THE PARTIAL ORBITAL HYPOTHESIS OF COLD FUSION

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INTRODUCTION

A hypothesis is presented here to explain various observed cold fusion (CF) experimental effects. Most significantly it explains where excess energy may be coming from and why nuclear signature events do not match the excess energy observed. The hypothesis is an extension of known physical effects to an atomic level, plus the assumption of the possibility that zero point energy (ZPE) enables (i.e. energy funds) quantum level events predicted by the the Heisenberg Uncertainty Principle (HUP). Alternately, the hypothesis may be viewed as an assumption that the free electron wave function expansion through time, predicted by the Schroedinger Equation (SE), is a real effect and the energy is funded by electron coupling with ZPE. A mechanism is described whereby localized free electrons and free nucleons initiate the defined energy creating condition. This condition is hypothesized to produce energy via electron tunneling with the energy loan paid back by ZPE. The hypothesized effect produces no ash and involves neither nuclear reactions nor electron shielding.

BACKGROUND EXPERIMENTAL RESULTS

The following are assumed to be valid experimental results needing to be explained:

1. CF effects, i.e. excess heat and nominal fusion ash, have been observed at low voltages and temperatures in hydrogen loaded metal cathodes of electrolytic cells.

2. CF effects don't occur in the electrolyte or anode.

3. CF effects generally occur in metal hydrides loaded above 85%.

4. CF effects seem to inexplicably, uncontrollably and suddenly turn on, run a while, and then turn off.

5. High frequency sound has been measured in association with measured deuterium loading.

6. Some high frequency current transients have been measured in electrolysis cells, but not enough was measured to account for the excess heat.

7. Cracks are typically observed in metal cathodes after loading. Cathodes are often

not reusable after an excess heat episode.

8. Warmer seems to be better. Warm cathodes have been reported by some experimenters to be more likely to activate the CF effect.

9. Various nuclear event signatures have been detected in addition to heat , including neutrons, gamma rays, and element transmutation. However, these signatures occur either in non-measurable quantities or in quantities which are orders of magnitude too low to explain the corresponding excess heat.

A feasible hypothesis must account for how the environment of the metal is different from the environment of an electrolyte, or a plasma. The proposed significant differences are: a low energy environment, the rigid structure of the metal lattice, it's maintenance of orbital shells in close proximity to all events, and it's ability to readily conduct low voltage electrons.

BACKGROUND AND ASSUMPTIONS

A key distinction made in this hypothesis is between electrons bound in metal atom shells, free electrons, and electrons associated with an electric current. Electrons in an orbital require an integral number of quanta of energy to jump out of the orbital, provided by absorption of an appropriate wavelength photon. Electrons jumping into a particular orbital give off a specific wavelength photon, the wavelength of which depends on what energy state they jumped in from. Electrons in an orbital exist as a very large (angstrom size) wave function, an electron charge probability distribution function.

Free electrons used to bombard small nuclei in a target exhibit small waveforms (appear particle like) in their reactions with the small nuclei. Exhibiting this particle like nature is called being localized. There is no lower limit established for the size of an electron. High momentum electrons are so small they have been successfully used to distinguish the graininess of quarks in nucleons. For this reason, it is assumed there must be some physically manifested difference between the actions of electrons bound in shells, and free electrons. The former manifests more of it's wave nature, the latter more of it's particle nature. The nature of this difference is partially described by the de Broglie formula $p=h/L$, where p is momentum, h is Plank's constant, and L is the wavelength of the particle. The faster an electron, the shorter it's wavelength, the more localized it is.

Electrons involved in flowing current in metal do so in very low energy orbitals, so can jump from atom to atom very readily. The atoms of a metal lattice are all bound together, yet have unused low energy orbitals, so provide continuous conduction bands for electrons throughout the lattice. This accounts for the environmental difference between an electrolyte and a cathode.

Although electrons, in response to an inducing field, readily move in cold metal, electrons on a cold metal surface in a vacuum can not break free unless enormous electrostatic field gradients (compared to electrolysis gradients) are present. However, this condition changes rapidly as the metal is heated. The hot end tail of the electron energy distribution expands in area rapidly as temperature, and therefore average conduction band electron energy, increases. The hotter the metal the less gradient needed to expel a free electron due to the atom's momentum. The electron ejection probability for a given area is a function of both temperature and voltage gradient.

