Low Energy Induced Nuclear Fusion Via Coherence Of The Quantum Vacuum, Zero-Point Energy Through Ultra Close Range Casimir Effects

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ABSTRACT: A new class of low energy induced nuclear fusion is described backed with a simple experiment that has been independently replicated and reported in *Fusion Technology* and other journals. The new process, dubbed ZIPP Fusion for convenience, produces visible microgram quantities of iron and numerous other elements from the apparent nuclear fusion of carbon monoxide and other simple molecules in a carbon arc electrolysis cell. The theory offered to explain the new process invokes the now well established reality of the Casimir effect as exhibited in the anomalous properties of Sonoluminesence, Condensed Charge phenomena and Cavity Quantum Electromagnetics, which are believed to cohere the otherwise random Zero-Point Energy of the Vacuum Fluctuations of Quantum field theory. In effect this process induces a variety of high energy, deterministic nuclear fusion reactions between relatively large nuclei, "triggered" by low input energies, generally not considered possible in the conventional view. A logical extrapolation of this discovery is that the Strong force of the nucleus is in fact an ultra-close range Casimir effect that literally holds the nucleus together from the outside rather than the conventional view of internal "glue" like bonding.

RESUME: Une nouvelle classe de fusion nucléaire induiteà basse énergie est décrite, soutenue par une expérience simple qui a été indépendamment répliquée et rapportée dans *Fusion Technology* et d'autres journaux. Le nouveau processus, dite fusion ZIPP par commodité, produit des quantités évidentes de microgrammes de fer et nombreux d'autres éléments à partir de la fusion nucléaire apparente de l'oxyde de carbone et d'autres molécules simples dans une cellule d'électrolyse à arc de carbone. La théorie offerte pour expliquer le nouveau processus s'appuie sur la réalité maintenant bien établie de l'effet Casimir qui se manifeste dans les propriétés anormales de

Sonoluminescence, de phénomènes de condensation de charge et d'électromagnétisme quantique dans les cavités, dont on pense qu'ils sont reliés à l'énergie aléatoire de Zéro-Point des fluctuations du vide de la théorie quantique des champs. En effet ce processus induit une variété de réactions déterministes de fusion nucléaire d'énergie élevée entre des noyaux relativement grands, déclenchées par des basses énergies d'entrée, généralement non considérées possibles selon les vues conventionnelles. Une extrapolation logique de cette découverte est que l'interaction forte du noyau est en fait un effet Casimir à ultra courte distance, qui tient littéralement le noyau ensemble à partir de l'extérieur, plutôt que le point de vue conventionnel de cohésion interne comme une colle.

1 Introduction

Carbon arc in water experiments performed by M. Singh [1], J. Bockris [2], M. Kushi [3], G. Oshawa [4] et al, have repeatedly observed the anomalous presence of Iron and other elements when a DC arc is struck between ultra pure carbon/graphite electrodes immersed in light water. Concentrations exceeding 2000 ppm iron and other elements have been noted in experiments utilizing electrodes which initially contained less than 5 ppm. A few of these researchers have also noted that excess heat is produced based on the temperature rise of the cell compared to the electrical energy input. Rigorous experimental protocols have normally been employed to ensure that the obvious explanation of cell contamination or impurities in the raw materials has been eliminated.

The heretical notion that nuclear reactions can occur at low input energies is not new. Historically, claims of this nature date back to the peers of Lavoisier himself. Early in the 20^{th} century, E. Fermi [5], one of the founders of nuclear physics reported the anomalous fusion of heavy ice and deuterium while attempting to generate neutrons, but apparently chose not to give it further attention. Oshawa also reported the nuclear fusion of Sodium and Oxygen in a plasma discharge vacuum tube experiment claiming production of Potassium.

In 1989, Pons and Fleichmann reopened this "can of worms" with their ill-fated press release claiming deuterium fusion in an ordinary heavy water electrolytic cell employing palladium electrodes saturated with deuterium. The resulting frenzy of interest quickly subsided in the heated controversy that followed due in large part to the inherent difficulties in reproducing the effect that would only occur after a long latent period of cell operation, and the glaring lack of conventional fusion indicators. Despite the official rhetoric and condescending denouncements from various quarters, research into low energy nuclear reactions continues around the world unabated, although with a much lower profile.

