Deflation Fusion:

Speculations Regarding the Nature of Cold Fusion

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PURPOSE

It is intended here to advance potential mechanisms underlying the production of cold fusion and low energy nuclear reactions (LENR). The possible existence of such mechanisms suggests new experiments and improved techniques that may lead to a better understanding of some of the anomalous behavior of these reactions, like unusual branching ratios. It is also intended to derive some engineering principles to utilize the mechanisms.

ELECTRON SCREENING IN FUSION REACTIONS

The term "electron screening" when applied to fusion reactions typically has two meanings. One type of electron screening is the effect of the distribution of charge in the electron wave functions of orbital electrons between two hydrogen nuclei. The charge of a single orbital electron is spread over a large volume, compared to nuclear distances, thus this screening is very tenuous. The electron screening in a hydrogen molecule actually thins out if the two nuclei are brought closer together than their average separation distance, thus increasing their mutual repulsion and restoring the molecular shape. This orbital electron screening requires long tunneling distances of the hydrogen nucleus to achieve fusion, due to the large size of the orbital in comparison to the nucleus.

Another kind of electron screening can occur when most of the wave function of one or two free electrons gets between two hydrogen nuclei. This can only happen if the screening electron de Broglie wavelength is small, therefore the momentum and thus energy of the screening electron is high, well over 2000 eV. This kind of electron screening happens with great frequency only in very hot dense environments.

Electron screening fusion reactions can be called electron catalyzed fusion. Proposed here is a third kind of electron catalyzed fusion, called *deflation fusion*. It is not an electron screening reaction. It is fusion occurring as the result of a multi-body quantum wave function collapse simultaneously involving electron(s) and hydrogen nuclei, especially deuterons. Wave function collapse is a term which has meaning depending on the quantum interpretation invoked. Regardless of interpretation, as applied here, it is a very real phenomenon. Consider the electron capture reaction.

An electron with a wave function covering a volume thousands of times that of a nucleus suddenly collapses to become part of the nucleus when the electron capture reaction occurs. Similarly, in the photoelectric effect, a photon from across the universe, having a wave function of very large size, can collapse its entire energy and momentum onto one tiny electron on one atom in order to eject it from its orbital.

An electron on one side of a Josephson junction has a wave function that initially extends to the other side of the junction with only a small (volume integral) probability. Yet, depending on the width of the junction and the potential across the junction, once the electron tunnels across, it builds a newly centered (center of mass) wave function having a small probability of being where it was on the other side. These are three examples of wave function collapse, where a quantum wave function can suddenly change both location and locus probability distribution dramatically. Such quantum wave function collapse can happen and indeed happens when it is energetically favorable for either electrons or nuclei. Tunneling and wave function collapse are phenomena well known to be intrinsically involved in cold fusion.[1] The deflation fusion description here is an exploration of a possible new form and combination of these events, especially as it might take place in a hydrogen loaded lattice.

Typically in deflation fusion the wave functions of an electron and two hydrogen nuclei momentarily collapse into a small volume, their centers of mass being co-located, to create an intermediate state. Weak and/or strong nuclear reactions may occur in this intermediate state. This process differs from an electron screening process, where the screening occurs prior to tunneling, and does not involve an electron in the nucleus. A key ingredient to making deflation fusion occur is stressing the electron wave function so as to make its collapse with two nearby nuclei energetically favorable. Another key ingredient is creating a configuration in which it is energetically favorable for two nuclei to tunnel to an electron, or a nucleus to tunnel to a deflated waveform nucleus-electron pair in close proximity, or vice versa. These processes are described in detail below.

TWO BODY WAVE FUNCTION COLLAPSE

An electron wave function collapse upon a *single* nucleus, followed by reverse tunneling, is much more likely than the three body events discussed above, but it is an unnoticed event, an event without any "ash" or consequences. When the reverse tunneling occurs, the final state is identical to the initial state. Neutron creation is energetically not favored from the two body event, because a neutron has more energy than an electron plus a proton, and also because neutron creation is a weak force interaction. A weak force interaction is improbable, even if an energetic neutrino or energetic nucleus supplies the energy, because weak reactions require a long exposure time. Typically tunneling is a two way possibility. All else being equal, *i.e.* energy neutral, the smaller the probability of a "tunneled to" volume, the less apparent time available in that small volume state. Still, the apparent time in even a very small probability state is finite, and thus interactions, like strong or weak force interactions, other tunneling, etc. are made possible from that state and their probabilities depend on the apparent percentage of time in that state. This is how electron capture happens, which *is* energetically favored in some nuclei, but not protium or deuterium nuclei. Note that, for the sake of simplicity, tritium will not be mentioned here except to note that it is essential to eventually test any effective cold fusion cell type with a 50-50 deuterium-tritium mix.

Some quantum interpretations see the electron as a point particle and its quantum waveform as, in effect, a probability distribution for its whereabouts. More accepted interpretations see the quantum waveform as merely a potentiality of particle existence in a given volume, without actual existence unless a measurement is performed. This latter view appears to the author to be wrong at least to the extent portions of the quantum waveform, that is any selected volume of the electron quantum waveform, exerts force as if there were partial charge located in that volume and the proportion of effective charge in that volume corresponds to the electron occupation probability for that volume. This apparent partial waveform charge accounts for location of the nucleus at the "center of charge" of an atom, dislocation of the center of charge in an electric field, the converse effect, *i.e.* the piezoelectric effect, and electron screening in hydrogen molecules.

