeV}).$$

The overall efficiency of the NC probe was 3.5%, especially because of the plastic scintillator volume which was about six times larger than the liquid one. In this case the neutrons could be slowed down (in the scintillator) to energies at which the n-p reaction became effective.

The time gate of NS probe operating was 500 s (each measurement was carried out in a time interval equal to 500 s). The time gates for measurements with use of NC detector had been chosen to 50, 40 and 20 s, respectively, and for time gates of 40 and 20 s discriminator levels were increased.

The plastic nuclear track detectors (CR-39 type) were placed close to the wall of the glass vessel. Before experiments they were calibrated with use of Am-Be neutron source as well as by means of the "plasma focus" discharge, in which the short (about 100 ns) neutron pulses were emitted (about 10^9 neutrons in one pulse).

The neutron registration efficiency of these track detectors, η, determined by these methods amounted to 2×10^{-3}. The CR-39 track detectors were employed in all our experiments.

The scheme of neutron measurement system used in the next experiments is shown in Fig. 3. This system consisted of three scintillation probes NC, N3 and SND with the NE-102A scintillators. Scintillation probes were connected to a triple coincidence system and, parallely, to counters. The probe named SND was connected also to an oscilloscope in order to measure the time duration of neutron pulses.

Aside from scintillation probes the two silver activation neutron detectors were used in this serie of experiments. The neutron registration efficiency η of these detectors was about 10^{-5} to 10^{-6}, respectively.

3. RESULTS AND DISCUSSION

All the neutron emission acts registered during the first experiment are presented in Fig. 4. The main feature of the neutron emission in our experiment was its pulsed character. The time duration of the single neutron pulse was much shorter than 1 s. The main part of neutron pulses was recorded only by one (NC) detector. Only in two cases the neutron pulses were recorded by two detectors (NS and NC) simultaneously. This can be attributed to the following facts:

- the NC probe had the overall efficiency about one order of magnitude greater than the NS,
- the NC probe could register the neutron recoil protons and γ-ray from the n-p reactions "simultaneously", but the NS probe could not, because it had the n-γ discriminator,
- if the time duration of the neutrons pulse had been shorter than about 10 μs, then, because of the dead time of the NS probe electronic system, the neutron pulse was not registered and/or it was counted as a background.

The absolute neutron yield measured in this experiment, by track detector (5×10^9) neutrons in compare with neutron yield registered in one pulsed discharge recorded by NC and/or NS detectors show multiple emission of very short ($\Delta t < 10$ ms) neutron pulses. However, our detectors were not optimized for registration of such short and intense neutron radiation pulses, and probably were not able to record a significant part of them.

Unfortunately, in our experiments such clear evidence of the pulsed neutron emission was not obtained. Furthermore, the measurements results had obtained by means of neutron spectrometer provided the evidence that there was not any continuous neutron emission. However, in all our experiments the track detector results indicated the total neutron yield on the level of $3 \times 10^8 - 5 \times 10^9$. So there is a serious disagreement between the track detectors results and those obtained by other diagnostics (scintillation probes, silver activation detectors).

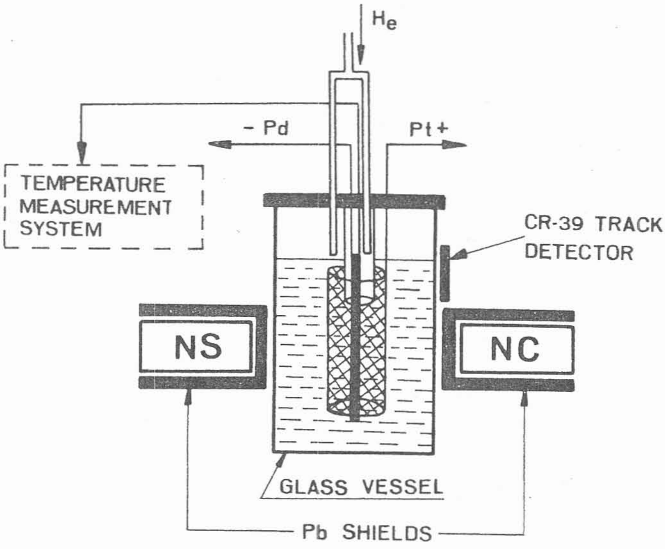

Fig. 1. The scheme of the experimental arrangement: NS - 2.5 MeV neutron spectrometer, NC - scintillation neutron counter, electrolyte - 0.5N NaOD solution in D_2O (99.8%)