The most recent claim by R. Taleyarkhan [6], et al, of Oak Ridge Nuclear Laboratories that D-D fusion can occur during the process of Sonoluminescence, provides further evidence of a theoretical basis for its occurrence. Replication of this Sonofusion experiment has also been reported at Los Alamos. Related to this work is a similar process that has been under investigation by this author [7] since 1996 as first published in 1998. With the publication of the ORNL experiments, a strong impetus has emerged to seek more official recognition of this companion process that has many of the essential elements of the Sonofusion process, including implosion of microscopic cavitation bubbles, accompanied by a plasma discharge within a dielectric fluid, with the intended fusion fuel entrained in solution. The results here presented are however, an order of magnitude more controversial in that much larger nuclei appear to participate in the fusion reactions that have been identified on a conjectural basis. The apparent fusion of such relatively large nuclei would appear to call for some major revisions to the existing paradigm.

What follows is admittedly a radical departure from conventional thought on the subject of nuclear fusion, which none the less, appears well supported by mainstream theory and experiments drawn predominantly from peer reviewed journals such as *Physics Letters* and *Fusion Technology.* This new process has been called ZEIPPIEN fusion, which is just another silly acronym that stands for Zero-Point Energy Induced Plasma Pinch of Ionized Entrained Nuclei. As a matter of convenience the truncated term ZIPP fusion is generally preferred. This label was chosen to earmark this new class of nuclear reaction, which is based in large part on the ground breaking Condensed Charge research of K. Shoulders [8], related investigations by H. Puthoff [9], recent discoveries in the field of Sonoluminesence and Cavity Quantum Electrodynamics, all of which involve Casimir effects, that are in turn rooted in the now proven existence of what is referred to as the Zero Point Energy of Vacuum Fluctuations, common to both Quantum and Classical field theory.

The reader will likely find that there is a fair amount of new subject matter to be grasped so a bit of background material is in order. In considering such “out of the box” ideas, one should keep in mind that historically the greatest obstruction to understanding new concepts is not ignorance, but rather the presumption of knowledge based in the existing flawed or incomplete orthodoxy. With this precautionary statement in mind to help ensure the utmost level of objectivity, the experiment and theory here presented are acknowledged outright as a rather simplistic, first attempt to explain these anomalous results from a larger perspective, rather than delving into a meticulous analysis of all the pieces of the puzzle. In any event much further work will be required to reach a clear, deterministic understanding of the processes described.

2 Theoretical Background

2.1 Zeropoint Energy

It is a peculiar prediction of advanced Quantum field theory that the vacuum of space, generally perceived to be an empty void is in fact full of a random flux of electromagnetic radiation that theoretically includes all frequencies ranging up to the incredibly high Planck frequency of 10^{44} Hz with a wave length of 10^{-32} m as suggested by th wave / particle duality expression of de Broglie, $\lambda=h/mv$. To help put this in perspective, very little is presently known of the EM spectrum above 10^{22} Hz implying that virtually nothing is known about the vast majority of the spectrum. Realizing that the energy per photon is directly proportional to the frequency, one can begin to appreciate the astronomical energy potential of this energetic field.

This ubiquitous energy of space, more commonly referred to as the Zero-Point Energy (ZPE) of Vacuum Fluctuations is an important but frequently ignored aspect of Quantum field theory, which must be accounted for when performing the math (Lamb shift), but is generally dismissed as an odd artifact of the theory, rather than a real phenomenon. Many physicists are still of the mistaken opinion that space is an empty void despite the growing mountain of evidence to the contrary. The Zero-Point Field (ZPF) is normally homogenous and isotropic, which simply means that it is everywhere essentially uniform and moving in all directions simultaneously. The term Zero-Point is derived from the fact that this energy remains as a residual background condition of the Universe even at absolute zero in a perfect vacuum where all thermal radiation has been frozen out. Advanced theorists have recently entertained the idea that this stochastic bombardment of the ZPE radiation is responsible for the quantum “jitter” or Zietterbewegung motion of all atoms that persists at absolute zero were classical physics would tell us that no such motion should occur.

Remarkably, when one considers the accumulated minuscule energies at all discreet frequencies, directions and polarities passing through even a small volume of space, it has been calculated that the energy density exceeds that of the nucleus of matter by no slight margin. Nobel Laureate, R. Feynman, a protégés of Einstein once estimated that there is more than enough energy in a coffee cup to vaporize all the world's oceans. One might obviously wonder how we could possibly exist in this seething sea of universal energy and not even be aware of it but in answer to that, the analogy of deep sea fish is offered. Despite the rigors of surviving some seven miles down in the bone crushing depths of the ocean, where the pressure in every cell of their bodies exceeds 13,000 psi, they experience no ill effects. The reason of course is that the pressure is entirely uniform and balanced. Similarly, our ability to detect the ZPF directly is restricted by the fact that it is essentially uniform, and we are totally immersed in it. Its most potent effects are confined to the atom and nucleus due to the extremely short wavelength of most of this radiation. Bulk matter being composed of mostly empty space is therefore largely transparent to it. Trying to take measurements of it has been likened to attempting to weigh a beaker of water while the entire lab is submerged. Furthermore, instruments capable of measurements at these incredibly high frequencies are as yet unavailable and the assumed predominance of non-herztian/longitudinal or scalar wave-forms confined primarily to the temporal dimension also appears to make observation in normal 3 space very problematic.