A momentary state exists periodically for hydrogen nuclei and nearby electrons in which a single small wave function exists for that state and the nucleus plus electron in that state can act as single small intermediate state particle. (This state may be viewed alternatively under some interpretations as a coexisting state, a partial existence potentiality, or a state which manifests on observation with some finite probability.) Call this small wave function state a *deflated hydrogen state*. That state, or particle, formed sometimes under observation and wave function collapse, is not a neutron, not a di-neutron, not a hydrino, not a hydrex,[2] and not a protoneutron as in the Mitchell Jones theory as discussed first on the newslist sci.physics.fusion. The deflated hydrogen state differs from the above listed particle concepts in that it represents a partial form of existence of the involved electron-hydrogen nucleus pair. The deflated hydrogen state (at least upon observation) exits for time intervals in the attosecond range, but it is repeated at a high apparent rate. Depending on the strength of the bond or resonance of the deflated hydrogen state, this momentarily bound state may be an intermediate state preceding deflation fusion. In other words, a three body wave function collapse may consist of a multistage process, a two body collapse to a deflated hydrogen state, possibly followed by some very small attosecond order duration of motion of the neutral charge deflated hydrogen, followed by tunneling of the intermediate state particle to a second nucleus, or vice versa, or even tunneling to or with a lattice nucleus. Cold fusion engineering then consists of designing ways to increase the probability of and thus the proportion of existence of the deflated state hydrogen, and thus the probability of deflation fusion, or of increasing the probability of multi-body wave function collapse.

The radius of a deflated state deuteron may be as small as about $8x10^{-17}$ m, due to the large momenta and thus the small de Broglie wavelengths of the deuteron and electron in that state and the high degree of magnetic binding required.[3]

Now that the deflated hydrogen state has been defined, it is easy to see the ideal configuration to engineer is one in which tunneling tends to occur in the deflated state, or tunneling to a site momentarily occupied by a deflated state hydrogen tends to occur. This is cold fusion.

It is not known the strength of the bond of the deflated hydrogen state, or its distribution, and thus the respective probabilities of one stage or two stage multi-body wave function collapse. It is likely the bond is very weak and variable because the deflated hydrogen state occurs extremely frequently and periodically. It might be expected the deflated state happens with a probability being roughly equal to the probability of the electron being in or highly proximal to the hydrogen nucleus. The probability may in fact have been observed to be much higher than this though. The deflated hydrogen state may indeed provide an explanation for the missing proton problem.[4,5] The probability of the deflated hydrogen state in water and other compounds may be as high as 0.25. When viewed in attosecond time frames, water is $H_{1.5}O$, not H_2O.

The electron hops into and out of, or otherwise coexists in, the deflated hydrogen state without any change in energy or apparent radiation. One way to visualize this state is that it is a partial state of the involved electron which is not observed unless wave function collapse occurs which precipitates a strong force reaction fusion event with another nucleus, or interaction occurs with a photon or particle, one possibly used to sense the state, or at least lack of interaction from the state.

Another way to view the deflated state is it is a brief state which is both energetically permitted and then ended by zero point field interaction. As with the orbital itself, there is thus no resultant radiation due to electron acceleration. Heisenberg is not violated because the time intervals are so brief.

An electron easily tunnels back and forth between an orbital state, or partial orbital state, and a deflated hydrogen state, *i.e.* coexists in those states, because it is energetically possible. In normal circumstances the deflated hydrogen state is not observed because it is so brief, though with new technology it may be observed because the deflated hydrogen state is neutral, thus the hydrogen nucleus can in effect momentarily disappear periodically, or with some probability, to a photon, neutron, or electron beam. There is nothing that traps the electron in the nucleus in the deflated hydrogen state because the potential energy change due to charge location is offset by the uncertainty energy, in essence the energy required to confine the electron to a small volume, zero point energy. However, this energy balance changes if deflation fusion ensues, because there are then two positive charges in the nucleus, and the electron must inflate its way out of this fused nucleus by accumulating zero point energy, and it radiates in the process.

It is reasonable to discuss or treat multi-body tunneling as a single event or process because a two stage deflation fusion process in which a deflated hydrogen is involved is essentially indistinguishable in outcome from a single stage multi-body collapse. Both can occur in attosecond range time intervals.

WHY KINETIC FUSION IS UNAFFECTED

The very brief existence of the deflated state explains why kinetically induced fusion can not make use of the Coulomb barrier being down, because there is insufficient time for a motional approach of two nuclei before the barrier is back up. Even at an energy of 2000 eV the proton has a velocity of $6x10^5$ m/s, thus travels only $6x10^{-13}$ m per attosecond. This is not enough to affect to a practical degree the tunneling rate for hot fusion.

ELECTRON FUGACITY

Much discussion has occurred in the cold fusion (CF) and low energy nuclear reaction (LENR) literature regarding the importance of achieving high D/Pd atomic ratios, *i.e.* high hydrogen loading in CF cathodes, and thus high hydrogen fugacity. Fugacity is similar to pressure in that it is a measure of the energy required to add an additional particle to a system.[6]

Much work in the cold fusion field has, from early on, focused on the difficulty of achieving high hydrogen fugacity[7] because lattice imperfections exist, electrode metals fail, diffusion occurs into cracks and occlusions,[8] and other sources of hydrogen loss exist.

Some work has focused on the importance of superimposed electrostatic fields in or on cathodes, specifically that of S. Szpak, P.A. Mosier-Boss, and F.E. Gordon.[9] This work noted structural and morphological changes in electrode structure, dendrite growth, etc. in the presence of strong electrostatic fields.

