Evidence for Stimulated Emission of Neutrons in Deuterated Palladium

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ABSTRACT

In order to study the effect of Palladium in cold fusion, metallic deuterated Pd samples have been irradiated with partly moderated Am/Be neutrons and the resulting neutron intensity has been measured by the FERMI apparatus, an efficient and sofisticated detector for moderated neutrons.

Once subtracted the vessel + (empty) Pd effect measured in "blank" runs, an excess of 13.0 ± 0.6 neutrons per sec. (≈ 4 % of the total measured rate) has been detected. Assuming 2.45 MeV energy for the neutrons emitted by the radiated sample, the resulting rate corresponds to several outgoing neutrons for every neutron impinging on the Pd-D sample. Similar measurements with Cadmium absorber gave lower effects. We don't observe any effect with gaseous deuterium.

The underlying process can be interpreted as d-d fusion in a Pd-D lattice perturbed by neutrons. The excess, predominantly due to thermal incident neutrons, demonstrates that the Palladium lattice strongly increases the probability for d-d fusion even almost at rest.

1. Introduction and methods

The main cognitive question concerning cold fusion is if the d-d fusion probability (almost) at rest inside deuterated metals like palladium (Pd-D) is many orders of magnitude larger than in vacuum and in the deuterium molecule. This is anyway not possible in Pd-D in a steady state, because the equilibrium d-d distance is much larger there than in the D_2 molecule.In fact all claimed evidences for cold fusion are connected to non static situations.

The main question can be approached by firing low energy deuterons to a Pd-D sample and detecting fusion products coming out. The cluster impact fusion experiments at

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Brookhaven [1] can be interpreted according to us (interpretation not considered by the authors) as a possibly positive answer (yet not including Pd). Results of accelerated single ions experiments have been reported at this conference. This approach suffers from a few drawbacks: 1) The ions explore only the surface of the sample; 2) fractal dimensions of the surface and field effects might play a role; 3) the metal surface is very often dirthened by different absorbed atoms; 4) the impinging energy cannot be so small to exclude "hot" fusion.

Our solution has been to use neutrons in order to perturb the equilibrium: the lower their energy the larger the effect (by elastic scattering), reducing the doubts of hot fusion. Moreover they explore the full volume of the sample. We use a moderated neutron source: repeated measurements with different moderators and absorbers can provide (by subtraction) the desired quasi-thermal projectile neutrons.

2. The experiment

As samples we have used metallic Pd, one cilinder (8 mm diameter, 2.5 cm length) and two square section wires (1.2 mm side, 3.0 cm length). They have been loaded in a stainless steel cell with 35 Atm. D_2 and low temperature thermic cycles. The loading has been measured first by pressure drop and then by mass, with a sensitivity of 10^{-4} g. We have found a D/Pd atomic ratio $\langle x \rangle = 0.71 \pm .01$ averaged over the full volume.

An Am/Be source (2660 neutrons/sec) has been put inside a moderator-collimator (fig. 1) made of poliethylene bulk and Cadmium walls. This "neutron gun" was designed by full MC simulation in order to have the maximum intensity of slow neutrons impinging on the target and the minimum number hitting directly the detector. A removable Cd sheet in front allows to change the spectral composition of the neutrons. The resulting spectra of the projectile neutrons in the two cases is shown in fig.2. The shaded area shows that by subtraction of two measurements we can obtain a

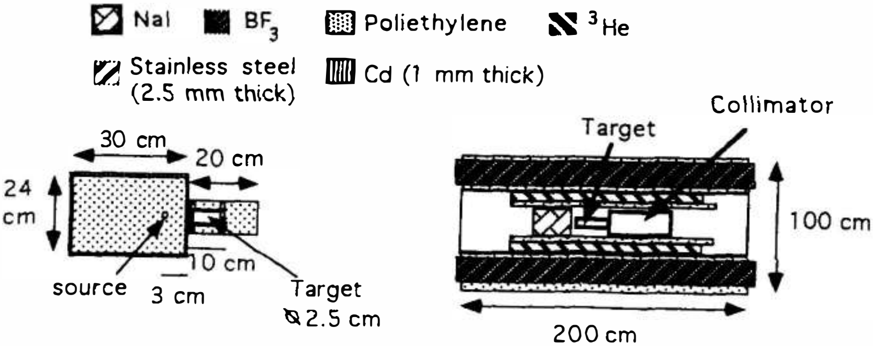

Fig. 1 : Longitudinal view of the collimator and of the FERMI apparatus

source enriched with thermal neutrons.

