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EVIDENCE OF NEUTRON EMISSION FROM A TITANIUM-DEUTERIUM SYSTEM

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INTRODUCTION

Recently, a considerable number of experimental investigations have been carried out in different laboratories to determine, whether a possible catalysis of deuterium-deuterium fusion processes in condensed matter takes place or not. In some papers evidence was found for a weak neutron production, similar as it was announced by Jones et al. [1] for the electrolysic of heavy water using Titanium cathodes. Some-what later the observation of neutron emission during the absorption of Deuterium gas in Titanium and other metals was announced, too [2,3].

The present paper describes experiments aimed at the replication of the results obtained in [2,3] for charging of Titanium with deuterons from the gas phase.

EXPERIMENT

The experimental arrangement was similar to that of De Ninno et al. [2]: In a sealed stainless steel vessel (length 75 mm, diameter 45 mm) 58 g of Titanium turnings are contained. The container can be evacuated by a vacuum pump and filled with definite portions of Deuterium gas through valves and pressure regulator. It can be heated up to about 400 degree Celsius by an electrical heater located outside of the vessel and also cooled down to liquid Nitrogen temperature. Both the temperature and the gas pressure in the container can be measured during the experiment by means of sensors located inside of the vessel.

The neutron production is observed using the fast neutron spectrometer, described in the publications [4]. It consists of a NE 213 liquid scintillator (diameter 5 inch, height 1.5 inch) coupled to an XP2040 photomultiplier. The proton recoil signals are stored in 5 broad channel ranges ChR N1 .... N5 for getting an improved counting statistics of the very small effects. The channel ranges have the following proton recoil energy (PRE) bounds:

ChR N1:	threshold	...	0.85 MeV	PRE
ChR N2:	0.85 MeV	...	1.7 MeV	PRE
ChR N3:	1.7 MeV	...	2.95 MeV	PRE
ChR N4:	2.95 MeV	...	4.5 MeV	PRE
ChR N5:	4.5 MeV	...	6.0 MeV	PRE,

Signals from registration of single dd-neutrons are expected to occur in N2 and N3, the efficiency of registration of dd-neutrons is about 1.7% and 0.8% for the first and a second run, respectively.

The background can be determined before and after the effect measurements, but also in between of them, putting absorber materials between the vessel and the detector. In the present experiment all effect measurements were taken within equal 10 min. time-intervals.

The change of both temperature and pressure in the course of the first experimental run are shown on Fig. 1, together with the detector counting rates in the ChR's N2 ... N5. D_2-gas was added in small portions. Fig. 1 shows, that this Deuterium was absorbed by the Titanium turnings very fast and after every adding portions of gas the pressure falled down rapidly to an effective saturation pressure, which increases with increasing the total ammount of already absorbed Deuterium. The counting rates are shown in the lower part of Fig. 1. Of special interest are the counting rates in ChR's N2+N3.

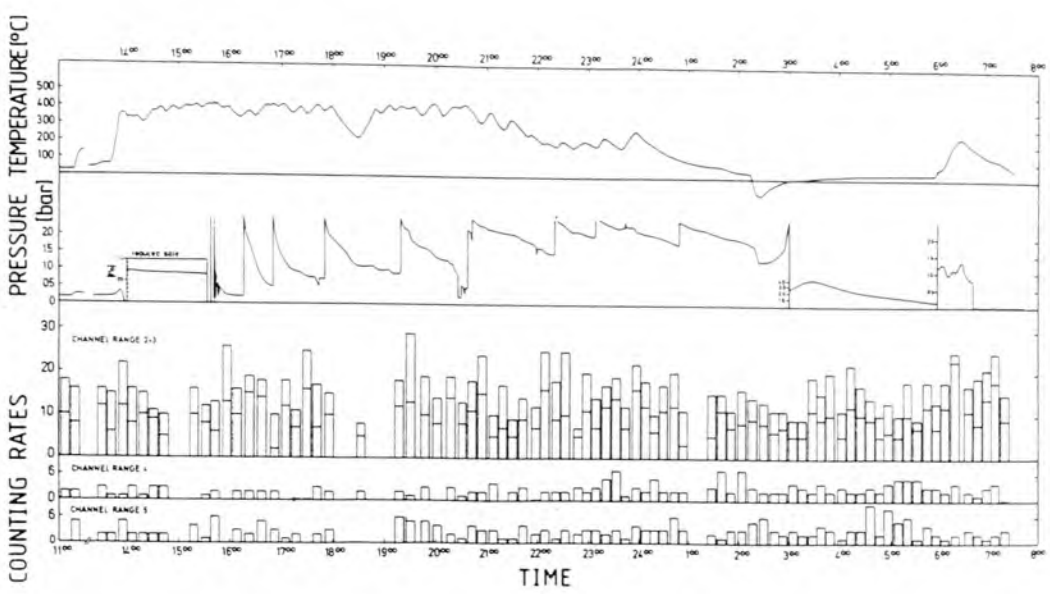

Fig. 1. Temperature, Pressure and Counting rates during the course of the first run.