The only effective method of detection requires a localized coherence of this otherwise homogenous, random energy. What is meant by coherence is that the uniform, chaotic and therefore unusable energy of the ZPF is organized by various methods to yield net effects, which can then be detected by conventional means or used to do useful work. One reasonably well established method of cohereing this random energy of the vacuum is known as the Casimir effect, which can manifest itself in a variety of ways. The reality of the Casimir effect is essential to the understanding of the ZIPP fusion process, so a bit of an introduction is in order.

2.2 The Casimir Effect

The Casimir effect was first theorized in 1948 in a thought experiment proposed by H. Casimir, based in the ZPE of Quantum theory. He reasoned that two conductive plates brought sufficiently close together will be forced together very slightly due to the fact that EM waves impart a small impulse force when reflected or absorbed. The narrow space between the plates shields out the longer wavelengths of the ZPF spectrum much the way radio waves are shielded out by the body metal of a car, which is why the radio antenna is located outside. The entire ZPF spectrum continues to impinge on the outside surfaces of the plates creating an imbalanced force due to the difference in radiation pressure, driving the plates together. P. Milonni [9] of

Los Alamos Laboratories has recently provided a detailed interpretation of the Casimir effect in terms of this net radiation pressure from the vacuum.

The direct measurement of the Casimir force, $F_c=\pi^2hcA/240d^4$ where, h is Planck's constant, A the area of the plates and d, the separation distance, has been performed on several occasions, first by M. Sparnaay in 1958 and most recently in 1998 by U. Mohideen [10]. Using an atomic force microscope, Mohideen's measurements where found to be within 1% of Casimir's theoretical prediction. One will note that this force increases very rapidly in proportion to the inverse of the forth power of the distance between the plates. The detectable onset occurs at a distance of approximately 1 micron. At a plate separation of 0.1 micron, recent measurements yielded a force of 10^{-10} Newtons which translates to a pressure of about 1 atm or 100 kPa at a distance of 0.01 microns. It is further conjectured that in the extreme atoms and indeed the nucleons themselves constitute small "plates". A simple extrapolation of this force down to the dimension of bonded atoms at 10^{-10} m yields a pressure of 10^{10} kPa, which oddly enough correlates reasonably well with the observed tensile strength of some metals. Extrapolating even further to the dimension of bonded nucleons, generally conceded to be in the order of 10^{-15} m, yields an astronomical net radiation pressure of 10^{30} kPa, which seems absurd, but certainly sufficient to hold the nucleus together against the coulomb repulsion of the protons. Assuming for simplicity an interface bonding area in the order of 10^{-30} m^2 between adjacent nucleons, yields a strong force of ~10 kN between the neutron and proton of a deuterium nucleus. Such numbers are admittedly hard to fathom but one does get at least some sense of the magnitude of this force if in fact the ZPF exists as predicted.

A more familiar example of the Casimir force can be envisioned by taking two finely finished Machinist's gauge blocks and placing them together. One will find that once contact is made they can no longer be easily separated and must be rung apart with a shearing force. This phenomenon has been traditionally explained as due to air pressure being eliminated along the smooth contact surfaces, but some of this effect would appear to be due to the initial onset of the Casimir force.

There are several other phenomena, which support the existence of the ZPF, including the strange behavior of cavitation bubble collapse within the emerging field of Sonoluminescence, and the dramatic alterations of spontaneous emission times as observed in the field of Cavity Quantum Electrodynamics, both of which are believed to be key factors in the ZIPP fusion process.

2.3 Sonoluminescence

Sonoluminescence deals with the production of mysterious, high intensity, picosecond light pulses which are known to accompany the collapse of cavitation bubbles, driven by ultrasonic waves in a dielectric fluid such as water. The source of these high-energy pulses which can vaporize metal with temperatures exceeding 10^6 K are not adequately explained by conventional theory. J. Schwinger [11] of UCLA has suggested that the effect is due to a coherence of ZPE from the active vacuum. This process of cavitation bubble collapse appears to be a special case of the Casimir effect with the water as a dielectric fluid enclosing a spherical cavity formed by the bubble. The dielectric bubble in effect replaces the metal plates of Casimir's original thought experiment.