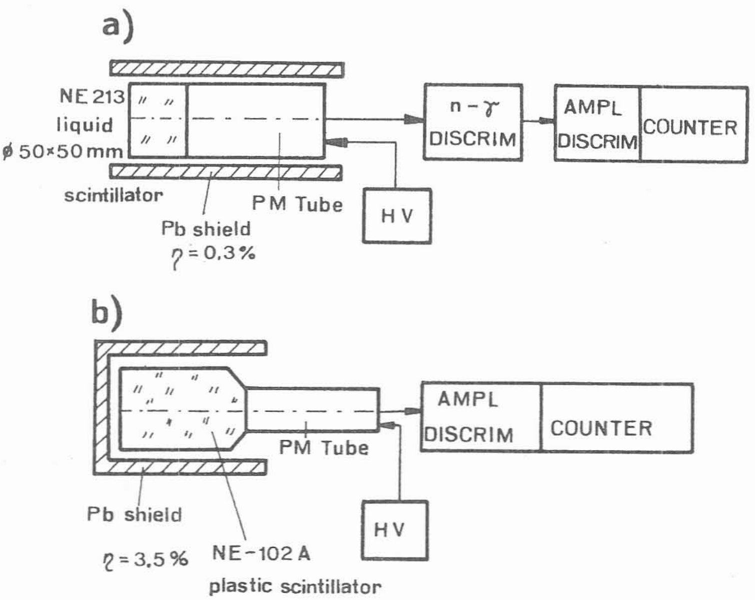

Fig. 2. Neutron registration systems used in the first experiment: a - 2.5 MeV neutron spectrometer, b - scintillation neutron counter, η - total registration efficiency (including the geometry of measurements)

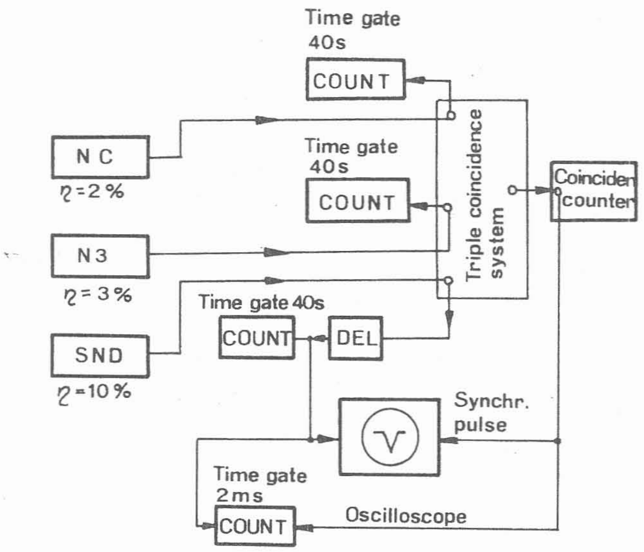

Fig. 3. Neutron registration systems used in the next experiments

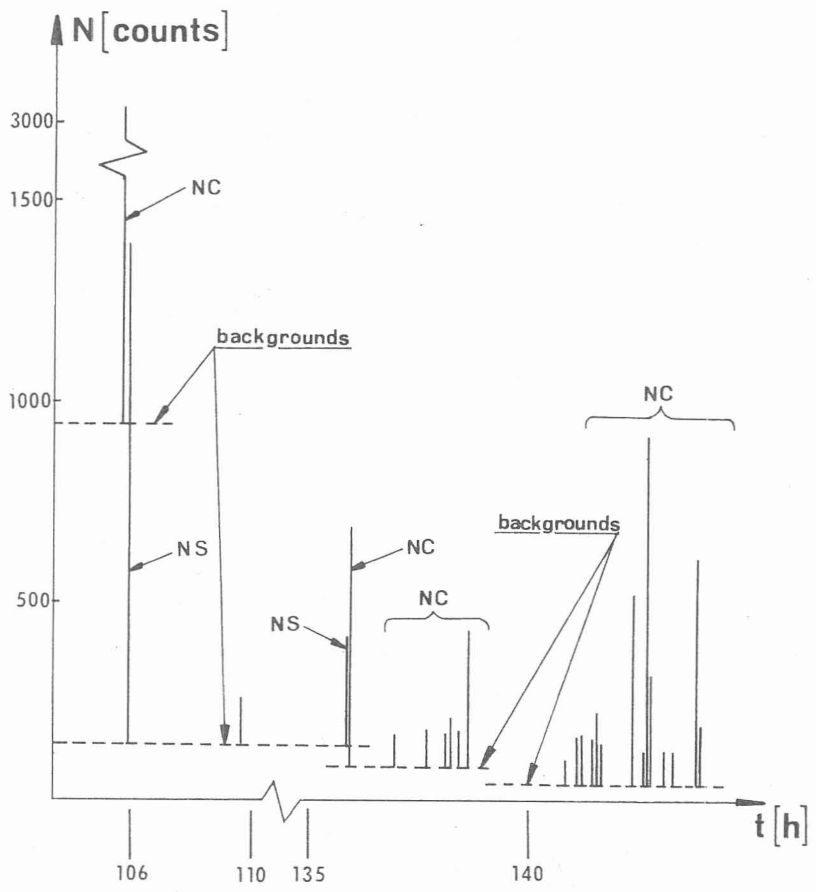

Fig. 4. Detailed time history of the neutron emission: NS - neutron spectrometer, NC - neutron counter, --- - background

In the near future experiments the authors will try to explain these disagreements which, mayby are connected with the specific time and space charakter of neutron emission.

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