Occupied orbitals are not readily compressed or distorted or migrated through by the ingress of another atom's orbital. If it weren't for this property we would all be living on neutron star earth.

Another relevant quality of metal lattices is the ability to transmit electrons, i.e. electron displacement waves, in response to very small charge movements near or in the metal. With suitable amplification, quantum level current fluctuations can be played on a loudspeaker, observed on an oscilloscope, or digitized for use in random cipher masks. This current (electron wave flow) response to a change in potential travels at near the speed of light.

Because of the near light speed response to small field effects, we can expect a proton (use proton to mean any H nucleus) moving at thermal speeds, located in a lattice site, to readily attract conduction band electrons to it's immediate locality as it thermally moves and approaches the band. Likewise, if departing a band the induced electron charge in the band would be expected to dissipate, i.e. in a net sense to move around the cell the proton is trapped in to the locality the proton approaches. Thus we would expect conduction band electrons, in a net sense, to pair up with free protons. These paired up electrons would then have their mobility reduced because they are tied to the diffusion mobility of the proton. The conduction band electrons are initially supplied by the current source driving the electrolysis.

THE HYPOTHESIZED EFFECT

As a free proton, adsorbed by a metal lattice in electrolysis, approaches it's paired conduction band electron, a voltage gradient is created such that it, along with the radiant thermal energy of the vibrating metal lattice, if the combined effect is sufficient, will produce a photon/phonon exchange that will expel the conduction band electron and make it a free electron. The expelled free electron, now exhibiting it's more particle nature, accelerates toward the free proton, possibly forming an orbital, but in some cases not. In the case of a partial orbital around the free proton, which terminates at a conduction band (i.e. blends or melds with the conduction band) of a metal atom, there is a momentum distribution, i.e. energy distribution, created which is greatest at the electron's closest point of approach to the free proton, and less in all directions the further away from the free proton. This partial orbital can be very complex, including many rotations and complex motions, as well as significant changes in wave form through time, varying in the degree of localization. [An alternative possiblity is that a partial orbital is interrupted by a high energy electron, say from cosmic rays or an internal beta source, and a waveform collapse occus, creating from the partial orbital an additional energetic free electron in the close vicinity of the nucleus.] The significant facts are that the electron enters the local influence of a nucleus, i.e. follows a partial orbital, emits one or more photons, and then leaves the influence of the nucleus.

As the electron approaches the end of a partial orbital, the possibility for tunneling exists. This is because there is an energy barrier, which if suddenly leaped, would result in a one way jump of the electron to the conduction band. An electron so doing would impart to the metal lattice any portion of the momentum and energy gained by it's acceleration toward the free proton which has not been paid back via climbing the coulomb hill, plus, when dropping into the conduction band, emit a photon to correspond to the original photon transaction that freed it.

Since the ejected free electron is acting in a more particle like role, there is reason to believe it (some) could accelerate to the close proximity of either a free proton or stable lattice nucleus, in some cases gaining KeV energies before completing a partial course around the nucleus. Before returning to a conduction band, this energy would be lost due to work overcoming the coulomb force of the nucleus. In addition, a free electron approaching, circling, or departing a nucleus would be experiencing significant acceleration, thus would be expected to give off one or more photons, converting some of it's kinetic energy to the mass of these photons.

As the electron continues on toward the band termination of it's partial orbital it is climbing an energy hill. However, if it can reach the band, there is a sudden energy cliff at the end, the electron falls back into a band and gives up a photon, converting energy to mass and releasing a photon of at least the mass of the photon that started the sequence to begin with. Now, since there is an energy barrier preceding entry to the conduction band, the possibility exists for the electron to tunnel through it. If the electron can do so, there are two possibilities for the creation of extra mass/energy: (1) any photon released while in the partial orbital would have been free, and (2) if the electron can tunnel the last bit of it's way there, it will arrive with more momentum (and energy) than if it did not tunnel, because it does not have to do the work to overcome the coulomb force of the proton.