The net effect of the ZPF in this case is directed radially inward, and as the bubble collapses in response to this force, more and more frequencies are excluded from the shrinking micro-cavity, causing the net imbalance of radiation pressure to rapidly escalate, culminating in a high energy impact of the bubble wall as it collapses on itself, yielding intense bursts of energy emanating from a coherence of the random energy of the vacuum. Research in this field is still quite obscure, but an article recently appeared in the November 98 edition of *Popular Science* moving it into the public domain. The Sonofusion process just reported at ORNL utilizes sonoluminescence to fuse deuterium dissolved in acetone.

The familiar, but mysterious phenomenon of cavitation, which can very quickly destroy stainless steel pump impellers, can be easily accounted for as a minor coherence of ZPE. Cavitation damage is generally associated with water systems due to its high dielectric value, but the problem also occurs with liquid metals for the same reasons.

2.4 Condensed Charge / Charge Clusters

Puthoff and his associates have been studying Condensed Charge phenomenon for over 20 years. This work deals primarily with the production and behavior of what is referred to as an Electron Valudum (large electron) or EV. Similar investigations into high-density electron charge clusters have also gone on in parallel in Russia at the Kirchatov Institute. An EV is a condensed cluster of electrons of approximately 1 micron in diameter, consisting of up to 10^{11} electrons, generally formed by high voltage discharge plasmas above a certain critical electron flux density. Its existence of course runs contrary to conventional thought because the mutual coulomb repulsion of electrons should theoretically prevent its formation. It is interesting to note that in the development of the electron beam weapons of the "Star Wars" program, engineers encountered problems with beam collapse, rather than the anticipated problem of diffusion; entirely contrary to their logical expectations. Invariably, EV's also contain a relatively small number of captive Ions that can be accelerated with the electron cluster to very high MeV energies using electrical potentials of only a few thousand volts.

Puthoff has demonstrated that these EV entrained high-energy ions can induce nuclear transmutation of elements in the anodes of his apparatus. Such experiments have generally been performed in gaseous atmospheres at relatively high electrical potentials of 5,000 volts or more and with extremely short rise times in the plasma discharge current. They also involve high-energy impacts of smaller ions such as those of hydrogen into much larger target nuclei. This process of accelerating a small number of positive ions attached to a large cluster of electrons has been calculated to be capable of delivering the extremely high MeV kinetic energies necessary to cause fusion in a more conventional manner. H. Fox and his associates routinely apply this principle to their own extensive research in low energy nuclear reactions. In contrast, the low electrical potentials, presence of a water medium and the apparent fusion of relatively large nuclei in the carbon arc experiments suggest an alternative mechanism, which this fusion theory attempts to address.

2.5 Cavity Quantum Electromagnetics

As implied under the subject of Sonoluminescence, microscopic cavities also appear to play a major role in many low energy induced fusion reaction processes. It is well established within the field of Cavity Quantum Electrodynamics (QED) that the spontaneous emission of an excited atom, once thought to be an immutable property, can be prevented from returning to its ground state by surrounding it with a microscopic metallic or dielectric cavity only a few microns wide. Atoms have been sustained in an excited state for very extended periods of time because they can neither radiate nor receive certain wavelengths from the vacuum. One theoretical basis for this invokes selective shielding from the ZPE spectrum [12]. As is the case with the Casimir effect the longer wavelengths cannot exist inside the cavity reducing the atoms exposure to the vacuum fluctuations. Puthoff [13] has suggested that it is the energy input from the vacuum that actually sustains the electrons orbit. The electron being a charged particle in accelerated motion, it should theoretically radiate its energy and eventually collapse onto the nucleus. Making the cavity small enough, and of a very definitive size can also greatly reduce the spontaneous emission time. Ever smaller "plates" and cavities could by extrapolation to the extreme view, conceivable include systems composed of individual atoms, nuclei and even sub-atomic particles, implying the ability to alter other spontaneous processes include nuclear decay and all of its related radiation phenomena.

