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OBSERVATION OF D-D FUSION NEUTRONS DURING DEGASSING OF DEUTERIUM LOADED PALLADIUM

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INTRODUCTION

Many experiments on charging palladium with deuterium, either electrolytically or by gas absorption, indicate a production of fast neutrons or other products of d-d fusion reactions accompanying the charging process under special, hitherto not fully understood conditions, see e. g. Ref. [1]. These results need further work towards experimental confirmation and understanding of underlying physical processes.

At the Dresden University of Technology after a first experiment confirming a very small neutron production during electrolytic charging of palladium cathodes with deuterium [2] further studies on the phenomenon of nuclear fusion in condensed matter are carried out, which systematically hint at a weak neutron production as a typical function of the period of charging [3].

The experiments described in this paper are designed to search for neutron events during the degassing of palladium samples charged with deuterium. Of special interest is the search for neutrons with an energy of 2.45 MeV, originated by the fusion reaction

$$d + d \longrightarrow n + {}^{3}He + 3.27\ MeV.$$

EXPERIMENT

In the present experiment two massive palladium samples are used, in which deuterium was stored. These samples are heated up on an electrical heating device in front of two neutron detectors. The measurements are carried out by short time runs of 10 minutes and alternating the sample under investigation between positions in front of both detectors. While with one detector the sample is observed, with the other detector the background counting rate for the empty position is registered. In this manner with two detectors the effect and the background counting rate are measured quasi-simultaneously for the whole period of the experiment.

For neutron detection and spectrometry two recoil proton detectors with 5-in.-diam.x1.5-in.-high NE-213 liquid scintillator coupled to XP 2040 photomultipliers are used. The pulse high spectra of these detectors are recorded by multichannel analysers. In some more detail the spectrometer is explained in a previous paper [3]. For an additional background reduction the experimental setup is surrounded by a shielding consisting of polyethylene and water of about 50 cm thickness.

The two cylindrical palladium samples Z6 (86.3 g) and Z8 (518.2 g) had been loaded cathodically with deuterium by heavy water electrolysis before the degassing experiment. The electrolyte was a solution of 1 M LiOD in heavy water enriched to 90 per cent in D_2O. The deuterium inventory in the samples is determined by weighing. From this follows an average ratio of D to Pd atoms of 0.74 ± 0.05 (Z6) and 0.80 ± 0.01 (Z8) after the electrochemical charging. Practically all deuterium leaved the samples during the degassing experiments.

The sample Z8 was degassed putting it on the already heated plate. The temperature measured after degassing on surface of the heating plate and on the top of sample Z8 was 375°C and 205°C, respectively. In a second experiment sample Z6 was degassed. But, this time starting at room temperature with switching on the heating device.

RESULTS

In Fig. 1 the counting rates during the periode of degassing sample Z8 are shown for two recoil proton energy intervals and both detectors. The hatched sections of the histograms indicate measurements with sample Z8 being in front of the detector, whereas the clear sections are counting rates for measurements with empty position in front of the detector. Both detectors indicate after starting the degassing in the energy range 1.9-3.3 MeV counting rates, which are significantly above the background . Later on, after the 13th run no difference between measurements with and without sample would be found. In the higher energy range 3.3-5.2 MeV no measurements indicate any difference between effect and background outside the statistical uncertainties. These results for sample Z8 give rise to the assumption, that neutrons occur within the sample for about 100 minutes after starting the degassing.

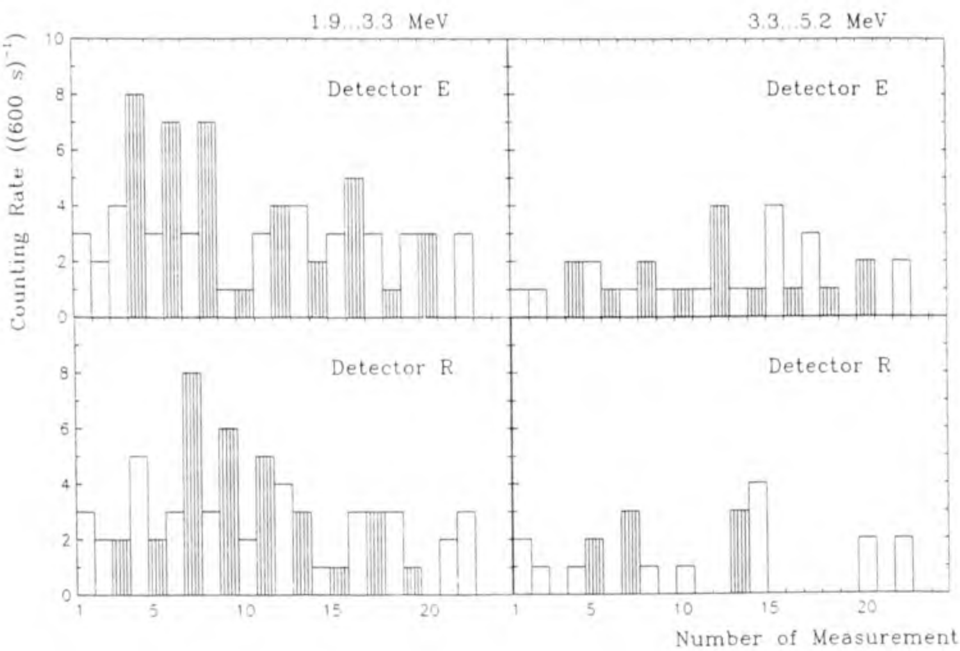

Fig. 1. Counting rates for the experiment with sample Z8 within the recoil proton energy intervals 1.9-3.3 MeV and 3.3-5.2 MeV from both detectors. The hatched sections of the histograms are measurements with sample, the clear sections without sample.