Now the crux of the issue. What happens in the very special seemingly paradoxical condition where a low energy free electron approaching a free nucleus, is accelerated toward the nucleus, expels one or more photons from the acceleration and thus ends up with insufficient energy to climb the coulomb hill away from the nucleus? It does not have the energy to climb out, and has insufficient energy to form an orbital. The proposed answer is that the size of the electron's wave function will spontaneously increase until sufficiently large that tunneling to an adjacent orbital becomes likely. Why? Because p=h/L, i.e. de Broglie's' formula shows the wavelength must increase. If the momentum, and therefore velocity, of the electron approaches zero, the wavelength will correspondingly increase. The Schroedinger equation possibly lends some evidence of this possibility by virtue of the fact it predicts that a free electron's potential wave expands through time, without accounting for the implied lack of energy balance. The closer to zero momentum the electron goes, because p=h/L, the larger the wavelength and the higher the probability of the electron "materializing" elsewhere in the lattice, and thus escaping the well, i.e. tunneling. Similarly, if the electron loses sufficient momentum such that a low radius orbit is indicated, such an orbit can not be maintained due to the uncertainty of the momentum, due to the HUP, i.e. (delta p)*(delta L)=h. The better you know the location the worse you know the momentum, and vice versa. As the locus of the particle becomes fixed closer to the nucleus, it's momentum becomes unfixed, thus it gains an average increase in energy, it's probability of tunneling out of the well increases. Similarly interpreting de Broglie's formula, as the locality of the electron becomes small the wavelength becomes small so the momentum becomes large.

DISCUSSION OF RATIONAL

Though this hypothesis contradicts the first law of thermodynamics on at least a local basis, it seems more consistent with published results than looking at nuclear effects which invariably create neutrons detectable by beta decay, transmutations, or gamma radiation, none of which have been detected in sufficient quantities to account for the heat generated. The reason the partial orbital hypothesis makes more sense is that it happens in a "mass to energy to mass exchange" regime (photon/electron) that is very active in the lattice at thermal lattice energies. There is a lot of infrared photon activity in the lattice, activity which increases with heat. The only assumption that needs to be made is that the electron wave expansion predicted by the Schroedinger Equation is correct, or that de Broglie's formula is correct, i.e. wavelength increases as momentum decreases, or that Heisenberg's uncertainty principle is correct, i.e. the more an electron's momentum is known, the less it's position is known, and vice versa. The laws of thermodynamics need not be violated if energy imbalances created by quantum level fluctuations are fueled by the quantum connection to an energy sea, i.e. vacuum fluctuations or zero point energy (ZPE). If quantum events distant from each other are connected in any way, the second law of thermodynamics practically demands that energy must flow from high energy to low energy locations. The key is simply finding a way to change the rate of the energy flow, to increase the degree of linkage.

The exchange that is mainly active in the lattice regime is low energy, so possibly is a more viable place to look than the nucleus to explain unexplained phenomena with regard to cold fusion effects. There is a wealth of data that something real but unexplained is going on in cold fusion experiments, and a wealth of data that says almost no excess heat can be accounted for by nuclear effects, ash, etc. [at leas in Ni/H systems.] Also, typical distances in the lattice are too large for nucleon tunneling to be a likely source of interaction. The regime is in a prime range for electron tunneling effects. If tunneling is a result of borrowing the energy to jump over an energy barrier, then perhaps there is some mechanism for not paying back the loan. I suggest that mechanism is driven by the uncertainty principle and fueled by vacuum fluctuations or ZPE.

Some support for the partial orbital hypothesis may be manifest in Rydberg electrons [1] which, due to magnetic fields, have very long complex paths and wander far from the nucleus, so far that they leave the quantum world for the mechanical one. These electrons exhibit quantum form near the nucleus, and increasingly mechanical form further away, all within the same orbital/orbit. They permit strange non-discrete absorption peaks and photon absorption beyond the ionization potential of the atom. Rydberg electrons venture far from the nucleus and then plunge deep into the electron cloud toward the nucleus. (The experimental results discussed were for barium atoms.) John Delos of William and Mary found that in a strong magnetic field quantum interference patterns permit only certain classical style trajectories which are "fuzzy" near the nucleus, but more localized or Newtonian far away from the nucleus. The main observed effect of the long trajectories is fuzzy photon absorption peaks.