Despite an intense focus on hydrogen fugacity, and some work related to superimposed electrostatic fields, no work has focused on electron fugacity. This is a complex area due to the quantum mechanical requirement for degenerate electrons to occupy ever higher energetic states once their density passes a critical value, and no conduction electron is free to "move" statistically speaking.[10]

One aspect of achieving high loading coefficients is that conduction band electrons, which are ionically bound to the adsorbed hydrogen in the lattice, are bound to a specific location when the adsorbed hydrogen reaches saturation and thus can no longer diffuse. In fact, one means of measuring cathode loading is to measure cathode conductivity. A key aspect of achieving high electron fugacity then, when no other means is applied or even known to be of use, is to achieve loading to the point no diffusion can occur. Cracked electrodes, lattice imperfections, unsealed exposed surfaces, and anything else that permits hydrogen diffusion leakage decreases electron fugacity as well.

As hydrogen is loaded into Pd at a given temperature the conductivity decreases to about $H_{0.8}Pd$, and then increases with increased loading. Beyond this point long range electron waveform interaction appears to become significant. More importantly, the sensitivity of lattice resistance to temperature begins to increase, especially near $H_{9.5}Pd$ loading, due to the increased sensitivity of the energetic long range electron wave function interaction to thermal disruption. This suggests the possible utility of loading at high temperatures and then reducing temperature to establish high electron fugacity and the energetic long range electron wave functions capable of energy focusing. In any event, these facts strongly indicate that both conductivity and its relation to temperature should be studied in relation to induced surface charge in thin films, and the existence of the deflated hydrogen state should be investigated in relation to these variables.

Though electron fugacity is highly related to hydrogen fugacity, they are not synonymous. Electron fugacity at the surface of a metal conductor clearly can be increased by increasing the magnitude of the negative potential of the metal. This increase of negative potential is synonymous with an increase in electron surface density. Excess itinerant electrons migrate to the surface of a metal conductor—to a point. When conduction bands at the surface fill up, addition excess electrons are forced to lower levels. At very negative potentials, orbitals of surface atoms deform out into the space beyond the normal surface. When complete hydrogen saturation occurs in a loaded cathode, additional conduction band electrons are forced to occupy locations within the volume of the conductor. Therefore the conduction bands at the surface fill up, pushing the excess conduction band electrons deeper into the metal.

If sufficient electron fugacity is achieved in a given volume of a lattice, then the addition of more electrons results in a higher energy state of the electrons, not a higher temperature of the electron "gas." It is at this point fusion may possibly be catalyzed by electron fugacity. Increased electron quantum state and reduced wavelength assists electron catalysis of fusion. The common three body tunneling deuteron reaction probabilities are energetically increased:

$$D + e- + D \rightarrow He + e- + energy$$
$$D + e- + D \rightarrow T + p + e- + energy$$
$$D + e- + D \rightarrow 3\ He + p + e- + energy$$

These reactions involve the simultaneous two body tunneling of an electron and deuteron, in deflated state, to the location of another deuteron, or vice versa, *i.e.* a three body reaction. Similar reactions can involve other isotope pairs or multiple isotope-electron reactions. When the fugacity of both hydrogen and electrons reaches a critical point, the addition of more energy to the lattice results in fusions. This is an energy focusing effect. An increase in the group energy state, *i.e.* group fugacity, can result in a pressure outlet involving only a few members.

Note that the eventual escape of the catalytic electron from the newly fused nucleus reduces the resultant *nuclear* temperature. The electron populated nucleus can radiate. The branching ratios from an electron catalyzed reaction will therefore differ from those of a kinetic fusion reaction which does not involve a catalytic electron in the initial bound state.

High surface electron fugacity of a cathode can be achieved by increasing the negative potential of the cathode, and thus the electrostatic field at the cathode surface. It can also be increased in small locations by a bumpy or dendritic cathode surface.

An alternative way, or more importantly an incremental way, to increase the electric field strength at an electrode surface is to bounce a laser beam off of it at a low angle of deflection. Laser stimulation of a very highly negative potential cathode surface may work in a gas environment, provided the surface out gassing is controlled by choice of a surface material with a low hydrogen permeability and which sustains both a high hydrogen and high electron fugacity by presenting an appropriately strong barrier to diffusion. Such a surface can be fed adsorbed hydrogen via a proton conducting backing like palladium. Laser stimulation of fusion on a cathode surface in the presence of a magnetic field is well known and is called the Letts-Cravens effect.[12,13]

DEFLATED PAIRED STATE

In a high electron fugacity environment, excess electrons can be expected to form pairs with other conduction band electrons, including those which are ionically bound to hydrogen nuclei. These pairs consist of electrons occupying the same quantum state with the exception of opposed spins. Such a pairing in fact creates a weak bond between the paired state electrons. The existence of such pairs in a highly loaded lattice provides a credible explanation for increased conductivity at high electron fugacities, as well as the increased sensitivity of conductivity to thermal disruption, though this hypothesis requires experimental validation, especially in cathodes with high backside potentials. At high loading, conductivity should vary depending on both temperature change and large swings in cathode potential. The existence of weakly bound paired electrons increases the probability of a *deflated paired state*. In such a state two small wavelength electrons exist in the nucleus. Such a state, having a negative charge, has a vastly increased probability of tunneling to other nuclei and of being a target for tunneling nuclei.

