New Hydrogen Energies in Specially Structured Dense Media : Capillary Chemistry and Capillary Fusion

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ABSTRACT

The analysis of presently observed facts suggests that excess heat (above break-even) and concomittant cold fusion processes result from two different mechanisms which have a common origin in e.m. current behaviour in dense media (the Ampère forces). They both result from already known properties of nuclear forces and quantum mechanics.

1. Introduction

The present 1992 Nagoya Conference clearly illustrates the existing gap between growing evidence of new phenomena, tied to the presence of hydrogen and deuterium, in various types of electrodes. It can now be stated

A) that one has demonstrated the Fleischmann-Pons claim that there exists a significantly (now reproductible) excess heat (above break-even)
1) in electrolytic heavy water phenomena (see their new experiment)
2) in specially prepared palladium plates coated with deuterium oxide and gold (see Yamaguchi et al.)
3) in glow-discharges on deuterated palladium (see Kucherov et al.)

FRONTIERS OF COLD FUSION

This property has also been observed in zinc, titanium etc: the most striking being in tungsten bronze (see Barabushkin-Kabir et al.). Apparently there is growing evidence
- that the initial non reproductibility of such experiments is related (as shown by Kabir) with defects (cracks etc.) in certain samples utilized
- that excess heat grows with current intensities (i.e. with conductivity) in electrolysis and with increased loading of the electrode with heavy water or deuterium
- that it appears with a time delay (varying from minutes to hours) after the loading reaction starts
- that due to the variety of material utilized, it does not result from known chemical reactions

B) The observation of very small quantities of "fusion ashes" i.e. neutrons, He^3, He^4, tritium (and charged particles) but the essential fact remains

1) that if they result (as believed by the author) from already known nuclear reactions (D+D etc.) *these are not, by very far, in sufficient quantities to explain the observed excess heat*

2) that these fusion reactions occur in conditions of temperature where there is no apparent possibility to explain in this way how the corresponding ions overcome their Coulomb repulsive barrier: hence their name "cold fusion".

3) that there is nevertheless an apparent correlation between neutron production (whether continuous or in bursts) with this excess heat production.

C) that the excess heat phenomena also appears *in the total absence of fusion ashes* in various set-ups utilizing hydrogen and ordinary light water. I only mention here the Baraboshkin-Kabir, Srinavasan and Yamaguchi experiments. This new fact evidently cannot be explained by fusion mechanisms and implies the appearance (tied to H and D properties) of a new still unknown chemical type of phenomena. The facts A) B) C) evidently imply the following set of immediate evident questions:

1) Where does the excess heat come from? For heavy water or fusable conductors such as deuterium lithium etc? For light water or hydrogen? Has it the same origin or not?

2) Why are such experiments not always reproducible with apparently similar samples? Does this result from structured differences in the same products? or not?

3) Why is there a delay in time?

4) What is the origin or the observed energy bursts? Why are they correlated with neutron bursts?

5) If excess heat does not come from fusion and/or known chemical reactions in various types of electrodes what is its nature and its relation with observed fusion processes?.

In the presence of such facts and questions two main theoretical attitudes are possible.

1) We are observing something entirely new in the nuclear domain in the presence of condensed matter: i.e. fusion is tied to some structured properties of palladium (loaded with deuterium or heavy water) related to its lattice reactions (i.e. phonon propagation etc) or collective resonance reactions of fusing plasma enclosed within lattice structures. This is the line now followed by most theoreticians starting with Prof. Preparata on this panel.

My criticism of this is 1) that this line does not (to my knowledge) explain point C). 2) that it does not explain the gap between the quantity of fusion ashes) (i.e. nuclear fusion reacitons) observed and the excess heat itself.

2) that (within of course the present energy interval utilized)

- the present nuclear theory is valid: including the various branching rations of the D+D reactions

- that the present quantum mechanics formalism is also valid in that field

- that the interpretation of the facts A)B)C) to explain A) and C) simultaneously thus implies the observation/action of new specific physical properties tied to the geometrical structure of the electrodes and/or absorption loaded material.

A) modifies both $H^+ + H^+$ and $D^+ + D^+$ reactions in order to obtain excess heat in terms of a new chemical-type reaction compatible with quantum mechanics.

B) explains simultaneously the apparition (in very small quantities) of the observed fusion reactions: at least for very low intensity currents.