ASH AND NUCLEAR SIGNATURES

There is a finite probability that tunneling will not occur before other events preempting the tunneling scenario occur. After emitting sufficient energy via photons, the electron in the partial orbital has lost momentum so can not return to a conduction band, so spirals into the proton, emitting photons as it goes, but can not combine with it because of the extra energy needed to create a neutron (i.e. about 0.5 MeV). If tunneling does not occur, you end up with a protoneutron, similar to or as described in Mitchell Jones' Protoneutron Theory of cold fusion as posted in sci.physics.fusion. This neutral charge protoneutron would be unable to stabilize and would eventually combine with a nucleus or another protoneutron, either of which it could join without penetrating a coulomb barrier. If, at thermal energies, protoneutrons were unable to combine with anything but protoneutrons, the potential also exists for creating 4n particles as described by Ramon Prasad in sci.physics.fusion to result in T3 and H4, but no neutrons.

Either way, through tunneling or protoneutron creation, the possibility of partial orbitals gives rise to a potential explanation for excess heat, with protoneutron creation, however brief, indicating a small but finite probability of ash creation. The electron tunneling process described is hypothesized to generate most of the free energy of cold fusion. The lattice conditions described could also generate nuclear fusion through mechanisms as described by others, but the size of the free electron partial orbital effect should be much larger than nuclear effects due to a higher probability of occurrence and the longer average tunneling distance of an electron.

No significant energy is hypothesized to be generated by any nuclear reactions or electron captures. The tunneling referred to is electron tunneling through the potential barrier at the end of the free electron's partial orbital.

CONDITIONS TO INITIATE COLD FUSION

What would be the conditions to initiate cold fusion? The conditions would be loading to a degree that there is a large density of free nuclei, plus thermal and electrical agitation. A significant number of free electrons must have sufficient energy to be localized enough to approach a nucleus closely, and thus emit one or more photons.

Thermal agitation is partially caused by the electrolysis current, but not enough to trigger an episode. Once loading reaches a critical point, minor cracks develop in the lattice. These cracks immediately fill up with neutral hydrogen, thus can act like a local capacitor. In addition, the sudden crack produces a high voltage wave and an acoustical shock in the lattice. At first these conditions are not sufficient to create a critical mass of self perpetuating events. Eventually though, in some cases, a "critical mass" of cracks provides enough capacitance, and enough electromagnetic energy from cracking, to sustain a large collection of ultra high frequency resonant oscillating circuits. These localized electrical fluctuations and heat provide the needed conditions to create massive numbers of free nuclei and electrons , some portion of which generate enough excess heat and electromagnetic energy to sustain the process.

The process can be expected to vary in intensity sporadically due to the unpredictable nature of a particular lattice with respect to fracturing, loading, etc. The end of the episode would occur at a highly unpredictable duration and energy output. It could not be expected that a cathode would be reusable without some kind of annealing process being performed. If an episode occurred, we would expect a measurable amount of sound or electromagnetic oscillations to occur, or both. The various experimental results to be explained are, at least qualitatively, explained.

Now the question remains, what voltage electron to initiate the partial orbital? To calculate this we need to know that the space inside a typical metal lattice accommodates a sphere of roughly 0.6 A radius, roughly the space required for an isolated H atom. H2 atoms may also be present in some metal lattices, due to the fact the ionic bond for H is 0.32 A radius. If a photon is to be generated by acceleration near the nucleus, it is reasonable that the de Broglie wavelength of the electron must be less than the distance to the nucleus at the moment of the electron beginning it's descent toward the nucleus. If this is not so, then the dipole moment of the electron-proton pair will be diminished, reducing the attraction and therefore the acceleration, and therefore the potential energy of the electron's descent. Also, it is necessary that a descent be initiated, as opposed to formation of a standard orbital. For this reason it is anticipated the de Broglie wavelength must be less than .32 A. At a larger wavelength, i.e. less energy, dipole moment shielding would occur, preventing a close approach to the nucleus by the electron. At .32 A, and in absence of a magnetic field, the hypothesized effects would begin to be noticed, but a smaller wavelength, e.g. half that size, should produce more significant effects.

Now: p=h/L, where p=mv so: mv=h/L, v*(9.11E-31kg)=(6.626E-34 joule*sec)/(0.32E-10 m), v=2.273E7m/sec. Looking at energy, E=.5mv^2=(.5)(9.11E-31kg)(2.27E7)^2, E=2.353E-16joule/(1.602 E-19 joule/eV)=1470 eV. So a minimal energy electron to initiate the process should be about 1470 eV, quite a bit to get inside a lattice! This can not be accomplished by temperature alone because 1 eV=1.15E4 deg. K, so the temperature would be 1470*1.16E4=17,000,000 deg. K. It would appear that, in the absence of a strong magnetic field, the main objective then to initiate the cold fusion effect is to get 2-3 keV electrons busy inside the lattice. Cosmic rays readily can do this, as well as a lattice fractures. HV pulses might accomplish this at the lattice/electrolyte boundary if the electrolyte is not too conductive, or EM pulses might do this, especially if conductor/insulator boundaries are present in the electrode. It seems like the most effective method would be putting beta emitters in the lattice. This could be accomplished by using a T2O electrolyte (18.6 KeV beta), or spiking the lattice metal with beta emitters. Even alpha emitters, disrupting lattice electrons, should work.