SURFACE POTENTIAL

Surface potential at a conductor surface point P is defined here to be with respect to the surface of some small volume $(dx)^3$ of a neutral matter, where there is no intervening conductive surface surrounding P and separating P from the neutral matter. Neutral matter is matter having an equal number of positive and negative charges. Establishing and measuring potential in this context is critical in achieving a desired or even known electron fugacity. For this reason, conducting LENR experiments in Faraday cages is essential. The small volume of neutral matter that defines zero potential can then be located within the Faraday cage metal itself. It should be sufficient to use a grounded Faraday cage as ground potential, *i.e.* potential zero, to achieve the electron fugacity goals for various experiments.

BRANCHING RATIOS

If sufficient electron and deuteron fugacity is achieved the probability of a three body electron tunneling reaction is energetically increased. When the fugacity of both hydrogen and electrons reaches a critical point, addition of more energy to the lattice results in fusions. This is an energy focusing effect. An increase in the group energy state, *i.e.* group fugacities, results in a pressure outlet involving wave function collapse of relatively few members, resulting in deflation fusion. Let us examine how this deflation fusion process might change branching ratios.

The following are standard D + D hot fusion branching ratios:

$$\text{D} + \text{D} \rightarrow \text{T}(1.01\text{ MeV}) + \text{p}(3.03\text{ MeV}) \quad (4.03\text{ MeV}, 50\%)$$
$$\text{D} + \text{D} \rightarrow {}^{3}\text{He}(0.82\text{ MeV}) + \text{n}(2.45\text{ MeV}) \quad (3.27\text{ MeV}, 50\%)$$
$$\text{D} + \text{D} \rightarrow {}^{4}\text{He}(76\text{ keV}) + \text{gamma }(23.8\text{ MeV}) \quad (23.9\text{ MeV}, 1\times10^{-6})$$

The initial effect of an electron in a newly fused nucleus is to reduce its stored energy in comparison to a hot fusion created nucleus. The tunneling of two deuterons and an electron to a point is the result of a wave function collapse. The amount of energy lost in the wave function collapse is dependent on the size of the combined intermediate result, which is a random variable.

From the electric potential energy Pe for separating an electron from two newly fused deuterons at radius r we have:

$$Pe = k\,(-2q)(q)(1/r) = (2.88\times10^{-9}\text{ eV m})\,(1/r)$$

which we can rearrange to obtain r for a given potential energy,

$$r = (2.88\times10^{-9}\text{ eV m})\,(1/Pe)$$

and we have for 23.9 MeV:

$$r = (2.88\times10^{-9}\text{ eV m})\,(1/(23.9\times10^{6}\text{eV})$$
$$r = 1.2\times10^{-16}\text{ m}$$

which is about ten times the diameter of a quark and approximately that of the deflated hydrogen state provided earlier, and thus in the realm of credibility. It is feasible for a two deuteron plus electron wave function collapse to initially consume all the available fusion energy.

If the three interacting particles collapse to approximately the deflated hydrogen size then all the 23.9 MeV available from ordinary hot fusion (and more) is consumed. This is certainly an energetically favorable tunneling reaction. Further, given that the collapsed intermediate nucleus radius is variable in size, according to some probability distribution, various total energy amounts are available per reaction. We can also see that the neutron producing reaction, D + D → 3He + n, having the least energy available from the fusion reaction (3.27 MeV), would necessarily be the least likely branch path. Thus it is clear how the electron catalyzed deflation fusion produces an initially cool nucleus and favors the reaction D + D → He. However, the nucleus can't stay cool. The confined electron gains energy from the vacuum, and from its immediate neighbors, which also gain zero point energy due to the small nucleus size.[14] The electron gains zero point energy until it has sufficient energy to tunnel out, and possibly take some kinetic energy with it also. In the process of the electron gaining energy, while it is confined with the nucleus hadrons and experiencing accelerations within the energetic nucleus, the nucleus can be expected to radiate. This is the bulk of the energy of cold fusion, of electron catalyzed deflation fusion—protracted low energy gammas and beta radiation. The most likely product is helium and the second most likely product, though comparatively rare, is tritium. The least likely products are helium-3 and neutrons, though trace amounts of these products are produced.

ULTRA-HEAVY HYDROGEN ISOTOPES

The existence of hydrogen-4 to hydrogen-7 and possibly beyond, as well as helium-5 to helium-8, may shed some light on the intermediate states of some LENR processes.[15] A deflation fusion of multiple electrons and two deuterons or more in a loaded lattice, possibly followed by a weak reaction, could produce these ultra-heavy hydrogen or helium nuclei as an intermediary state. The ability to shed four neutrons or more from a heavy hydrogen or helium intermediate state implies the ability of a quad-neutron to tunnel to a heavy nucleus in the lattice. This could explain various observed jumps of four in nucleon number of lattice elements in LENR experiments. Further, a deflated hydrogen state of an ultra heavy hydrogen may look like a clump of neutrons to the lattice atoms, and thus easily tunnel long distances to them because the tunneling is energetically neutral electrostatically speaking, and favorable magnetically.

It is notable that hydrogen diffusion occurs via tunneling the typical separation distance of the lattice metal nuclei, *i.e.* from one lattice site to an adjacent site. However, the typical distance between a hydrogen nucleus and lattice nucleus is half that. *The tunneling rate of a deflated hydrogen nucleus into close proximity of a lattice metal nucleus is thus greater than to the same proximity of a hydrogen nucleus in an adjacent site.* If the tunneling hydrogen nucleus is in the deflated state, *i.e.* neutral, its final destination is unaffected by the Coulomb barrier, only affected by its mass and the tunneling distance. The size of a nucleus is affected by nuclear structure and excitation state. We would thus expect deflated state tunneling to occur into lattice nuclei with greater probability until a low energy small nuclear structure is achieved. This feature may be of special use in deactivating nuclear waste. A typical final nuclear state should tend to consist of multiple alpha particle structures.

