Possible explanations for failures to detect cold fusion

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In a series of experiments Jones et al. have detected neutron excesses having indicated some fusion processes within deuterated metals. However, most efforts to reproduce their experiments have failed. Possible sources of failure of later experiments are discussed in this paper.

Jones et al. claim to have detected neutrons which might have originated from d–d fusion at Brigham Young University [1–9], in the Gran Sasso Laboratory [10–12] and at Los Alamos National Laboratory [13–15]. Several authors have tried to explain these observations conventionally. Statistical insignificance was claimed [16], statistical and systematical biases were suggested [17], variations of the cosmic neutron background were considered [18,19], bursts of solar flare neutrons were suggested [20] and cosmic muon catalyzed fusion was proposed [21,22]. However, all these explanations can now be excluded [23,24].

Several authors assume that microscopical hot fusion (MHF) could be the source of the neutron excesses above [13–15,23–36]. According to this idea deuterons accumulate around impurities and dislocations in the metal lattice, where these accumulations can grow to bubbles. If there are off-equilibrium conditions these bubbles can form cracks. Simultaneously, there can arise high electric fields which will yield so much energy that the deuterons are able to fuse.

Several arguments support the idea of MHF [24].

(1) Menlove et al. [13] have detected acoustical emissions which have indicated the formation of cracks.

(2) According to the idea of MHF each cm³ of deuterated metal should be able to emit about 10⁴ neutrons [28]. This agrees with the observations of Jones et al., Bertin et al. and Menlove et al.

(3) MHF demands that bubbles can arise only if there exist dislocations and impurities. Indeed Menlove et al. have not observed any neutrons where they have cleaned their titanium too well [15].

(4) According to MHF large cracks are able to release very short bursts of neutrons. Dozens of very short neutron bursts have been detected by Menlove et al. [13].

(5) The experimentalists have found out that their bursts have preferentially arisen at temperatures –100 to 0°C [13–15]. Exactly at these temperatures the crack growth rate has its maximum [15].

However, before one states that MHF could have been the source for the excess neutrons one should explain why so many experiments have failed to reproduce the results above. We will list four possible sources of failure.

(1) MHF occurs only if there are non-stationary conditions, i.e. temperature and/or applied current have to be varied [28]. Note also that Jones has written, “A characteristic feature of our experiments is the generation of non-equilibrium conditions in metal–deuterium systems. We accomplish this, for example, by changing temperatures in D₂-gas loaded cells and by pulsing voltages in electrolytic cells.” [15]. During a lot of those experiments which have failed to detect excess fusion products neither temperature nor applied current have been varied.

(2) Jones et al. were stimulated to perform their experiments by reports upon high ³He/⁴He ratios in solids, liquids and gases associated with areas of high

heat flow [37–39], high ^3He concentrations in metals [40] and an excess heat of Jupiter [41]. These reports and their studies in muon catalyzed fusion [42–46] led Jones et al. to the idea of screening and squeezing effects on D_2 molecules within metals [1,47]. This idea has been refuted [48–69]. But we have to consider that this idea led Jones et al. [1] suggest to perform high energy ion implantation experiments. However, these experiments are not appropriate to test MHF, because high energy deuterons cannot build any large bubbles. And even if they could the implanted keV deuterons would yield such

a large fusion neutron background that neutrons originating from MHF would be overlooked.

(3) The experiments have to be sensitive enough to test the claimed neutron production rates. For electrolysis cells the claimed rates are 10^{-23} – 10^{-24} $\text{d-d}^{-1} \text{ s}^{-1}$ (experiments of Jones et al. [1,3–8] and Bertin et al. [10,11]). By assuming MHF at deuteron energies of 10 keV the corresponding heat output is 10^{-4} W g^{-1} [24]. For gas loaded cells the claimed rate is $6 \times 10^{-26} \text{ d-d}^{-1} \text{ s}^{-1}$ (experiment of Menlove et al.; as they were not able to reproduce

Table 1
Electrolysis experiments.

First author	Sensitivity ($10^{-24} \text{ d-d}^{-1} \text{ s}^{-1}$)	Current (mA/cm^2)	Material	References
Armstrong	?	100	Pd	[73,74]
Gai	0.2	200	Pd/Ti	[19,75]
Lewis	1.5	64	Pd	[76–78]
Williams ^{a)}	0.5	14–530	Pd/Ti	[79,80]
Salamon ^{a)}	200	?	Pd	[81,82]
Kashy	0.6	2–12	Pd	[71]
Broer ^{a)}	2.2	63–70	Pd	[83,84]
Deakin	32000	300	Pd	[85]
Rehm	40	10–650	Pd	[86]
Southon	10	1000	Ti	[87]
Ziegler	0.2	150	Pd	[88,89]
Price	0.06	1	Pd/Ti	[90]
Briand ^{b)}	100	3.3	Ti	[91]
Aleksan ^{a)}	0.08	64–128	Pd/Ti	[92]
Miskelly	?	64	Pd	[93]
Alber	0.3	120	Pd	[94]
Blagus ^{a)}	0.3	18–200	Pd	[95]
Schilling	0.4	3–4	Pd	[72]
Baurichter	30	20–80	Pd	[96]
Schrieder	3	11	Pd	[97]
Roberts	7	50–250	Pd	[98]

^{a)} The current was not varied during the runs.

^{b)} There was only searched for excess heat. The upper limit was 10^{-12} W/cm^3 .

Table 2
Deuteron implantation experiments.

First author	Sensitivity ($10^{-24} \text{ d-d}^{-1} \text{ s}^{-1}$)	Current (mA/cm^2)	Voltage (1000 V)	Material	References
Durocher	?	10	60	Pd/In	[99,100]
Behrisch	8	17	1.5	Ti	[101]
Roth ^{c)}	10	0.3	0.3–6	Ti	[102]
Chambers	350000	0.11	1.5	Pd	[103]

^{c)} The voltage was not varied during the runs.

Table 3
Gas loaded experiments.

First author	Sensitivity (10^{-24} d-d $^{-1}$ s $^{-1}$)	Temperature (K)	Material	References
McCracken	36	77-293	Ti	[104]
Price	?	293	Li	[70]
Price	20	77-293	Pd/Ti	[90]
Botter	0.002	293	Pd	[105]
Eberhard	0.1	77-293	Ti	[106]
Balke	0.005	77-293	Pd/Ti	[107]
Silvera	2.5×10^6	4.3-400	Pd	[108]

the signals at will, so the mean rate might be much smaller).

(4) According to Menlove et al. [13] there occurs meanly one burst per 20 h at temperatures about 200 K and one burst per 400 h at room temperature (if there is used about 100 g of Ti). Hence, when one looks for bursts one has to examine a number of temperature cycles, because the bursts occurred while the cells were warmed up. Price [70] might have detected no protons, because he had performed only about 100 cracks. Menlove et al. [13], however, have measured tens of thousands of acoustical emissions, where only six bursts have taken place. This means that less than one out of 1000 cracks yields bursts.

We see that apart from the experiments of Kashy et al. [71] and Schilling et al. [72] all the experiments listed in tables 1-3 can be attributed to a minimum number of possible sources of failure above.

Eventually, the current applied by Kashy et al. [71] and Schilling et al. [72] has been too small, i.e. the variations of current might have been without action.

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