C) leads to reasonable predictions for new types of experiments.

§1. Charged particle Concentrations in Capillary Conductors

Within this later frame let me present here some facts and assumptions which (in my opinion) should be introduced as founding stones of a forthcoming developed *model of the (presently known) facts presented at this* Nagoya Conference. The first class of new facts now experimentally related with new current properties in condensed matter have been known and confirmed for some time. They are known to specialists as consequences of the action of the "Ampère Forces" empirically discovered long ago by Ampère (1823) and recently revived/justified by Graneau[1], Phipps[2], Rambaut and Vigier[3] and very recently by Saumont[4]. This force (which does not contradict presently known laws of classical and quantum electrodynamics for free charged particles) represents the collective interactions of charged current elements (i.e. of a mixture of positive ions with orbital and conducting electrons) presents the new remarkable characteristic of introducing unknown (now confirmed by experiment[4]) longitudinal repulsive forces between colinear current elements. Written in the usual notations (DFmn is a Newtonian force of repulsion (if positive) or attraction (if negative) between two current elements of length d_m and d_n and passing currents i_m and i_n respectively. The angle of inclination between the elements is ε and α and β are the inclinations of the elements to the distance vector r_{mn}) we have

$$\Delta F_{mn} = -\frac{\mu_0}{4\pi} i_m \cdot i_n \cdot \frac{dm \cdot dn}{r_{mn}^2} \cdot (2\cos\varepsilon - 3\cos\alpha \cdot \cos\beta) \quad (1)$$

which gives for the longitudinal force

$$\Delta F_{mn} = \frac{\mu_0}{4\pi} \cdot i_m \cdot i_n \frac{dm \cdot dn}{r_{mn}^2} \quad (2)$$

This longitudinal force in gaze_ous liquid and solid conductors has been shown (as illustrated in the two following figures (1) and (2) to distort the usual current i.e

Fig.1

Fig. 1 showing how a tungsten conductor is cut into pieces called usually (beads". The tungsten wire is photographed during the currentpause (Uppsala expeirments).

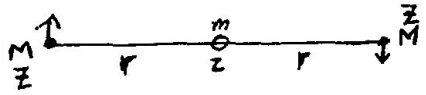
Fig.2

Sketch of an X-ray photograph of deuterium fibre fragmentation

has the evident consequences of creating standing longitudinal current concentrations in conductors i.e. to split them into string of beads which interrupt the current at high intensities. This creation of strings of (repulsive) current concentrations correspond to the nodes of the longitudinal standing waves of wavelength 1/n (with n integer) which appears between the extremities of a limited current with fixed end points separated by a distance 1. If an electrode contains rows of capillaries the ionization or injected currents thus induces (as a quasi-static wave system is created) the possibility of screening effects (which induce fusion) or, as we shall see, new ion-electron-ion systems which might explain excess heat.

§2. Interpretation of Excess heat in terms of a new type of chemical reactions

Two different physical consequences can be derived from the existence of the current beads on the behaviour of ionized ions i.e. the creation of hitherto unknown very tightly bound states $H^+ + H^+ + e^- = H_2^+$ and $D^+ + D^+ + e^- = D_2^+$ states which correspond to the combination of two ions which rotate rapidly in stable type Bohr orbits around an electron squeezed between them. This new type three body system corresponds to a new unknown quasi-molecular state (whose stability will be discussed later). As we shall now limit ourselves here to a simplified calculation. This corresponds for deuterium (according to the usual formalism) to binding energies of the order ~50 kev which account for the excess heat released without appreciable fusion contribution. [This idea first suggested by Barut (in a private communication) was also proposed (with the same 50 kev binding energy) by Gryzinski in Gamov type analysis (Nature 338 (1989) 712) of the collision between (H or D) ions and atoms]. The electron's orbit flattens perpendicular to the line of the colliding ions . It can be squeezed between them and stabilized there by the surrounding electron cloud. [This method of quantization and the role of intervening electrons explains some types of observed regular collective motions (i.e. cluster formations) which can contain triangular, tetrahedral cubic... configurations which move collectively and have been observed to have strongly enhanced (by many orders of magnitude with individual particles)]. This configuration naturally arises when the Ampère force cuts the current into beads in a capillary since the situation of the ions then resembles what happens to fast going cars which crash successively into each other during a slowdown (accident) on a modern highway. This situation is very different from the usual quantum mechanical interpretation of chemical phenomena i.e. of the normal states of H_2^+ and D_2^+ which are assumed (according to the Born-Oppenheimer approximation) to correspond to the rapid motion of the electron in the field of two almost fixed nuclei. If one first neglects the spin and considers two masses M (with charges z) rotating at a distance r from a mass m (charge z) i.e.