Because deflated state hydrogen has no net charge, the probability of deflated state hydrogen tunneling long distances is greatly increased due to lack of a tunneling barrier. In D + D fusion in the lattice, a lattice where diffusion is occurring and thus there is a high tunneling rate of ordinary deuterons, the tunneling D is therefore most likely to be in the deflated state, and the static hydrogen in the tunneled-to location where fusion occurs is therefore likely to be in the deflated state. However, either type of tunneling resulting in deflated hydrogen plus hydrogen occupying the same lattice site is highly probable. For this reason, and because the wavelength of hydrogen is much larger than heavy nuclei, D + D fusion can be more likely than low energy nuclear reactions with the lattice nuclei.

It has been noted that in some cases magnetic fields improve the success rate of producing LENR. This is highly consistent with the deflation fusion concept in that a magnetic force aligned between hydrogen locations and lattice atom locations provides a potential that greatly increases the probability of tunneling in the deflated state. However, it is most notable that it is not a magnetic field alone which should have an effect, it is a magnetic *gradient* that provides a magnetic force and thus an increased tunneling probability for deflated state nuclei. Attempts to produce magnetically enhanced LENR rates should thus attempt to optimize both the magnitude and direction of the magnetic *gradient* across the lattice, not just place a magnetic field through the lattice. It is especially noteworthy that powerful magnetic gradients can be induced within a lattice by use of coherent X-rays.

THE BACK SIDE CELL

The method of applying high electron fugacity to deuterium loaded cathodes has the objective of creating an energy focusing effect, forcing co-centered wave function collapse, resulting in deflation fusion. The objective is to create simultaneously a high deuteron fugacity and electron fugacity. Fugacity of a particle type in a given environment is similar to pressure in that it is a measure of the energy required to add one more such particle to that environment. It is of interest that as electron density increases, the fugacity of a given amount of loaded hydrogen *decreases*. Increasing electron fugacity increases the loading feasible with a given amount of electrolysis energy, though adding one particle of each increases the fugacity of *both*.

The application of extreme fields to the back side of a loaded cathode is one way to increase electron fugacity. That is to say a cathode can be loaded electrolytically from one side, the electrolyte side, and yet be charged to millions of volts at the back side surface. The back side surface can interface to a vacuum, hydrogen gas, high pressure dry nitrogen, clear HV oil, glass, or any convenient highly transparent and sufficiently insulating medium on the high voltage back side of the cathode. Call this high voltage side of the cathode the cathode *back side*. The back side is the surface opposite the hydrogen loading surface. Call a cell having such a two sided cathode a *back side cell*. Such a cell may have two separate compartments in order to implement the independent surface loading or deloading potentials. Accomplishing this in a practical manner requires formation of a surface layer on the cathode back side surface which reduces the rate of hydrogen evolution from the back side. Such a layer could be an insulating oxide layer thin enough to support electron tunneling, but not excessive deuterium or helium tunneling, or could be a low diffusion rate metal thin film, like a gold or copper alloy.

A back side cell allows diffusion to occur through the cathode, the hydrogen coming in the front side and out the back side. The diffusion rate out the back side is controlled such that the hydrogen fugacity is maintained at an adequate level, while the diffusion rate is simultaneously maintained. Call this technique *back side de-loading*.

A high density of electrons at the cathode high voltage back side surface and just beneath the back side surface increases both the hydrogen final density and diffusion rate throughout the cathode, especially if it is thin. It also increases the probability of wave function collapse of surface deuterons due to Stark effect orbital stressing due to high electric field conditions at the cathode back side surface and immediate subsurface.

Application of a powerful magnetic field parallel to the cathode vacuum surface incrementally stresses the deuteron orbitals there via the Paschen-Back effect and the formation of Rydberg orbitals, which, in addition to destabilizing electron waveforms and reducing the discreteness of normal quantum effects, also increases the probability of electrons locating within the volume of the nucleus or experiencing simultaneous wave function collapse with and within it. A strong laser beam nearly parallel to but striking the cathode back side surface increases the above combined field effects dramatically.

An alternative arrangement is to orient the powerful magnetic field as normal to the cathode back side surface interface. In this case the laser beam effects are diluted somewhat due to being normal to the magnetic field, though the vector sum of the fields is still enhanced.

IONICALLY BOUND ELECTRONS AND PARTIAL ORBITALS

An adsorbed hydrogen nucleus, here for convenience simply called a deuteron, has an associated electron always very close by in the lattice. This electron and its associated deuteron are considered to be "ionically bound" in the lattice. When a deuteron is adsorbed at the face of the cathode, it is bound to a free conduction band electron already there in the cathode surface, an electron provided there by the electrolysis potential. This ionic bonding greatly restricts the bound electron's wave function. The adsorption of the deuteron also momentarily reduces the potential of the cathode, *i.e.* the electron fugacity of the cathode, and results in an electron current to the cathode from the power supply which restores it. Loading of the cathode requires current beyond that required for the electrolysis of the evolved gas. The cell current has to accommodate both the evolved gas plus adsorbed hydrogen.

The electrons ionically bound to adsorbed hydrogen are no longer fully conduction band electrons. Their wave functions are diminished in size. As loading completes, the conduction bands are frozen and conductivity diminishes. Cathode conductivity is in fact the measure commonly used to estimate loading, though loading percentage has been correlated with and confirmed by other methods, like neutron and X-ray scattering. The size and mobility of conduction band electron quantum waveforms in fully loaded cathodes is unusually small, compared to ordinary conductors, due to the high deuteron density.