3 Apparatus and Procedure

The carbon arc experimental apparatus consists of a simple low voltage, pulsed DC electrolysis cell which produces a plasma arc between ultra pure carbon/graphite pellet electrodes 1.2 cm long and 6 mm in diameter, immersed in ultra pure light water. The graphite electrodes were obtained from *Ultra Carbon* and are typically used for performing high precision gold assays using DC arc spectroscopy methods. The manufacturers certified analysis provided with the electrodes claims total impurities of <0.5 ppm. The pellets are made by carefully breaking off pieces from the 10 cm electrodes revealing a sintered graphite construction. Up to nine of these pellets are confined in series within a perforated ceramic tube composed of 99.9 % pure Silica (fused quartz) and immersed in, 0.5 L of double distilled, reagent grade, light water that has been, de-ionized to <1µmho and micro filtered down to 0.5 microns with a certified analysis of <1ppm total impurities. Fused quartz was chosen for its excellent thermal stability and because silicon cannot be detected by the analytical method used, reducing the prospect of sample contamination from the apparatus. Graphite pellet holders cut from other materials such as clear ceramic glass were also used on occasion to facilitate visual observation of the plasma discharge. An ice bath of concentric bowls was frequently employed to help keep the cell operating temperature down. Cell temperatures above 80 ^{o}C were generally avoided by letting the cell cool off occasionally with a lid installed to prevent evaporation and contamination. Arcing was usually performed with the Pyrex bowl open to atmosphere but some limited testing with a loose lid installed while arcing was also done for comparison. Rough calorimetry tests were performed using a foil wrapped and insulated bowl to compare input energy with cell temperature increase.

A Variac transformer in conjunction with a full wave rectifier both rated at 20 amps was used to provide a pulse rate of 120 Hz DC from a normal 115 VAC supply. An applied potential of about 8 Volts rms for each arc in series appeared to be an optimum test condition, yielding an average current of approximately 5 amps. For a total of ten arcs this corresponds to a load voltage of 80 VDC at 5 amps. Up to 10 arcs in series, including two feeding electrodes, were used to provide rapid results and to help limit the current flow and power consumption to a practical level using the laboratory equipment and facilities available. Excess current in the plasma discharge would appear to reduce the yields as observed by Singh and Bockris. Multiplying the frequency of plasma discharges was also conjectured to improve the fusion efficiency. However, single arcs also produce anomalous results as amply demonstrated by other research groups. Pulsed DC was used primarily as a matter of safety and to ensure a high rate of discharge. Alternating current also produces similar results. Special care was taken to ensure very light intermittent contact in order to provide a low current, stochastic discharge between the pellets and the feeding electrodes, otherwise short circuit currents exceeding 50 amps would occur. The plasma discharge was continued for a total elapsed time of approximately 1 hour in order to provide a sufficient quantity of carbon/graphite residue for chemical analysis (~0.5g). A 5 mm diameter polished neodymium magnet, was occasionally used to pull magnetic materials from the cell early in the arcing process to provide a first qualitative indication of fusion. A Ludlim Geiger counter was used to detect radiation in the vicinity of the cell during arcing but nothing above normal background was detected. The settled, suspended and dissolved residue resulting from the consumption of the electrodes was then collected for analysis.

Collection of the individual residue samples listed in Table 1 below was done according to the following methods. Sample A, was extracted from the cell by first decanting most of the water and then drying the settled residue. Samples B and C were collected by gently boiling off the water used in the cell in order to collect any dissolved or suspended material. Control sample B was produced in the same manner using 0.5 g of crushed, carbon/graphite in 0.5 L of Reagent grade water in order to alai concerns about contamination during the drying process used with the other samples. Control sample A was analyzed with out any water preprocessing. Crushing of the control samples was done using Pyrex glass and fused silica tools to avoid contamination during the crushing operation. The dried samples were then analyzed by the Saskatchewan Research Council Laboratory using standard ICP-AES techniques for broad-spectrum metals analysis.

4 Observations and Results

Gas production from the electrolysis of water and plasma induced oxidation of the graphite pellets electrodes logically resulted in significant production of O_2, O_3, H_2, CO, CO_2 and steam. The presence of a combustible gas mixture presumed to be hydrogen and oxygen was verified. Exposure to air would also introduce significant amounts of N_2 and traces of other gasses. Qualitative tests with a lid installed during arcing to prevent gross mixing with air showed comparable iron yields, indicating that efficient mixing with air may not be too critical. Other more complex gas molecules including hydrocarbons are presumed to be formed during arcing, but for the sake of simplicity were not identified or considered in the present analysis. An odor reminiscent of sulfur also attends the arcing process indicating the possibility of some production. Consumption of the electrodes was observed to take place primarily at the anode end of each of the pellets. Visible, microgram quantities of iron or nickel containing carbon residue could be extracted from the cell in less than 10 minutes using a small 5 mm diameter polished Neodymium magnet. The relatively large quantity that can be collected even within the first ten minutes would indicate the initial conditions of the cell may be the most conducive for the formation of iron and presumably other elements. The analysis of the carbon residue is tabulated below for the four samples collected as described earlier. The last column is one set of typical DC Arc Spectroscopy results provided for comparison that were reported by Singh, et al of B.A.R.C in their 1994 carbon arc in water experiment reported in *Fusion Technology*.