Other methods might include bombarding a thin foil electrode from the side opposite the electrolyte with charged particle emitters or with by using an electron beam.

EFFECT OF STRONG MAGNETIC FIELDS

One effect of strong magnetic fields on orbitals observed by Delos is the cancellation of the quantum potential wave function at many locations, leaving more Newtonian like "orbits", some of which plunge deep into the electron cloud toward the nucleus. This ability to suppress the electron's quantum fuzziness and permit nucleus approach at a lower voltage is exactly the effect needed for energy producing effects at low voltages. Delos worked on stand alone barium atoms with electrons in stable or metastable (i.e. repeated) orbits. However, it seems reasonable that the hypothesized brief partial orbitals, or orbitals terminated in conduction bands, would result in similar deep nucleus approach effects, resulting in high energy photon emission by low voltage electrons, followed by electron waveform expansion and electron tunneling to freedom in the conduction bands. It is possible even small magnetic fields could create some effect in this regard. Since magnetic fields have not been a measured or controlled variable in many experiments, this effect, combined with cosmic rays, may account for some of the unexplained contrariness of CF experiments.

HYPOTHESIZED EFFECT IN GASSES

To some degree, the hypothesized effect could occur in a gas. The significant missing element is the adjacent metal conduction bands. After approaching a nucleus and emitting one or more photons, if an electron should lose too much energy to climb out of the energy well, the electron's momentum would be small, so it's location uncertainty should expand sufficiently for the electron to "tunnel up" to an orbital. Upon a subsequent and sufficient thermal or photon collision, the electron could be freed (ionized), and the process could be repeated. This seems like a much less effective environment than a metal lattice, but a strong magnetic field should greatly enhance the probabilities for "energy creating" events.

OCCURRENCE IN NATURE

Evidence of zero point energy (ZPE) exists directly in the form of low temperature experiments, and indirectly through experiments that verify the Heisenberg Uncertainty Principle (HUP). As temperature approaches absolute zero, thermal vibrations subside to nearly zero, but can not come to zero, regardless the amount of thermal energy extracted. The reason for this is if all motion stopped, then the relative location of every atom would be known absolutely, therefore, by the HUP, the conjugate variable, momentum, would be infinite. This can not be, so absolute zero can not be reached. More importantly, there must be a source of energy to offset the energy extracted. Unless the energy comes from a coupling process, the first law of thermodynamics is violated. Since the average temperature of the universe is less than 4 deg.. K, this coupling must occur in a very low temperature, i.e. velocity, regime to get a positive energy flow.

Obtaining useful energy from a cryogenic environment sounds difficult at best. Observation of cryogenic production of energy in natural environments is unlikely. However, if the energy can artificially be obtained from individual particles without affecting the entire thermal environment, then a practical device may be built. What I have suggested is the possibility that if a free electron can give off a sufficient amount of it's energy in the form of photons (a usable form of energy on the macro scale) while falling into a coulomb well, such a low energy electron can regain that energy from the ZPE sea to climb back out of the well.

By the partial orbital hypothesis, the conditions whereby this might happen are very special. The electron must (a) be free (i.e. not in an orbital), (b) must possess sufficient kinetic energy to fall into the well without forming an orbital, (c) must release most that kinetic energy in the form of photons while in the well, and (d) must not be disturbed by other particles prior to tunneling out of the well. This set of circumstances precludes efficient coupling in high temperature plasmas (d), low temperature static environments (a) & (b), and dielectrics (a) & (b). Also, the ability of a low energy electron to closely approach a nucleus so that (c) can be met requires some amount of magnetic field to be present. The condition hypothesized to create the free electron in the metal lattice is the approach of an adsorbed proton to the conduction bands of the lattice, thereby stripping a paired electron from the band.