In a fully loaded lattice the ionically bound electron has no room for a full orbital about the deuteron. The ionically bound electron occupies what has been characterized as a "partial orbital," or "confined orbital," where the probability of conduction band existence and orbital existence is split. The application of extreme magnetic fields, which in ordinary atoms produce fuzzy non-quantum like electron existences at extreme ranges from the nucleus, may do the opposite for partial orbital electrons. These extreme orbitals in ordinary hydrogen with increased quantum numbers due to excitement and extreme magnetic fields are called Rydberg orbitals. The probability of orbital electrons being in or near the nucleus increases dramatically for Rydberg orbitals. Similar effects exist for strong electrostatic fields.

In the case of partial orbitals, where the conduction band existence is energetically suppressed, the close-to-the-deuteron portion of the wave function takes on increased probability, increasing the probability of wave function collapse onto or with the deuteron. Electron-nucleus interaction probabilities are increased by the increase in the near nucleus electron density. This premise may sound far fetched, but the chemical-nuclear relationship is no longer easily dismissed because it has been firmly established with regard to electron capture.[16] A nearly one percent difference in half life occurs simply due to the difference between electron wave functions for ^{7}Be atoms inside C_{60} instead of Be metal. Further, the half life for ^{7}Be atoms inside C_{60} was found to decrease upon cooling, and this was correlated to electron density at the Be nucleus.[17]

When loading reaches a 1-1 ratio of deuterium to metal, and essentially all lattice sites are deuteron filled, additional loading requires that some lattice sites contain two or more deuterons. Multiply occupied sites actually occur well before 1-1 loading is achieved. These sites therefore also contain within them much more dense wave functions of the partial orbitals of the ionically bound electrons. In these sites a two way or three way tunneling event of deflated state hydrogen becomes likely, resulting in a three way or multi-way wave function collapse. The resulting large neutral body then has some probability of tunneling en masse to a lattice nucleus. The probability of such events is increased dramatically when the probability of the deflated hydrogen state is increased well above 0.25 by orbital deformation.

USE OF A CALCIUM OXIDE BARRIER

The cathode high voltage back side, either in gas back side mode or dielectric back side mode, can be coated with a layer of calcium oxide (CaO) to provide the much needed diffusion barrier. Evidence for this application is provided by Iwamura's work,[18,19] which can be interpreted to show that a thin diffusion barrier is effective at building hydrogen fugacity and thus deflation fusion. There are numerous references to Iwamura at lenr-canr.org.

Hydrogen diffusion in Pd is almost entirely by tunneling. When diffusing through a CaO barrier, toward the back side, the deuteron leaves behind an electron on the front side, which can simultaneously tunnel across the same barrier, or not. When an electron is left behind on the front side of the barrier, the deuteron would have found a matching electron on the back side of the barrier to make that tunneling event favorable. (Alternatively the deuteron-electron pair could have tunneled while in the deflated hydrogen state, but this state has low probability normally.) This suddenly unveiled electron on the (high hydrogen fugacity) front side then starts a chain of deuteron tunneling events on the backed up high pressure front side of the barrier, progressing away from the barrier toward the front of the cathode, and such tunneling events are the stuff of which deflation fusion is made. Increasing the probability of tunneling by this method greatly increases the probability of dual deuteron tunneling, and thus deflation fusion. The tunneling process in this case is always toward the location of a catalyzing electron left behind in a vacant site. This process is clearly made far more likely in general by providing a source of electrons on the back side of the barrier to initiate the tunneling chains on the front side.

BACKSIDE DE-LOADING ISSUES

Backside de-loading is a method which has good rationale within the deflation fusion model. It permits continued high tunneling rates even after high loading is achieved. The problem then is to achieve the backside de-loading in a practical way.

The key is establishing a backside diffusion barrier, and using the right cross-barrier potential in order to match the de-loading and loading rates so as to sustain high hydrogen fugacity. It is also an objective to provide a high electron charge density immediately opposite the de-loading barrier. One means of increasing charge density is to increase field strength by using a high dielectric strength material opposite the barrier. One means of suppressing hydrogen diffusion is to make the potential of the back side surface extremely negative, thus making escape of positive hydrogen nuclei more suppressed. A highly negative cathode back side provides potentially catalytic excess electrons in the conduction bands located between de-loading hydrogen nuclei in adjacent cells. Simultaneously de-loading nuclei thus have a high probability of electron catalyzed fusion in a lateral direction across the electrode surface because there is an optimized probability of a catalyzing electron between the tunneling pair. The potential of the back side can be raised to an almost arbitrarily high negative value by use of high dielectric strength very low conductivity dipole liquids on the back side.

Now for a differing approach to back side de-loading. One way to achieve many of these objectives is to make the back side an anode immersed in water. The water acts as the dielectric. The field strength across the two layer anode-water interface is well over 10^6 V/m even at a few volts electrolysis potential.

The anodic diffusion barrier can be deposited and even maintained or healed by anodization.[20] The target for hydrogen tunneling then is OH- molecules in the interphase, and any free electrons that might be ionized off them and attached to the anodized barrier. De-loading hydrogen nuclei in adjacent cells then have a comparatively high probability of fusion in a direction lateral to the anode surface due to surface electron catalysis.

One problem with this approach is keeping the electrons from tunneling across the backside barrier to the hydrogen instead of the hydrogen tunneling through the back side barrier to the electrons. The down side to electron tunneling through the backside barrier is (1) deflation fusion is accomplished best by simultaneous deuteron tunneling to an electron and (2) fusion on the front side of the barrier will cause disruption of the lattice, destruction of the barrier, and possible helium blockage.