Table 1: Carbon Residue Sample Analysis

	CON A (μG/G)	CON B (μG/G)	SAMP A (μG/G)	SAMP B (μG/G)	SAMP C (μG/G)	MAX YIELD	BARC (μG/G)
Al	3	28	540	740	890	30 X	200
Ba	2	1	16	26	9	25 X	N/A
B5	0	2	4	N/A	11	5 X	N/A
Ca	2	42	210	1930	800	50 X	N/A
Cr	0	0	47	16	13	New	100
Cu	1	4	63	24	100	25 X	N/A
Fe	3	20	950	750	450	50 X	1000
Pb	0	2	18	N/A	4	10 X	N/A
Mg	2	6	120	530	140	90 X	N/A
Mn	0	0	8	13	8	New	50
Ni	1	0	10	12	16	New	500
P	<10	<10	50	N/A	40	5 X	N/A
K	< 40	<40	180	N/A	640	15 X	N/A
Na	2	50	210	430	670	15 X	N/A
Si*	N/A	N/A	N/A	N/A	N/A	N/A	500
Sr	0	0	3	22	10	New	N/A
Ti	0	1	46	N/A	13	50 X	N/A
Zn	1	8	170	500	290	60 X	N/A

*Not detectable by ICP-AES N/A – Not Analyzed

As expected the sample results varied considerably due primarily to the unregulated parameters of cell operation such as temperature and slight variations in the method and protocols employed. It is however, quite apparent that there is consistent level of primarily metals showing up in these carbon arc cells that are well beyond that which could be explained in terms of cell contamination or impurities in the raw materials. Yields approaching 90 times the initial amount found in the water processed control sample were attained. The more typical yield was about 35 times the initial amount. In four cases no detectable material was found in the control sample indicating that all of the element was apparently new. The detection of small amounts of Boron would seem to indicate the possibility of an asymmetrical fission of Carbon. It should be noted that non-metalic elements may be present in significant amounts but cannot be detected by ICP-AES analysis.

Rough calorimetry tests performed on a preliminary basis would indicate that a single high current discharge yields higher energy, with a 60 kJ of input resulting in ~120 kJ of water heating (COP=2). In contrast, series arcing produced lower yields typically less than a COP of 1.5. These energy balance results are not however, regarded with much confidence due to the complex array of unknown reactions that are occurring including simple hydrocarbon combustions. True measurement of power is also difficult with sharp current spikes and less than stellar instrumentation. Calorimetry issues aside, the analytical data presents a compelling verification of previous experimental claims. Up to 10^{19} atoms of new material was formed in some cases. Accepting the analysis to be reliable, a literature review of advanced scientific concepts was conducted to determine if some explanation for these anomalous phenomena might exist. This review included the material covered earlier as theoretical background dealing with Zero-Point energy of Vacuum Fluctuations, the Casimir Effect, Condensed Charge clusters, Sonoluminescence and Cavity Quantum Electrodynamics.

