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STATEMENT OF HYPOTHESIS AND BACKGROUND ASSUMPTIONS

The Atomic Expansion Hypothesis (AEH) is the idea that atomic expansion (AE), the increase in the size of an ionized atom or molecule, like H+, which occurs when it takes on an orbital electron, can perform work on the surroundings of the ion, and that the amount of energy released can be greater than the initial ionization energy, provided the ion is in a sufficiently confined space when the expansion occurs. This is an idea that leads to various possible experiments and, if correct, may provide a basis for the design of over unity devices. If correct, the AEH also explains various previously observed results.

This hypothesis is another expression among many of the idea that the excess heat from cold fusion devices does not come from fusion, or transmutation, but from extraction of energy from the zero point energy (ZPE) sea, the zero point field (ZPF). This is not to say that transmutation or conventional fusion does not occur in cold fusion experiments, only that the heat producing source of cold fusion (CF) devices is primarily ZPE. It is an assumption of this hypothesis that ZPF energy is what keeps atoms from collapsing and is part of the glue that holds atoms together without radiation. There have been various publications referencing ZPE, especially by Dr. H. E. Puthoff [1 - 6]

Atoms, more particularly orbitals, though quantized in energy, can be deformed, both in shape and electron probability distribution. These deformations can occur as a result of external stress on the orbitals due to collisions or pressure, or because of electromagnetic fields. The deformations are capable of storing energy, converting kinetic energy into potential energy, and back. With the exception of the occasional resulting photon emissions, such collisions are perfectly elastic, which is why the gas laws and thermodynamics work so well. It is true that collision and pressure deformations of orbitals are also electromagnetic in origin, but differ from purely field generated deformations in that the collision/deformation caused fields (or field distortions) are highly localized and mostly cancel at a distance, and in the fact that the field distortions convert kinetic energy into potential energy at a high energy density.

HOW MUCH ENERGY AND POWER IS AVAILABLE FROM ZPE?

John Wheeler and Richard Feynman, when first examining the possibility of vacuum energy, calculated that there is enough energy in the vacuum of a light bulb to boil all the seas. The problem is designing a mechanism to effectively extract this energy. The energy available is dependent upon the method used to extract it, be that polarization of the vacuum, the Casimir Effect, etc. The atomic expansion method depends upon the amount of orbital deformation achievable per transaction, and the transaction repeat rate per volume achievable. It does appear the two goals, high repeat rate, and high confinement, typically oppose each other.

The ZP energy fills every vacuum. If there is not a cutoff frequency, that energy is infinite. Assuming a cutoff frequency of near the Plank frequency (wavelength) of about 10^{-33} cm, the energy density is on the order of 10^{94} g/cm³. Multiply by c² and you have an enormous energy density - which does not have to remain constant, but can replenish itself from the ZPE sea if tapped.

The energy density rho(w) is characterized by H. E. Puthoff (Ref. 7) by:

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 $rho(w) dw = [w^2/pi^2*c^3]/[hw/2] dw \\ = (hw^3) / (2*pi^2*c^3) dw joules/m^3$

Rearranging we have:

rho(w) dw = (h/(2*pi^2*c^3)) w^3 dw joules/m^3

rho(w) dw = K w^3 dw, where K = (h/($2*pi^2*c^3$)) joules/m^3

Integrating over w=0 to w=B to get cumulative energy density f(B) to cutoff frequency B:

 $f(B) = K/4 B^{4}$

This indicates that the total energy density of the vacuum (though not constant if tapped) is proportional to the fourth power of the cutoff frequency being tapped. The big problem is figuring out how to tap this energy. If a method of tapping ZPE energy is found, conservation of energy is not violated, the second law of thermodynamics is violated, as the replacement energy ultimately flows from elsewhere in the universe.

Of interest is that most of the ZP energy is in the top frequencies of the ZP spectrum tapped. The bottom 98 percent of the frequency distribution tapped contains (.98)^4 or 92 percent of the energy. The top two percent contains about 8 percent of the energy. This implies it is best to utilize the smallest possible wavelengths in a ZPE extracting mechanism, and therefore, most likely, the smallest possible structures. This leaves atomic structures as the most likely regime to get good results.