The presence of adsorbed hydrogen, plus all the other conditions (a)-(d) seem to represent a very unlikely set of conditions to occur naturally. The conditions to create cold fusion are very special conditions. There is some evidence that the necessary conditions do exist in the earth to some extent, that evidence being core heating and tritium production, but these could be signatures of fission reactions. In addition, there is much evidence that ball lightning occurs in nature. No known non-nuclear mechanism exists for maintaining a glowing ball of air or plasma for seconds. However, ball lightning is so rare that even its existence is questioned. It does not appear a significant amount of energy is generated or transferred by the proposed process in nature, but it does seem likely the process does occur to some extent in nature.

POSSIBLE METHODS OF HYPOTHESIS VERIFICATION

To verify the hypothesis several things might be done. One would be to bombard ionized hydrogen or hydrogen compound gas with electrons of energies from 1.5 to 3 KeV. A significant increase in radiant energy should be noted across that range. Calorimetry should be performed. A similar experiment could be conducted by bombarding the front side of a metal foil which is loaded with hydrogen from the back side by electrolysis. These experiments should be carried out over a wide range of magnetic field intensities.

A potential signature of the proposed process is a two peak photon energy distribution. One peak would be in the x-ray range, generated by electrons plunging near the nucleus, the other peak would be at a substantially reduced wavelength and generated by the corresponding proton (H nuclei) acceleration, the energy ratio being roughly 1836. The low energy peak would be reduced by a factor of roughly 1.9983 for deuterium and 2.9926 for tritium free nuclei.

FREE ENERGY DEVICES SUGGESTED BY THE HYPOTHESIS

Building a conventional CF cell, but using a tritium (i.e. T_2O) electrolyte and "spiking" the metal lattice with strong beta emitting metal isotopes. This would provide a continual stream of high energy electrons deep in the lattice to initiate chain reactions of the form e -> photon -> e -> photon, etc. The electrode should be immersed in a strong magnetic field.

High voltage high frequency electrical oscillations in the electrode, separate from the electrolysis DC current flow, can be created by including the cathode in an oscillator circuit. The oscillator could be made small and included in the calorimetry cell. The current oscillations would not be through the electrolyte, but the cathode only. The electrode should be immersed in a strong magnetic field.

Any device to induce contrary electron/nucleus motion in a gas in a magnetic field. Ball lightning seems to be the ideal embodiment of such a thing! However, HF HV fields in an H_2 or steam environment might do the trick as well.

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SUMMARY

A hypothesis has been presented to explain various observed cold fusion experimental effects. Most significantly it suggests where excess energy may be coming from and why nuclear signature events do not match the excess energy observed. The hypothesis is an extension of known physical effects to an atomic level, plus application of known quantum mechanical effects. A mechanism is described whereby localized free electrons and nuclei initiate the defined energy transfer condition. The hypothesized effect produces no ash and involves neither nuclear reactions nor electron shielding. Various tests and devices are indicated by the hypothesis.

Footnotes

[1] "The Philosopher's Atom", von Bayer, p. 102, Discover, Nov. '95

Update Notes from Sept 1999 follow.

Here consider a bi-phasic sub-orbital state, s time in orbital phase, (1-s) time in conduction band phase. Using:

q = 1.6021773x10^-19 coul

e0 = 8.8541878x10^-12 coul^2/N-m^2
 = 8.8541878x10^-12 farads/m

h = 6.6260755x10^-34 J s
 = 6.6260755x10^-34 kg m^2 s^-1

m_e = 9.1093892x10^-31 kg

r0 = Bohr radius
 = 5.29x10^-11 m

Ef = heat of formation of Pd2H

= 9800 cal/mol= 0.425 eV/atom

Eu = energy of ionically bound electron due to its uncertainty
when confined within (uncertainty) radius r
= (1/m_e)(h/(4 Pi r))^2
= (3.0521351x10^-39 J m^2)/r^2
= (1.9049921x10^-20 eV m^2)/r^2

Eh = energy of lattice particles due to heat
= (8.929x10^-5 eV)/(deg. K) = 00.0357 ev at 400 K

Er = energy removed due to change in average distance (delta_r),
from ground state radius (in conduction band phase)
= -13.6 + q_e^2/((8 Pi)(e0)(r)) [where r is uncertainty radius]

Ke = kinetic energy of electron at radius r
= q_e^2/((8 Pi)(e0)(r)) = (1/2)(m_e)(v^2)