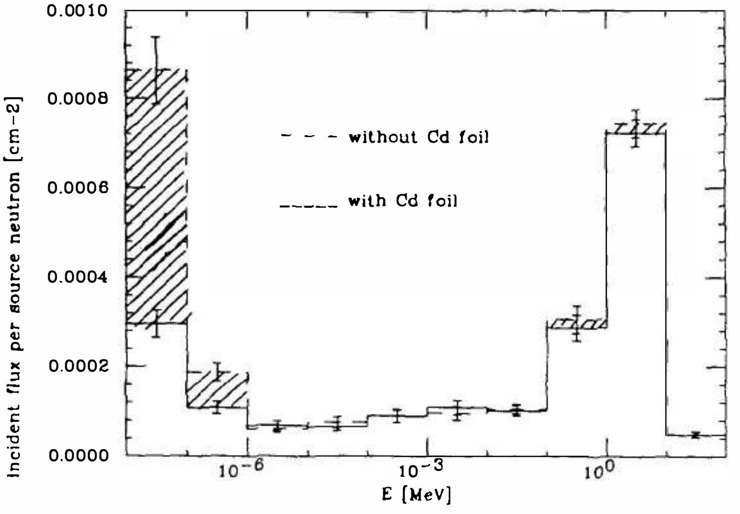

Fig. 2: Energy distribution of the relative neutron flux on the sample

As detector we have used FERMI apparatus, outlined in the previous contribution: it provides neutron detection with high efficiency for a broad range of energies, 0.5 MHz up to infinite time resolution for bursts, sofisticated electronics and data acquisition, full Monte Carlo simulation (experimentally tested), statistical energy determination. The experiment is setup inside the underground Gran Sasso laboratory, were the neutron background is 10^{-3} times lower than in Rome.

The Pd samples were put inside a stainless steel cell to be inserted in the detector (fig. 1) close to the neutron source. A poliethylene collar 2 cm thick surrounded the target cell. We have performed several blank measurements: 1) with cell in air; 2) with 35 bar D_2 in the cell; 3)cell with Pd in air, together with the main case of Pd-D in 35 bar D_2. Every measurement was repeated twice and every case was measured with and without Cd sheet in front of the source.

3. Results

The results are shown in table 1. The three columns concern the series of measurements with different neutron spectra: the third is the subtraction of the second from the first, to single out the effect of predominantly thermal neutrons.

Every column is a complete set of measurements, with blanks and repeated runs to check systematic errors (we find internal consistency of the data). The measurements with gaseous (incoherent) D_2 give a negligible effect, as expected by the simulation, which includes the neutron

Table 1 : rates in Hz for different experiments

Run type	No Cadmium	With Cadmium	Difference
Empty cell	298.54 ± .45	288.43 ± .46	
Pd sample	296.51 ± .39	286.60 ± .54	9.91 ± .67
Pd-D +D_2(35 bar)	309.54 ± .44	293.42 ± .54	16.12 ± .70
(Pd-D +D_2) - Pd	13.03 ± .59	6.82 ± .76	6.21 ± .96
Emitted neutron excess (MC eff.)	58.3 ± 2.6	30.5 ± 3.4	27.8 ± 4.3
Incident neutrons (MC)	11.3 ± 1.0	9.42 ± .92	1.86 ± .38
Excess/incident	5.16 ± .52	3.24 ± .48	14.9 ± 3.8

capture. After subtraction of the blank rates, we find an excess in both series with 22 and 9 (6.5 for the difference) standard deviations significance respectively and corresponding to 2 - 5 % of the total measured rate.

Our statistical energy determination (by distribution of counting rates of our 9 counters) has poor resolution in this case, due to the subtraction of large numbers. We then assume at present (we are working to improve the method) 2.45 MeV for the energy of the neutrons emitted by the samples. The corresponding efficiency was 22.3 %. With this number we determine the emitted rate of neutrons and comparing it with the incident one, we conclude that several neutrons have been emitted for every incident one. The last number to the right shows that most of the effect is due to thermal neutrons.

The results can be explained only by the influence of Pd lattice (since we don't find any effect with incoherent D_2). Fission neutrons (we have to check if our samples come from reactor) cannot likely account for the effect, because the measurement with Pd alone has been subtracted. We have checked other systematic errors.

4. Conclusions

We find an effect we attribute to multiple d-d fusion in Pd-D stimulated (perturbed) by thermal neutrons. The excess of several neutrons for every incident one implies that the Pd-D lattice has a far larger probability per unit time of emitting neutrons than the D_2 molecule.

We are checking if the time distribution of the events is consistent with our interpretation.The experiment is being repeated for confirmation.

References

1) Beuhler,R.J.;Friedlander,G.;Friedman,L.,1989,Phys. Rev. Lett.,63,1292;
Beuhler,R.J. et al.,1990,J. Phys. Chem.,94,7665.