Further evaluating f(B) for dimensionless frequency B (in Hz) we get:

 $f(B) = [1.556 \text{ x } 10^{-61} \text{ joules/m}^3] B^4$

Now, considering radiation on an atomic scale, i.e. wavelength of 1 angstrom, or 10⁻¹⁰ m, we get B \sim [3 x 10¹⁷ Hz.] so:

 $f(B) = [1.556 \text{ x } 10^{-61} \text{ joules/m^3}] [3 \text{ x } 10^{-17} \text{ Hz.}]^{4}$

 $f(B) = 1.26 \ge 10^9 \text{ joules/m}^3$

 $f(B) = 1260 \text{ joules/cm}^3$

If only the top 2 percent of the accessible ZPE frequency band is utilized, we get an energy density of about $1260/8 \sim 100$ joules per cm³.

Now, to consider power tapping capabilities, and some pretty big guesses. Given the extreme ZPE energy density at high frequencies, it is reasonable to assume that the tapped energy, i.e. energy removed from the imaginary cm³ can be replaced at nearly the speed of light, or about 10⁻¹⁰ second to replenish the cm³. Given a collection of atomic sized devices located in the cm³, we

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could use the macro size of 1 cm instead of 1 angstrom as the distance from which the replenishing energy must come, even though the higher ZPE wavelengths within the angstrom dimension micro structure volume could resupply the volume initially, with the minor resulting deficit at all ZPE frequencies spreading like a wave throughout the universe. This conservative choice gives an event cycle rate maximum of 10^{10} event cycles per second, each cycle taking at most some fraction of the 100 joules residing in the imaginary cm³. If we can somehow extract 1/10,000 the ZPE energy in the cm³, we would be able to extract 10⁵ joules / cm³ / sec., or 10,000 W/cm³. If there are only 1 out of 10,000 sites active per cycle, and we could extract 1/10,000 the ZPE energy in each site per cycle, we would get 1 W/cm³.

However, since we are using such a small part of the ZPE spectrum, replenishment might be able to happen from the locality as fast as 10⁻²⁰ second per cell, so would not be a practical limitation in any sense. Such a local replenishment would depend upon the existence of a mechanism for the energy of higher ZPE frequencies being converted to and replenishing the frequency band being tapped. The potential energy release is unlimited from any reasonable standpoint. The real limitations are event density and event repetition rate, and these are strictly design parameters that depend upon the ingenuity of the designer and choice of medium.

This is not to say that finding a method of extracting any net energy is easy. Though the ZPE sea abounds, it is very difficult to extract the energy from it. This is possibly the main value to the AE concept. If there is any truth to the idea that ZPE provides the support for orbitals, then ZPE does interact with our environment in a big way continuously. Massive energy exchanges occur in springs, sonic devices, etc., simply from orbital deformation. Enormous forces can be involved and enormous energies, even in the compression and expansion of relatively cold systems, like metal lattices. The intended method of extracting energy from the massive ZPE sea is to cause orbital expansion to occur in a confined space, thus creating extreme orbital deformation without supplying the deforming energy to the process. This is like manufacturing watch springs that are already wound.

A PROPOSED MECHANISM FOR PRODUCING HEAT IN A METAL LATTICE

1) An ion, e.g. H+ or He++, is injected into a metal lattice. This can be accomplished via high energy ion acceleration or via electrolysis.

2) As the ion comes to a halt in the lattice, any kinetic energy initially imparted to the ion is given up to the lattice.

3) The ion takes up an electron from an adjacent atom or conduction band. If from an adjacent atom, that atom may momentarily shrink (or lose a bond and expand), but will quickly return to size by obtaining an electron from a conduction band. The net result is an electron from the locality is taken up by the ion.

4) An orbital is formed about the ion, increasing the size of the ion.

5) As the electron occupies the orbital, quantized EM energy (e.g. a photon), equivalent to the original ionization energy, is released - heating the local environment.

6) As the small ion and acquired electron(s) expands from nuclear dimensions to atomic dimensions, at some point force is applied in all directions to the lattice provided the interstitial

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sites do not accommodate the size of the de-ionized product. Further expansion of the de-ionized product to it's final size results in work being performed on the lattice. The energy thus produced has no antecedent. It is derived solely from the force that keeps atoms from collapsing. However, unlike a collision, no initial compressive kinetic energy was supplied. The energy is supplied from the ZPE sea.