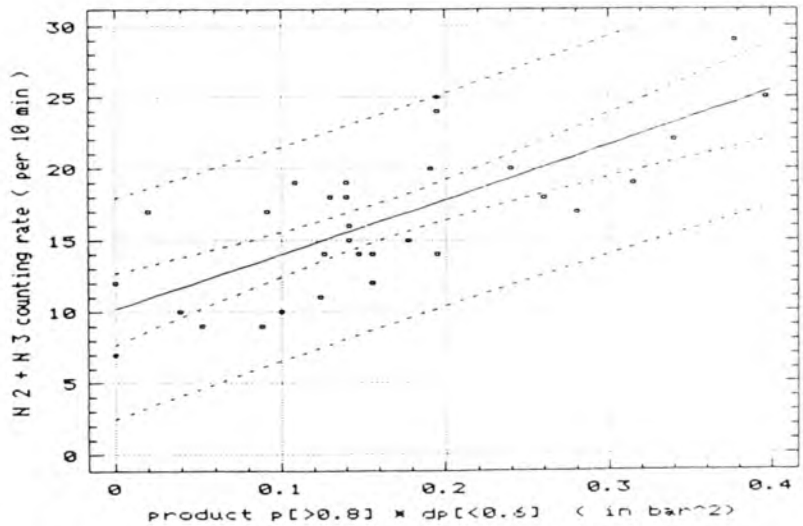

Fig. 2. Correlation analysis between the N2+N3 counting rates and the product p·dp.

We investigated, whether there is a correlation between the counting rate N2+N3 and the average gas pressure p, its decrease dp during the 10 min measuring interval or their product pdp. We found practically no correlation between the counting rate N2+N3 and the pressure p (correlation coefficient 0.018). The correlation with the pressure change dp is more pronounced (correlation coefficient 0.565). The most pronounced correlation appears between counting rates and the product pdp. On Fig. 2 the corresponding analyses for restricted areas p ≥ 0.8 bar and 0 ≤ dp ≤ 0.6 bar are shown, giving a correlation coefficient of 0.742.

Both "effect" and "background" spectra are transformed in a counting rate difference versus proton recoil energy spectrum, averaged over 250 KeV PRE bins, see Fig. 3. The PRE spectrum obtained is in accordance with the expectation, that the origin of registrated difference counts could be signals from dd-neutrons having 2.45 MeV energy: The energy determined from the slope of the PRE can be estimated with E_n = (2.65±0.25) MeV. There is also a weak, but statistically not significant indication for events with nearly the double dd-neutron energy.

In a second run using the same Titanium turnings but somewhat different geometry and procedures of changing both temperature and pressure the regression analysis of the measurements again shows, that there is no correlation of the counting rate with the pressure p (correlation coefficient -0.019) but a weak correlation with dp (correlation coefficient +0.239). The largest correlation coefficient is between the counting rate and pdp, however, it is only 0.363. This means, that correlations where less pronounced than it was observed for the first run.

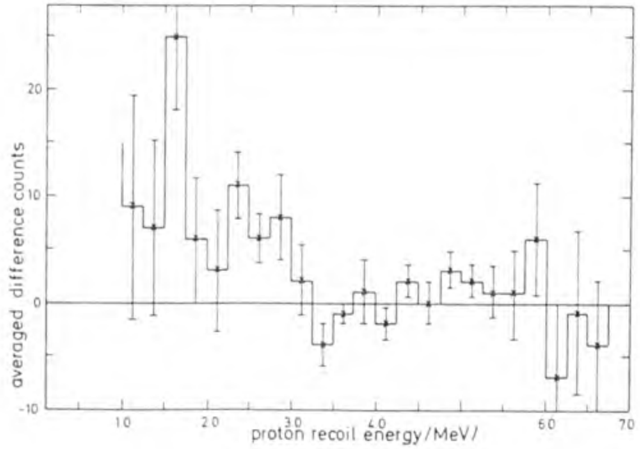

Fig. 3. Cummulative proton recoil spectrum after subtracting the background.

DISCUSSION AND CONCLUSIONS

In both experimental runs we have observed definite signs for a weak neutron production with a PRE spectrum, which corresponds to the assumption, that dd-neutrons have been detected. Following the paper of Jones et al. [1], the reaction rates should be expressed in terms of the fusion rate λ_{dd} per dd-pair and second. If we assume a full loading of the Titanium, corresponding to TiD_x with $x = 2$, the number of dd-pairs in the Titanium probe is equal to the number of Titanium atoms in it, which is equal to $7.28 \cdot 10^{23}$. The fusion rate obtained is $6.6 \cdot 10^{-25} s^{-1}$ or $2.67 \cdot 10^{-24} s^{-1}$, for the average and maximum effect, respectively.

However, we have seen, that there is no correlation between the reaction rate N_{dd} and the pressure p. This means that there is also no simple proportionality between N_{dd} and the number of deuterons absorbed in the sample! In opposite, the present experiment gives some indication, that the dd-reaction rate is gouverned by dp, that means by the particle flow into the metal per second. May be even more pronounced is the dependence on $p \cdot dp$, that means to the product of already absorbed deuterons and the additional flow of particles through the surface. This would be qualitatively in accordance with a simple plasma model of dd-fusion processes in condensed matter, published recently [5]. However, direct quantitative application of this model in the present case is difficult, due-to the complicated surface-to-volume geometry of the titanium turnings.

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