this gives the Hamiltonian

$$H = \frac{2p^2}{2M} + \alpha\left(\frac{2Zz}{r} + \frac{z^2}{2r}\right)$$

which when quantized by the usual Bohr-Sommerfeld method $\int p dq = n\hbar$ with ($\hbar = c = 1$) i.e. fields $p = -(m\alpha/n)(2z + Z/2)Z$) i.e. energy levels $E_n = -\frac{1}{4}\frac{M\alpha^2 Z^2 (2z+\frac{Z}{2})^2}{n^2}$

- For the H_e atom this yields $E_0 = -6{,}12$ Ryd close to the observed value -5,69 Ryd.

- For $\bar{H}_2^+$ and $\bar{D}_2^+$ the Bohr energy levels are approached by $E_n = -(9/16)(M\alpha^2/n^2)$ which correspond to ground states of 28,1 kev and 56,2 kev for $\bar{H}_2^+$ and $\bar{D}_2^+$ of course. This crude calculation should/can be extended to include spin-spin and spin-orbit calculations and also made relativistic (a detailed calculation is submitted for publication) using an effective potential

$$V(R=2r) = (L(L+1)/MR^2 - (3\alpha/R) + 4(\alpha/m)^{1/2}R^{-3/2}n$$

which yields very different minimal values and $1/M\alpha$ (Bohr radius for the proton) for $\bar{H}_2^+$. At short distances spin-spin interactions grow like $1/r3$ (compared to $1/r^2$ for Coulomb interactions. Spin-orbit interactions (i.e. $V_{LS} = e M_e((\vec{L}\cdot\vec{S})/Mr^3) \simeq M\alpha^4(M/m)$) are of the order of 10 kev (40 kev for D) i.e. comparable to the Coulomb potential. They are attractive or repulsive according to the sign of $\vec{L}.\vec{S} = (1/2)(J(J+1) - L(L+1) - 3/4)$ so that the attractive case can increase the binding energy to stabilize the new configurations and thus help fusion tunnelling in some cases.

This model implies evident consequences

- Evidently the excess heat energy obtained with H_2^+ is one fourth of the amount obtained with $\bar{D}_2^+$

This heat depends on the number of $\bar{H}_2^+$ and $\bar{D}_2^+$ (or light and heavy water $\bar{H}_2O$ and $\bar{D}_2+O$) i.e. on the loading of the capillaries contained in electrodes. Excess heat is created only when they are formed i.e. not necessarily immediately since individual capillaries' internal situation evolve with time.

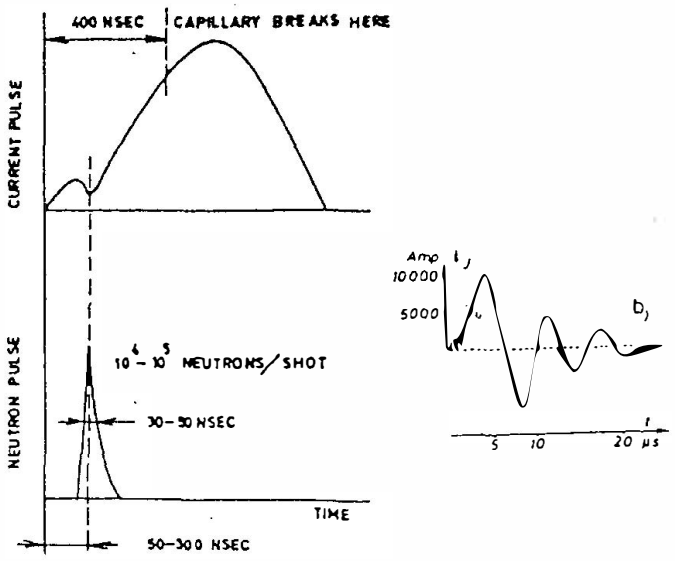


Fig.3. Drawings reproducted from the refs. [14] and [16] showing the principal elements which describe the capillary fusion experiments performed by Lochte-Holtgreven et al. [14] F.C. Young et al. N.R.L. 20 (1983) 439. [16] J.D. Sethian et al. P.R.L. 59 (1987) 585.