ENERGY DERIVED FROM ATOMIC EXPANSION IN LIQUID OR GAS PHASES

Energy might be similarly obtained in a gas or liquid phase, though not with the efficiency of a metal lattice. A conducting liquid, like mercury, would behave similarly to the metal lattice, but the force resisting the AE would be almost entirely inertial, thus much smaller than the resisting force of a molecular bond. The force resisting the AE would still be exerted over a slightly sub-atomic distance, so the excess energy produced per atomic expansion would almost entirely be proportional to the AE resisting force.

Similar arguments can be made for the collision of an ion with a non-ion in a gas. The main difference here is the lack of an electron source to bring the net charge to zero, and thus the cost of extracting the electron from the neutral atom to fill the ion's orbital. A negative balance in ionization potentials (e.g. H+ hits He) must be overcome using the kinetic energy of the collision.

Similar arguments can also be made for gas/metal interfaces where low energy ions strike metal electrodes, but do not penetrate. Here again, the AE is only inertially confined, and results in the ion product being accelerated upon its rebound from the plate.

EXAMPLE OF POSSIBLE MECHANISM FOR PRODUCING HEAT IN A GAS

1) Hydrogen is ionized to create H+ in a mixture of H2 and Rn (radon gas). This might be accomplished in an arc, a point or wire discharge, or via RF, x-ray, or other indirect excitement.

2) The H+ ion comes into contact with a Rn atom, stripping an electron from the Rn atom producing a H atom and Rn+ ion. In the event one of the other noble gasses is used in place of Rn, some of the H+ kinetic energy is required to strip the electron, and the post collision noble gas atom may still ultimately retain the electron even though a momentary H orbital forms during the collision.

3) An orbital is formed about the H+ ion, suddenly increasing the size of the ion. The expansion, fueled by ZPE, imparts "free" energy to the atoms in the form of potential, then kinetic, energy as the collision progresses.

4) As the electron occupies the H orbital, quantized EM energy (e.g. one or more photons), equivalent to the original ionization energy less the Rn ionizing energy, is released - heating the local environment.

5) The initial momentums and energies of the H and Rn nuclei gets applied to their shells, distorting them, and are returned to the environment via the normal elastic collision mechanism.

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6) Eventually the Rn+ is reconstituted to Rn and a photon is released, gaining back the complete energy of ionization of the H atom initially.

The net energy gained is the energy of expansion (AE energy) of the H+ orbital in close proximity to the Rn+ ion - thus imparting additional kinetic energy to both.

WHAT DOES THE AEH EXPLAIN?

The AEH provides a possible explanation for the varied effectiveness of the alpha, beta, and gamma phases of CF loading. I suggest that in the initial loading phase the adsorbed hydrogen is, as suggested by others, alternately in H and H+ form, but primarily in H+ form. It is primarily ionically bound to the lattice, especially when in motion. An H atom almost fits inside a tetrahedral lattice cell, but not through the triangular portals between cells. In the beta phase, many of the cells are occupied by H molecules, and in such a state, diffusion between cells requires displacement of some H molecules, the diffusion paths tend to be blocked, and the continued diffusion requires the ionization of a path blocking H or its tunneling out of the way. Some degree of H confinement upon the reconversion from an H+ to H would occur, thus some small AE excess energy might be produced in beta phase. In the gamma phase, H loading would be to the point that additional loading would force the formation of H2 molecules in the tetrahedral sites and in the face holes. In looking at the geometry of the Ni lattice and H2 molecules, it appears such a formation is possible with only a deformation of the lattice of about 2 percent. This would, however, imply extreme confinement and local pressure, which would dramatically increase the work done by ZPE in supporting the H2 formation, or "expansion".