Preventing the above problems should be possible by energetically denying them by driving front side electrolysis at a much higher voltage once loading is complete. This can best be accomplished using a coordinated pulsed mode. Operating with a superimposed pulse, applied simultaneously on both the front and back side potentials, to trigger hydrogen barrier tunneling, is efficient because it gives the lattice time to diffuse replacement hydrogen, backside gas a chance to dissipate, and the interphase to recover, while providing maximum fugacity during the pulse.

An alternative, on the back side, is to use pulsed AC on top of a DC trickle current used to sustain the anodized layer. Very high frequency high voltage AC intervals with low duty cycles, on the back side, would cause tunneling directions across the back side of the barrier to switch directions, alternating many times per volume diffused, and thereby increasing fusion prospects per diffused atom. It also increases the probability of OH- de-ionization, loosing free electrons to attach to the back side diffusion barrier.

High voltage AC and DC has been used by the author to anodize aluminum and zirconium electrodes with a barrier driven at over 1000 V.[21] Such a surface barrier tends to self maintain even when used with AC electrolysis. Such a barrier permits the use of very high positive and/or negative potentials that may be of use in generating high electron fugacities at the back side when the back side is in the high-voltage cathode phase of the cycle. The negative potential of the back side can increase to a substantial amount, *i.e.* the point where the substantial barrier can be tunneled by the electrons. The surface layer of the electrode metal thus contains a large electron density in an extreme fugacity condition. Further, due to the use of AC, hydrogen tunneling is ongoing in the lattice, in directions that alternate with the AC current flow. Hydrogen tunneling rates can be further enhanced by application of lateral currents through the electrode. This is an ideal environment for deflation fusion to occur, a high tunneling rate high fugacity excess electron environment.

FUSION OUTSIDE THE LATTICE

The high probability of a deflated hydrogen state indicates that back side de-loading into any hydrogen dense, high field environment, where the back side is positive, an anode, should generate fusion between the de-loading hydrogen and some of the deflated state hydrogen adjacent to the de-loading back side anode. Though water or a very weak electrolyte should work to some limited degree, a non-conducting back side liquid might be best for this purpose; a hydrogen rich liquid like anhydrous ammonia or benzene might be ideal, possibly augmented by a porous high dielectric constant field concentrating solid dielectric layer. The high field strength increases the probability of de-loading hydrogen atoms making it to deflated state hydrogen in the liquid. A back side surface barrier assists this process by increasing hydrogen fugacity in the lattice and by forcing back side de-loading to occur by a hydrogen tunneling process, with some enhanced probability of being in the deflated state, into the liquid layer adjacent to the anode surface, which is hydrogen rich, and thus has a high probability of containing hydrogen in a deflated state. Key to making this work is establishment of an extreme field on the back side electrode surface. The structure of water near a high voltage anode and possible mechanisms for energy generation therefrom has been described by the author.[22] Though possible excess heat has been observed, this environment has not been tested by the author in a back side de-loading mode. It is especially noteworthy that coherent laser light applied normal to a high voltage back side anode should be effective in creating liquid mode deflation fusion due to the unusually close proximity of stressed orbital hydrogen in OH and H_2O molecules in the electrolyte at the anode surface.

THERMAL CYCLING AND HIGH TEMPERATURE ALLOYS

A powerful means of orbital stressing is cooling a loaded lattice. The lattice contracts and applies enormous pressure on the loaded hydrogen atoms. This approach to orbital stressing has limited utility for electrolysis loaded cells. However, it may be of great utility when applied to high temperature cells, which are better suited for high efficiency energy generation. Operating in high temperature gas mode opens up a vast set of possible cathode materials which are of no use at ordinary electrolysis temperatures.

Work in hot gas phase loading of metal cathodes in the presence of an electric discharge was achieved, even early on, by Claytor *et al.*[23-25] Some alloys were found to be more effective than others at producing tritium. What is suggested by the deflation fusion mechanism is that the critical ingredients should be: adsorbed hydrogen partial orbital stressing, high electron and hydrogen fugacity, high hydrogen concentration, all combined with as high a diffusion rate as possible. Provided all these ingredients can be brought together, the elements in the lattice should be of secondary importance—though without a proper choice of alloy and temperature operating profile, these critical ingredients are in fact not possible. What the deflation fusion model brings to the table is a basis on which to design or select alloys for testing, as well as an emphasis on temperature control and cycling. It also suggests some basic materials science investigations of hydrogen loading characteristics and tolerance of various alloys over a high range of temperatures. High hydrogen loading density and avoidance of embrittlement, or at least achieving fast annealing, are key requirements.

High temperature hydrogen adsorption is feasible using high strength alloys of iron, tungsten, molybdenum, and other metals which are incapable of adsorption at room temperature. Excess heat and nuclear reactions have been observed in gas loaded nickel alloys at high temperatures by Focardi *et al.*, even using ordinary hydrogen.[26,27] $LiNi_5$ lanthanum-nickel, $LaNi_{4.5}Co_{0.5}$, and mischmetal nickel alloy have been suggested.[28] Another candidate for hot loading might be $Li_xB_yMg_z$.[29] Hot operating alloys can be designed to maximize bond strength, annealing ability, operating temperature range, and hydrogen loading as well as helium de-loading characteristics in a controlled temperature range cycling profile.