Fig. 2 shows the recoil proton spectrum within the time interval between the fourth and ninth measurement, when the counting rate difference for sample Z8 is at maximum. For the determination of the background all the other 38 measurements are used. For comparison in Fig. 2 also a recoil proton spectrum measured with good statistics for 2.48 MeV neutrons from the d-d reaction at a neutron generator is included. The agreement between both spectra is very well. From this can be concluded, that the energy of neutrons detected during degassing of sample Z8 is about 2.5 MeV. This confirms the assumption, that these neutrons are originated by d-d fusion.

The results for the sample Z6 are different from those of Z8. There are no results coming out of the background measurements. Both samples are distinguished mainly by their different masses, which is assumed to be the reason of the different behaviour observed.

For comparison the experimental data should be expressed in terms of nuclear reactions events per deuteron pair and second as done in many papers, following the deuteron pair fusion model from Ref. [4]. From measurements number 4 to 9 with sample Z8, when the effect is near to its maximum, this

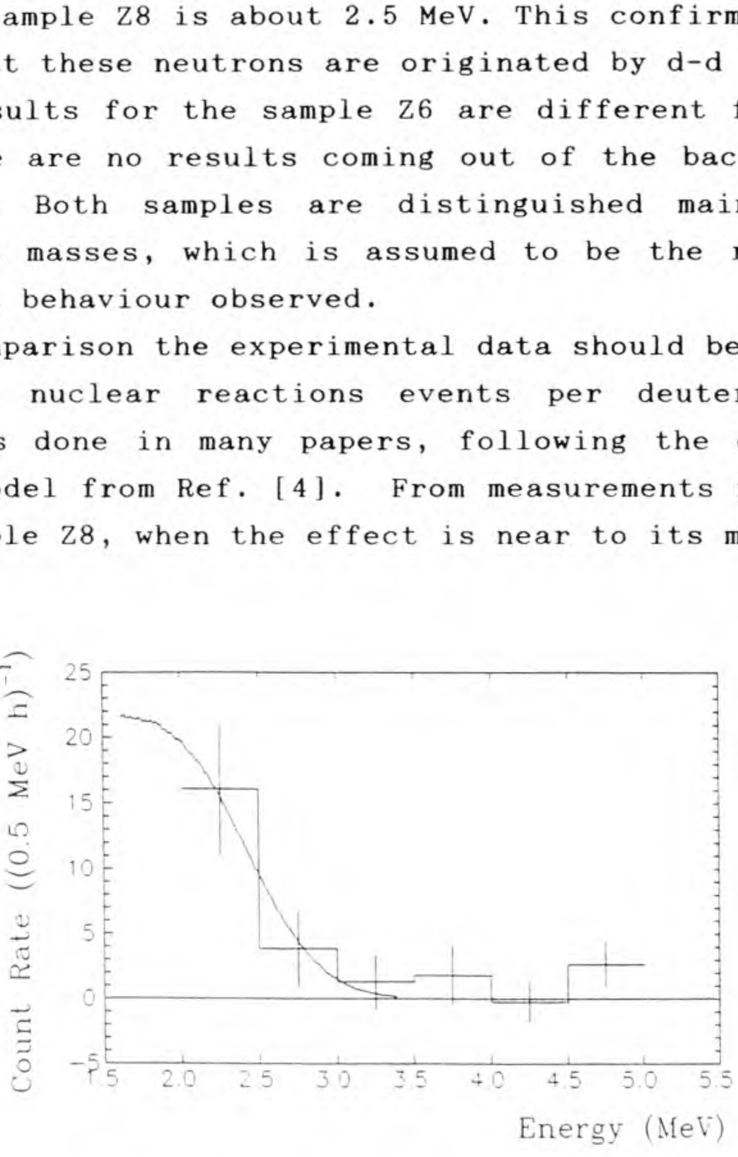

Fig. 2. Proton recoil spectrum during degassing of sample Z8 with 0.5 MeV energy bins and spectrum for 2.48 MeV neutrons from d-d reaction at a neutron generator (curve).

gives λ_{d-d}=(3±1)x10^{-25} per deuteron pair and second. This value is in the same order as our results from previous experiments on neutron production at electrochemically loading of palladium samples with deuterium [2,3,5]. As in our previous analysis a d-d neutron production becomes observable during non-equilibrium conditions only.

From measurements with Z6 an estimate of an upper limit for λ_{d-d} could be obtained. Starting from the 1σ-statistical error of one single short time run as an minimal observable effect, this yields $\lambda_{d-d} < 10^{-24}$ per deuteron pair and second. From this point of view, the results from Z8 and Z6 are not incompatible. A more detailled analysis of these experiments will be published elsewhere [6].

CONCLUSION

The present experiment with a 0.5 kg palladium sample shows a definite excess neutron counting rate for an period of about 1 h. This period is just the time interval during which the deuterium is expulsed from the massive palladium sample. The energy of detected neutrons is near to 2.5 MeV, as expected for d-d fusion neutrons. Therefore the conclusion is obvious, that these neutrons are caused by the d-d fusion reaction. The neutron excess counting rate, which is time dependent, corresponds in its maximum to a d-d reaction rate of (3±1)·10^{-25} per second and deuteron pair.

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