Some numbers regarding H2 molecules and the face centered cubic geometry of the Ni lattice:

H atomic radius: .79 Å H covalent radius .32 Å H2 bond length .7414 Å Ni atomic radius 1.62 Å Ni covalent radius 1.15 Å Ni bond length 2.4916 Å

From this it is determined that the face hole will pass a sphere of radius 0.2885 Å and the tetrahedral space will accommodate a sphere of radius 0.6118 Å. However, an H2 molecule can be placed across one axis of the tetrahedron with each atom partway through a face hole. In fact, the H2 atom could pass through the face holes with only an expansion of the bond length of 2*(.3200 - .2885) = .063 Å. This is an increase in bond length of about 2.5 percent. Less expansion is sufficient to fit the H2 into the tetrahedron. Note that it is also possible, when there is sufficient heat, to trap or form an H2 molecule in the face hole and that the three Ni atoms can act like two hammers and an anvil, or a tri-jawed anvil - popping the H2 molecule apart, each atom then expanding in separate tetrahedral spaces. Such an expansion is at least inertially constrained, thus AE energy could result. Note that each half of the H2 "dumbbell" resides in a different tetrahedral space. These spaces can act as pistons, i.e the vacuum will accumulate zero point energy. This energy may assist the cracking of the H2 by the anvil by exerting a Casimir force on the expanding H orbital surface. Further, when the orbitals of the expanding H and the boundary metal atoms make

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contact, a kind of orbital "blow through" may occur, creating free electrons that further heat the lattice. The H nucleus would be accelerated in the direction of the center of its tetrahedral site by the expanding H orbital. This momentum could carry the H nucleus on into the next tetrahedral site, thus ZPE may help facilitate the H diffusion. Sufficient energy might momentarily create an H "supermolecule," two H nuclei orbited by two electrons. Such events would increase the likelihood of fusion, if only a small amount. Maximizing the ZPE extraction via these means would mean loading the lattice at a (or eventually heating it to a) temperature near the melting point of the Ni in order to permit maximum occupation of the triangular face holes by H2 atoms. Similar arguments apply to the Pd-D system.

The following chart of FCC elements shows possible candidates for such a mechanism:

Elem.	Bond	Covalent	Atomic	Face Hole	Tetrahedral
	Length	Radius	Radius	Radius	Space Radius
	(A)	(A)	(A)	(A)	(A)
Ge	2.4498	1.22	1.52	0.1944	0.5123
Pt	2.7460	1.30	1.83	0.2854	0.6417
Ni	2.4916	1.15	1.62	0.2885	0.6118
Cu	2.5560	1.17	1.57	0.3057	0.6373
Pd	2.7511	1.28	1.79	0.3083	0.6653
Au	2.8841	1.34	1.79	0.3251	0.6993
Ag	2.8894	1.34	1.75	0.3282	0.7031
Al	2.8630	1.25	1.82	0.4030	0.7744
Ce	3.6500	1.65	2.70	0.4573	0.9309
Yb	3.8800	1.74	2.40	0.5001	1.0035
Ca	3.9470	1.74	2.23	0.5388	1.0509
Pb	3.5003	1.47	1.81	0.5509	1.0051
Sr	4.3020	1.91	2.45	0.5738	1.1319

Since hydrogen has a covalent radius of 0.32 Å, it appears superficially that Pd, Cu, Ni, and Pt are the only reasonable candidates for the suggested anvil/piston mechanism. However, this table is only an approximation, and a detailed analysis of the crystal structure, utilizing the Schroedinger Equation, is required. It is especially noteworthy that Pt, Cu, and Au are relatively impervious to hydrogen adsorption at standard temperatures. The best candidates capable of both trapping the H2 in a face hole and also being capable of anvil pressure on the bond appear to be Nu, Cu, and Pd, but again, detailed analysis is required. Also, the more impervious elements might become active at a high temperature, especially Pt and Cu. Note also that above Al in the table, the H atom, having a radius of 0.79 Å, appears to readily fit into the tetrahedral space without orbital deformation. This would greatly diminish the free energy generating potential.

The AEH model also may explain why various discharge tubes, especially those containing H2 or He, appear to produce excess energy. The ions are injected into the metal lattice where they are confined prior to atomic expansion. A repetitive ion oscillation may produce a kind of synchronized shock wave in the metal surface causing it to rebound and add energy to the impinging and reflecting particles at the surface. The source of the AE energy may be primarily in the electrodes, especially cathodes, but to some degree may occur in the gas as well, or at the electrode surface due to AE surface effect expansion.