This is the probable path for practical cold fusion development—use of hot temperature-cycled cathodes. This path has the obvious advantage of a large Carnot efficiency.

High temperature cells are loaded in gas phase, by high pressure, by high voltage DC with a high voltage high frequency signal, or microwaves, applied as well for ionization purposes. The lattice temperature is cycled from hot, for loading, to less hot, for high stressing heat generation. Before returning to the hot loading phase, various temperature cycles might be used to facilitate helium de-loading, and annealing of cracks, as was achieved by Claytor *et al.*

A simple version of this cell type could merely consist of a hot wire used as a cathode for gas phase loading and thermal cycling. Nichrome wire is readily available and may provide the needed characteristics. Control circuitry would be required to prevent cascade driven current runaways due to the high electron emission from a hot cathode. A higher DC voltage can be used in the reduced temperature hydrogen compressing phase. Using a cell designed to accommodate a liquid cathode material, and a readily melted lattice material, the lattice material could be fully melted between some thermal cycles in order to remove helium and restore the lattice.[30]

A through-cathode current can be used to simultaneously achieve DC loading while applying AC to the lattice to increase tunneling rates. A low duty cycle through-electrode pulse is of use in the compression phase to promote high diffusion rates while avoiding overheating the electrode. The through-electrode AC capability also has use for heating the lattice for annealing, loading, or other purposes. High pressure hydrogen or high voltage gas loading or a combination can be used. The source of heat for annealing or melting can be through the ceramic compartment walls instead of supplied by electrodes.

SUMMARY

A new partial state of existence of hydrogen, a small neutral state, the *deflated hydrogen state* has been defined. The deflated hydrogen state is a very small and ghostlike neutral charge alternate existence for the nucleus with attosecond magnitude duration. There is evidence for an astronomical effective frequency of occurrence of the deflated hydrogen state, even when the hydrogen nucleus is in a molecular site. This state can be thought of as (1) providing a tunneling target for hydrogen otherwise diffusing through the lattice, and (2) having its own probability of tunneling as a combined electron-nucleus body. The fact the deflated state entity is neutral greatly affects the probability of a given tunneling outcome in the vicinity being within fusion range. This significantly reduces the width of the Coulomb barrier—and in fact momentarily makes it disappear, makes it irrelevant. This enormously increases the probability of a fusion event. Further, the existence of the deflated hydrogen state helps explain the unusual branching ratios and ash produced by cold fusion experiments.

The very brief existence of the deflated state explains why kinetically induced fusion can not make use of the Coulomb barrier being down, because there is insufficient time for a motional approach of the nuclei before the barrier is back up.

A hydrogen nucleus diffusing through a lattice does so by tunneling from its occupied site to a vacant site. Tunneling to an adjacent unoccupied site is energetically favorable for a hydrogen occupying a site adjacent to multiple occupied sites, *i.e.* in a high fugacity environment. An adjacent site occupied by a deflated state hydrogen nucleus provides a tunneling opportunity for a hydrogen nucleus because the deflated state is neutral and thus the Coulomb barrier is down, at least with some probability. If the tunneling event occurs, but not to a locus close enough to cause fusion, which is not possible when the Coulomb barrier is up, then when the deflated nucleus is unveiled by electron departure, the hydrogen tunneling event can be reversed, or otherwise the tunneling chain of events can be moved forward to a lower fugacity site. In a fully loaded environment, a momentarily unoccupied cell will have multiple candidates likely to tunnel simultaneously into it. If one or more of the tunneling candidates tunnel in deflated state, or if the cell is not actually unoccupied but merely occupied by a deflated state nucleus (such a cell appears to the neighboring nuclei as unoccupied), then deflation fusion opportunities are maximal, even for multi-body events.

The deflation fusion model provides a set of principles for increasing fusion likelihood: (1) maximize the *combined* hydrogen fugacity and diffusion rate because neither is especially useful without the other, (2) maximize orbital stress to increase the probability of the deflated hydrogen state, (3) maximize the magnetic gradient along an axis chosen to optimize either LENR or CF, and (4) maximize electron fugacity in order to increase the electron quantum states, *i.e.* aggregate electron energies, and thus further objectives (1) and (2) as well as provide an energy focusing effect. It further appears providing periodic barriers to conduction band electrons, but through which hydrogen readily diffuses, increases LENR probability.

The backside de-loading scheme, defined in various forms,[31] was designed to achieve multiple of the above objectives simultaneously. Cycling through high temperature loading and lattice readjustment by diffusion, cooling to some extent to compress the lattice, and then driving diffusion by through-lattice current, is also designed to especially achieve objective (2), while increasing thermodynamic efficiency and providing a broader choice of lattice materials. Engineering high electrical resistance of the hot lattice, combined with a strong through-lattice-current driven diffusion, then fulfills various objectives. Inclusion of non-conducting hydrogen diffusion tunneling barriers in the lattice increases the probability of deflated state tunneling and thus fusion. These are the principal techniques immediately suggested by the existence of the deflated hydrogen state, and thus of deflation fusion.

The explanations of deflation fusion here are mostly expressed in a serialized event form, so as to be understandable. It may well be that in reality these things only exist as potentialities, amplitudes which result in final event outcomes with some probability based on simultaneous multiple complex inputs. A stepwise process model provides a comfortable means of understanding that which is otherwise complex to comprehend or describe.

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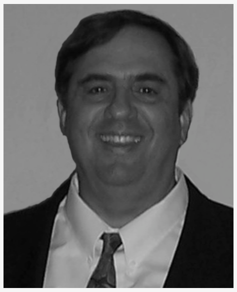

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