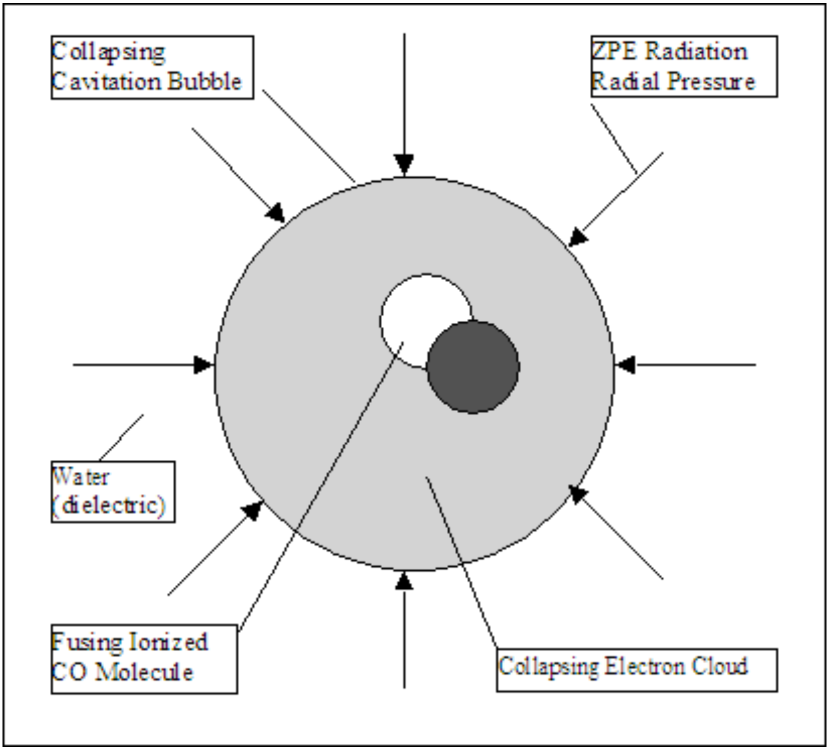
5 Discussion

Based on the initial constituents of the process and the analysis of the end products a lengthy list of nuclear fusion reactions are implicated, on a speculative basis as summarized in Table 2. The reactions are categorized as molecular, diatomic and atomic according to the reactants conjectured to be involved. Diatomic reactions would appear to be the most prevalent although none of these have been verified and a variety of other reactions are suspected. What follows is a simple qualitative description of two possible variants of how such reactions might occur constituting a new class of nuclear fusion based in the background material covered earlier. Other variants of the fusion process are possible but are not included hear to avoid unnecessary confusion at this early conceptual stage. The fundamental principle of all these, is that the high MeV energies that are presumed to be required to induce fusion, are obtained through a coherence of the random ZPE of the Vacuum fluctuations, "triggered" by the relatively small input energy of the plasma discharge and or cavitation bubble collapse.

ZIPP fusion in the particular case of the immersed carbon arc cell is thought to proceed according to the following simple process. Low voltage pulsed DC is applied across the carbon pellet electrodes arranged in series and immersed in light water as previously described. At a loose contact separation distance of less that 0.1 mm a plasma discharge occurs, releasing a sudden, momentary, high density surge of electrons in a confined manner through the water between the individual pellets, creating sparks that form void channels occupied only by electrons and a relatively small number of entrained ions. The void channels then break up into strings of microscopic cavitation bubbles. The combined ZPE induced Casimir effects of cavitation bubble collapse and high density electron flux condensation, then join forces in a momentary, localized coherence of the ZPE field as illustrated in Figure 1. This coherence gives rise to a force due to radiation pressure which literally squeezes the electrons and entrained ions within the low pressure cavity into what has been called an EV, effectively overcoming the inferior coulomb repulsion of the electrons The Ions imbedded in the EV are likewise compressed resulting in a form of condensed matter. Multiple plasma Ionizations of the embedded ions would also contribute substantially to the shrinkage of the atom.

Electrolysis of water is also happening between the electrodes forming hydrogen and oxygen. Some of the oxygen formed immediately oxidizes the carbon of the anode and the suspended residue, when ignited by the plasma, to form primarily carbon monoxide and carbon dioxide, some of which remains in solution. A wide variety of other gasses such as N_2 are also presumed to be present. This combination of dissolved gasses and carbon solids becomes ionized and entrained by subsequent plasma discharges forming electron filled microscopic bubbles that collapse to form an EV, compressing the ionized molecules and atoms into single large atoms of roughly equivalent atomic mass. The compaction of single CO molecules would appear to form Si and Al. Once condensed, the EV remains relatively stable as a tightly compacted cluster under the continuing influence of the ambient ZPE field allowing sufficient time for the squeezed, condensed ions to "gently" fuse into a new element. These newly formed ions remain embedded in the EV until it disintegrates on impact with the anode expelling carbon residue and releasing the fused ions. The vast majority of electrode consumption therefore takes place at the anode. Any excess protons are ejected to form hydrogen or alternatively, capture an electron to form a neutron, to establish a stable nucleon ratio. The released ions then recapture whatever electrons they require to satisfy their orbital requirements to form complete atoms. This process occurs repeatedly in a stochastic manner in response to the pulsing supply voltage, at a rate exceeding 1000 discharges per second. Heavier elements such as iron are formed as a result of a two-stage fusion process with diatomic forms of the lighter elements such as Al or Si serving as the precursors formed during the first fusion stage. This process can continue in successive stages with ever larger precursors to theoretical form any element. However, fusion of the heavier elements becomes more problematic as the nucleus builds up and is less apt to fuse in a definitive manner in the time available for the nuclear rearrangement to occur within the EV. Reactions involving heavier atoms would therefore tend to be less common and would involve asymmetrical reactants one of which is a much lighter element such as H or He. Carbon and oxygen having lower atomic masses, conveniently paired in a molecular form as CO, are well suited to the ZIPP fusion process. It should also be noted that other simple molecules such as C_2, CO_2, O_2 and O_3 appear to participate in this fusion process to form a wide range of predominantly metals. Some of these reactions are listed in Table 2 for consideration.