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The AEH may also explain the mechanism by which cavitation devices produce excess heat - namely that some of the H2O is ionized in the cavitation bubbles and the collapsing bubble results in the ions being injected into the high pressure water wall where the ions reconstitute and expand, undergo AE, adding pressure, thus kinetic energy, to the collapsing pressure wall.

The AEH may also explain the over unity performance of an arc in producing water gas in that collision of H+ with C, or CO or CO2 could potentially create AE energy.

Here are some ionization potentials of interest:

H 13.598 C 11.260 CO 14.014 CO2 13.773

Note that no kinetic energy is required to trigger the AE reaction between H+ and C and that little is required for CO or CO2. Note that the AE reaction might possibly push the chemical equilibrium in the arc toward the production of CO by supplying the excess energy required to split the second O from the CO2. Two things are bothersome about this concept though. One is that if the AE effect exists it should have been observed in chemistry long ago. Another is that, unlike the case where H+ and a noble gas are used, a bond can form between the H and the reactant, so the kinetic energy would end up in molecular vibration, or in reducing the probability of such a bond. The main difficulty, though, is that the shared orbital, the bond, creates an attractive force instead of a repulsive force. AE excess energy is based upon repulsion, not attraction. Perhaps one difficulty answers the other. In any event, He++ would make a more logical AE generator than H+ in this application. The He would act as an energy booster, and thereby as a kind of catalyst, in cracking the H2O and CO2 bonds. Such a process may work best at very low voltages and high frequencies, especially in a manner similar to that suggested by Puharich (Ref. 8) for cracking water. His method adapted to a steam/CO2 environment, catalyzed by He, could assist in the production of water gas. Such a gas could be used, within a sealed glass envelope containing both discharges, to feed oscillations (due to operation in the negative resistance range) of a higher voltage arc or electric discharge, to produce electrical energy directly, without mechanical devices.

SO WHAT ABOUT DESIGN CRITERIA?

This model results in some concrete design suggestions:

1) Produce ions (especially H+ or He++) in as large a quantity and as efficiently as possible.

2) Accelerate or transport the ions into a confining and preferably conducting medium where they are deionized under pressure.

3) Utilize the increased pressure and heat in the confining medium.

4) Make the confining medium as gas recycling as possible, preferably extracting energy from the higher pressure and temperature post-AE gas before repeating the cycle.

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SOME APPLICATION AND EXPERIMENTATION THOUGHTS

1) Mercury, though not as confining as a lattice, may make a good medium for ion injection as it would expel the gasses quickly. Mercury also conducts electricity well. Other metals could be used at higher temperatures; however, electron emission from hot cathodes would not be good as it would increase the power demand. The increased power would have to be utilized to result in more ionizations. The simplest possible test device may be a small sealed glass tube of H2 or He with a point anode at the top and mercury cathode at the bottom, activated with high frequency high voltage pulsed DC current. An improvement might be to use two anode electrodes, isolated from the cathode, with a lower voltage discharge between the anodes to do the ionization.

2) Hot anodes are fine as they will increase ionization and kinetic energy of the gas. An arc created by an isolation transformer may make a very good anode.

3) It may be possible to use water as a cathode. The atomic expansion may assist in boiling the water at the surface. The water could provide it's own H2 from the evolved steam which migrates to an arc anode. It might be good to use a helium atmosphere to get safe recombination. An electrolyte would, of course, increase the cathode conductivity.

4) Electrolysis (or arcs) under water may produce usable energy if done under extreme pressure. Simply use the evolved high pressure gas to move pistons. Additional process stages could be added for recombination and heat recovery. Some of the energy of compression, by the AEH model, would come from the ZPE sea.

5) As suggested earlier, a closed tube with an electrically excited mixture of H2 and a noble gas, especially radon, may produce some over unity results.

6) The process of producing water gas, i.e. burning carbon in an arc under water to produce CO and H2, may be improved by avoiding the use carbon rods altogether. This might be done by recycling the CO2 and H2O (as steam) into an arc and driving its equilibrium to a mixture of H2O, CO2, CO, and H2 in the arc. The AE energy would assist in driving the reaction in reverse in the arc and would be the energy derived from the recycling process. This process might be assisted by adding He to the atmosphere as the He has a much higher ionization potential (24.587 volts) than CO or CO2, and will not bond with it.

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