E0 = kinetic energy of ground state electron
= 13.6 eV

E1 = kinetic energy of electron in adsorbed state
= E0 - Er

Electron velocity in orbital phase is:

v = 2.18x10^6 m/s

so time for a full orbital is about:

t = (2 Pi r)/v = (2 Pi 5.29x10^-11 m)/(2.18x10^6 m/s)

t = 1.525x10^-16 s

f = 1/t = 6.559x10^15 Hz

but this frequency may have nothing to do with how fast the electron hops between phases of the sub-orbital state. It could well be that both phases are occupied simultaneously in typical QM fashion, with a finite probability of observance in one or the other phases. Now, suppose the electron is found s*100 percent of the time in orbital phase and (1-s)*100 percent of the time in conduction band phase of its existence. We can assume the ground state kinetic energy that the external hydrogen atom electron contains is, immediately upon adsorbtion, spread into its two phases, its two new simultaneous existances, plus to the heat of formation:

$$E0 = s*E0 + (1-s)*Eu - (1-s)*Er + Ef$$

So:

$$(1-s)*E0 = (1-s)Eu - (1-s)*Er + Ef$$

$$(1-s)*(E0-Eu+Er) = Ef$$

$$(1-s) = Ef/(E0-Eu+Er)$$

$$s = 1 - Ef/(E0-Eu+Er)$$

At a conduction band confinement of about 2 angstroms, typical for 0.8 loading:

$$Eu = (1.9049921x10^-20 eV m^2)/(2x10^-10 m)^2$$

$$Eu = 0.476 eV$$

and

$$Er = -13.6 + q\_e^2/((8 Pi)(e0)(r))$$

directly giving:

$$s = (0.425 eV)/(13.6 eV - 0.476 eV)$$

$$s = 0.0362$$

thus the electron spends about 4 percent of its time in the conduction band phase of its existence while in the sub-orbital state. [Note - this number looks way too low, but I have checked the above several times and can not find anything wrong with it. I would have expected it to be closer to 96 percent.] In this state where the confinement is 2 angstroms, and loading is less that 0.8, we know that no net energy is produced or absorbed by the vacuum, all is in equilibrium. However, if the conduction band state is further compressed, say to 1 angstrom, typical for 1.0 loading, it is reasonable that Eu will increase, given that

Eu = (1.9049921x10^-20 eV m^2)/r^2

Eu = 1.905 eV

for an increase of 1.905 Ev - 0.476 eV = 1.429 eV. This gives a new but similar s:

s = (0.425 eV)/(13.6 eV - 1.905 Ev)

s = 0.0407

Note that as the ZPE energy is acquired more time is spent in the orbital phase, which acts to some extent as a controlling mechanism.

An electron gaining this extra 1.429 eV of energy would likely be freed and replaced with a lower energy itinerant electron from the conduction band. Unfortunately it would probably destroy the confinement configuration and trigger proton tunneling as well, thus providing a long delay for retapping the ZPE sea at the site. It might destroy the adjacent lattice bonds also. However, conduction bands seem to be capable of sustaining very energetic electrons, so it is questionable that this energy would be applied to a lattice bond directly as opposed to being diffused in effect throughout the local volume, since it come from the conduction band phase of the electrons existance.

To estimate the power that might be produced, assuming the lattice is stable, we have to know how fast such a replacement might happen. It seems like 10^8, the half life of an unstable orbital state might provide a reasonable guess for an upper bound. This sets an upper limit on the power to be extracted from the vacuum at 1.429 eV per site per 10^-8 seconds, or:

Power = 1.429x10^8 eV/s per active site

= 2.29x10^-19 W per active site

Using an atomic volume of 8.78 cm^3/mol of vanadium, we have Na atoms in 8.78 cm^2 or Na/8.78 = 6.86x10^22 atoms per cm^3. Achieving 1 W then amounts to obtaining (1 W)/(2.29x10^-19 W) = 4.37x10^18 active sites. This represents 4.37x10^18/6.86x10^22 = 6.37x10^-3 percent of the sites. However, if the active site restoration cycle lasts 10^-5 seconds instead of 10^-8 then about 4 percent of the sites must be active to obtain 1 W/cm^3. The number of active sites should grow rapidly between loading increases beyond a 0.8 [V]/[H] ratio, but almost none should exist prior in a bcc lattice.