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Rapid Communication

Observation of neutron bursts in electrolysis of heavy water

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In an attempt to create conditions for the occurrence of cold fusion of deuterium, we have observed bursts of neutrons in the electrolysis of heavy water using both palladium and titanium as cathodes. The bursts are several times above the background, last for about five minutes and are aperiodic.

There has been a spurt of activity around the world to verify the recent claims of Fleischmann and Pons[1] and Jones *et al.*[2] that it may be possible to induce nuclear fusion at room temperature through the electrolysis of heavy water using cathodes which are good absorbers of hydrogen such as palladium and titanium. Room temperature fusion of deuterium induced by μ-mesons, with a mass around 200 times the electron mass, is known for quite some time[3]. The μ-meson replaces the electron in the deuterium molecule to allow a reduction in molecular size and bring the two deuterium nuclei close enough to undergo fusion. Loading of deuterium into the lattices of cathode materials in sufficient concentration during the electrolysis of heavy water, which may create conditions favourable for cold fusion at measurable rates, is a novel method with far-reaching consequences.

The nuclear reaction leading to the fusion of two deuteron nuclei are as follows:

$^{2}H + {}^{2}H \rightarrow {}^{3}He + \text{neutron}$

$^{2}H + {}^{2}H \rightarrow {}^{3}H + \text{proton}$

$^{2}H + {}^{2}H \rightarrow {}^{4}He + \gamma$

All these reactions are highly exothermic. Of these the first two are considered to have similar cross-sections and the third has a very low probability as known from scattering experiments. The two groups mentioned above have tried to deduce the signature of fusion through the observation of neutrons and excess enthalpy generated in the process. Only a weak neutron signal was seen by Jones *et al.*[2] They had to plot the difference of foreground and background spectra to enhance the visibility of the observed neutron spectrum. It has also been claimed[1] that the total enthalpy generated in the process cannot be accounted for by the observed neutron yield alone; it appears there is a large discrepancy. The results just mentioned have been viewed with cautious suspicion by several groups. Aware of the tremendous implications of such an experiment, many groups have taken up the task of verifying the results.

In an effort to check the possibility of creating cold fusion reactions through the elctrolysis of heavy water, we have performed several small scale experiments. Selection of cathode material was dictated by availability, we had only a small foil of palladium to start with. In an initial experiment we used this palladium as the cathode but later turned to titanium which was available in plenty.

Observation of neutrons directly from the cell remains by far the most clinching evidence of a nuclear fusion reaction as compared to the measurement of heat generated. As the neutrons are produced in heavy water, a known moderator of neutrons, it is rather difficult to employ spectrometric techniques. Measurement of thermal neutron flux, on the other hand, is relatively simple and can best be done using BF_3 and/or ^{3}He counters. We have adopted this strategy so as to produce unambiguous results free from controversies.

A long ^{3}He proportional counter with gas filled at 4 atm pressure was used throughout in conjunction with conventional counting electronics, e.g. a low-noise pre-amplifier, linear amplifier, single channel analyzer and a decade scaler. The lower threshold of the single channel analyzer was set high enough to reject pulses due to background γ-rays and accept only thermal neutron signals. This was checked frequently using an Am-Be source contained in paraffin.

The electrolytic cell and the experimental set-up are shown schematically in Fig. 1 for the case of titanium cathode. There was no water jacket when the palladium cathode was used. Two thermistors were used; one recorded the temperature of water and the other was placed directly in contact with the cathode to re-

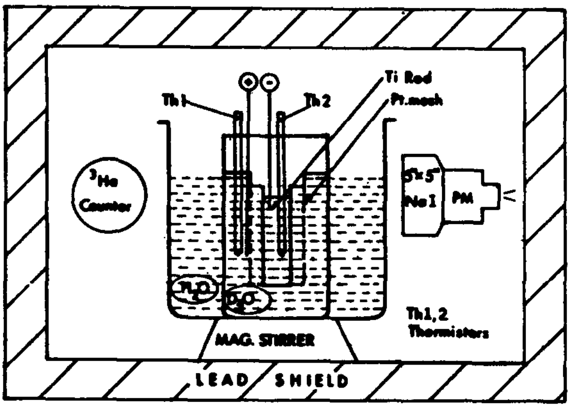

Fig. 1—Schematic layout of the experiment for titanium cathode

cord its own temperature. Platinum was used as the anode in all the cases. A small quantity of sodium chloride was added during electrolysis. Water in the cell was continuously stirred using a small magnetic stirrer, ensuring uniform distribution of heat.