There exists the possibility to start chain formation of $\bar{H}_2^+$ or $\bar{D}_2^+$ which would explain heat bursts i.e. fusion waves of the Winterberg type. After some time the reaction stops and the new compound molecules ($\bar{H}_2^+$, $\bar{D}_2^+$) leave the system for good.

We now come to the question of "cold fusion".

&3. Cold Fusion Process in Capillaries

If one recalls that in some experiments there exists a correlation between excess heat and neutron emission and accept the fact that the later cannot explain the former the simplest possibility is to attribute both a common origin i.e. the beads of current concentration described above. Since it is evident that in $D^+ + D^+$ ion fusion the ions do not have a sufficient velocity to overcome the repulsive Coulomb barrier the only possibilities left are

- to assume a screening mechanism (i.e. lowering of the barrier followed by tunneling) tied to electron concentrations: a process discussed by many participants here (also supported by Rambaut and myself[5]).

For lack of space and time I will not discuss it here but only recall/indicate that it has been analyzed in various ways in the literature... and even extended to possible double screening processes (electrons plus ions) by Rambaut.

- to assume that the presence of an electron between two ions leads to unstable quantum closely bound quasi molecular quantum states which facilitate tunneling[5]. The existence of these new types of cold fusion mechanism opens interesting new possibilities for research and future utilisation. From the observed correlation between excess heat neutron emission and injected current pulses of the type utilized in capillary fusion (of z-pinch) one may obtain excess energy which mainly originates in this case from fusion processes. This is already strongly suggested by capillary experiments initiated in France (presently developed in Belgrade using $Li(ND_4)_3$ as conductor by Professor Marić on my suggestion) which shows growing neutron fluxes with growing current intensity (at significantly intensities) plus increasing neutron fluxes with decreasing capillary diameter.. They evidently justify the results obtained in Kiel some time ago by Lochte-Holtgreven and are represented in Fig. 3 . In Belgrade as in z-pinch experiments (by Sethian et al. (PRL [16]) one has obtained neutron bursts of $\sim 10^{12}$ neutrons in a few nanoseconds in frozen deuterium threads) by shooting $\sim 10^6$A in a few nanoseconds. Evidently the neutron flux grows like a high power (~8 or 10) of the current intensity. The Belgrade experiments suggest that big efforts should be made 1) to reduce the time duration of the triggering current pulses 2) to build fast switches to suppress the input current (second maximum in Fig. 3) after the Ampère force has cut it itself (see the first maximum of Fig. 3)

Conclusion

From this too brief analysis one can derive some experimental proposals and recall two quotations

A) New experiments are urgently needed

1) Redo all experiments presented here with heavy and light water (or with hydrogen and deuterium

2) Look at clustering theoretically and experimentally and look for radiation emitted by $\bar{H}_2^+$ and $\bar{D}_2^+$.

3) Push forward microscopic structural analysis of palladium bronze etc to look for capillaries (seen in bronze by Kabir) and compare systematically successful and unsuccessful samples

4) Try high current intensity very short current discharges in various situations (in conducting fusion material) to see if they increase excess heat production using loaded electrodes to increase the effect.

B) A big theoretical open minded effort is evidently needed

1) As stated by Einstein "Humanity is w.r.t. modern science like an inexperienced harseman on a wild horse". Evidently the wild horse of cold fusion has left the stable and is presently running

2) As stated to me long ago by Yukawa himself "When new facts appear the true theoretician should adapt his theories to these facts not the reverse. We are still far from a correct disantanglement of facts in condensed matter.

References

(1) P. Graneau, Ampère-Newmann electrodynamics in metal. Hadronic Press (1983).

(2) T.E. Phipps, Phys.Lett.A 14 (1990) 6.

(3) H. Rambaut and J.P. Vigier, Phys.Lett.A 142 (1989) 447 and 148 (1990) 229.

(4) R.Saumont, Phys.Lett.A 165 (1992) 310.

(5) See the summary of our proposals given by M. Rambaut. Phys.Lett.A. 163 (1992) 335.