The cell and the detectors were properly shielded with lead bricks to avoid background γ-rays interfering with our measurements. The water jacket served as a moderator for fusion neutrons. When a palladium cathode was used, there was no water jacket, but a thick paraffin jacket was used around the neutron counter. Capture gammas produced in water by the reaction $n + p \rightarrow d + \gamma$, if any, could be recorded in the 5" × 5" NaI(Tl) integral assembly (Harshaw) placed near the cell. It so turned out that the thick paraffin jacket used around the ^{3}He counter made it more sensitive to cosmic ray background. Therefore, although some neutron bursts were observed after about 8 h of electrolysis using palladium cathode, no definitive results could be obtained. In the subsequent titanium run, we removed the paraffin jacket.

The background was monitored with the cell in place for about 20 h to look for any cosmic ray bursts. The results are shown in Fig. 2. It is significantly flat within statistical limits for the whole period. The results of neutron counting as a function of time at 15 min intervals are shown in Fig. 3 for the case of titanium cathode. Three different current densities, viz. 15 mA/cm^2, 30 mA/cm^2 and 40 mA/cm^2, were used over a period of 44 h. No burst of neutrons could be found with the lowest current density. With the increase of current density at least four neutron bursts were conclusively seen (Fig. 3). The overall background is smooth throughout. The size of the bursts was 4-6 times the background and their duration was approximately 5 min, although we could not record data at finer time intervals to pinpoint the bursts. We do not see a continuous increase in the neutron counting rate and there does not seem to be any consistency in the period of occurrence. The counts rise from the background and level off again after the burst. There was a gradual rise in temperature both for water and the cathode. The final temperature attained was 53°C and 40°C respectively for palladium and titanium cathodes in our experiment.

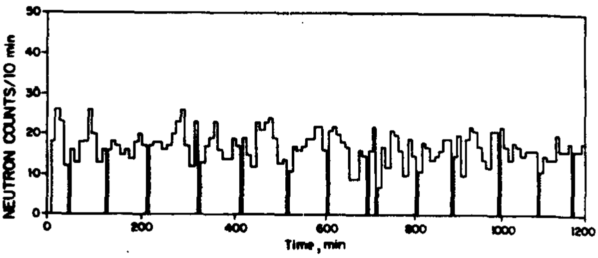

Fig. 2—Background neutron count as a function of time [The heavy water cell was always kept in place during this study]

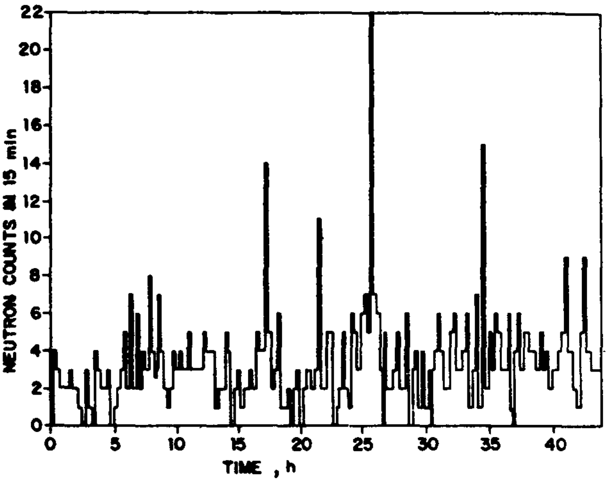

Fig. 3—Neutron count as a function of time during electrolysis of heavy water using titanium cathode [The data were recorded at 15 min intervals]

We used a sintered titanium rod for the cathode and this might not have good lattice properties to give large yields of neutrons. The current densities were also smaller than those used by other workers. Most important of all, although removing the paraffin jacket around the ^{3}He counter was good for reducing the cosmic ray background, it also reduced the efficiency to count fusion neutrons in general. The signal thus recorded and shown in Fig. 3 corresponds to the thermalisation efficiency achieved by the heavy water cell and the light water jacket.

We failed to observe the 2.2 MeV thermal neutron capture γ-ray. We attribute this mainly to the heavy background of 2.7 MeV γ-rays from radon products and its single escape peak around 2.2 MeV. We feel that the non-existence of the capture γ-rays may also be due to the rather weak neutron emission and perhaps not-so-thick water jacket.

Apart from neutrons, the signature of fusion reactions can also be found by detecting the radioactive decay of tritium. This, however, requires larger cells to produce enough tritium. We are planning more elaborate experiments to study these alternative methods and also to investigate the parameters governing the cross-section of fusion in these processes.

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