Figure 1: ZIPP Fusion Process



A less likely alternative to this two-step process is a single stage reaction involving a balanced tetrahedron composed of two CO molecules in close proximity to each other. For reasons related to molecular polarity and geometry, two CO molecules would naturally align themselves at right angles as they approach each other to form the points of a radially symmetric and stable tetrahedron. This would presumably be advantageous to the uniform radial compression by the ZPE field. Once the stable tetrahedron is formed the process of compression would continue unabated as the void cavity and electron cloud collapse until the four condensed ions are fused into a single large ion according to the process stated above. The product of this fusion reaction would be predominately Iron with two protons being prompt converted to neutrons through electron capture to satisfy the required nucleon ratio for stability. If this compression is not entirely uniform or too violent, additional protons may be scattered from the compacting nuclei yielding hydrogen and elements of lower atomic number such as Chromium. The excess energy yield of this process is apparently due to fusion, but from a more fundamental perspective, comes from the coherence of the ZPE of the vacuum.

The reason for the more prolific fusion that occurs in the first few minutes of arcing is believed to be primarily due to the more sintered appearance of the broken ends of the pellets that exists at the start of the experiment. These rough surfaces give rise to more powerfully focused plasma discharges and allow more water and gasses to be present in the discharge path. Once the faces become smoothed the space between pellets becomes diminished with a close fitting convex and mating concave surfaces, giving rise to weaker, dispersed plasma discharges. The amount of dissolved gas would also tend to peak early in the experiment before the cell heats up too much. Experimental runs using an ice bath appeared to give marginally better results. Seasonal variations in the yields of various elements are also suspected from minor Doppler effects caused by the earth's changing relative motion through the ZPF.

Given that coherence of ZPE appears to be the root cause of the ZIPP fusion process, it follows that the ZPF is the fundamental cause of the Strong force, through an ultra close range Casimir effect operating at the level of the nucleus which literally forces the nucleons together against the extremely high, but inferior coulomb repulsion of the protons. The nucleus is in effect held together from the outside by the force transferred to it from the continuous bombardment of the ubiquitous ZPF, not from within by some mysterious gluons as is generally now believed. There is also now compelling evidence that the same external pressure principles may apply at the molecular and macroscopic level also. A 50 year old controversy in material science requiring an ad hoc solution has recently been resolved by F. Grimer [14] by adopting the unorthodoxed view that materials are actually held together by external pressure, not internal attraction or "glue" like bonds as generally assumed.

The fusion reactions observed appear to necessitate a more definitive atomic structure that may be considerably different than that presently envisioned. The notion of an extremely small nucleus surrounding by a confusing milieu of orbital electrons fusing in any sort of predictable and discreet manner would seem extremely unlikely.

The properties of ZIPP Fusion are summarized as follows:

a) Products of ZIPP fusion are normally stable isotopes. Some very short-lived radionuclides may be formed, but have yet to be detected.
b) ZIPP fusion is aneutronic and without significant levels of other radiation such as gamma rays, alpha and Beta particles.
c) The high MeV energies required to overcome the Coulomb repulsion of the fusing nuclei is supplied from the coherence of the ZPE field via the combined Casimir effects of electron plasma condensation and cavitation bubble collapse within a dielectric or metalic fluid.
d) Ionization of the reactants by the plasma discharge is also important in promoting compaction of atoms to a form of condensed matter and eventual fusion.
e) Excess energy is attainable from the coherence of ZPE field via Casimir effects. Fusion is however not necessary to yield excess heat and may in fact reduce the amount of heat liberated due to efficient energy storage within the fusion products.
f) Fusion of relatively large atoms in a predictable manner is possible, implying a uniform smooth compression of discretely structure nuclei, as opposed to a high velocity impact of adhoc nuclei.
g) The fusing Ions are compressed while entrained in a collapsing electron plasma enclosed within a microscopic cavitation bubble.
h) If the compression process is too violent or not quite uniform, protons may be ejected from the fusing nuclei to form hydrogen. Hydrogen is released as both a fusion byproduct and also from the electrolysis of water.
i) Electron capture by the fusing ions to convert excess protons to neutrons is a common occurrence and is key to the production of stable isotopes without neutrons or radiation.
j) Some of the oxygen formed by electrolysis reacts with the carbon ignited by the plasma to form primarily carbon monoxide, some of which subsequently becomes entrained and ionized by the collapsing plasma to form fusion products.
k) CO and CO_2 formed from the oxidation of the anode and other simple molecules such as C_2, O_2, O_3, N_2, H_2 and Al_2 become involved in fusion reactions through subsequent entrainment in the cavitation bubbles formed by the condensing plasma.

l) Fusion products are usually formed from paired atoms of the reactants. The size and geometric configuration of fusing ions is important in promoting fusion. Reactants of similar size and arranged in a balanced, inherently stable configuration facilitate uniform compression. Diatomic elements and simple molecules such as CO are therefore particularly well suited to this form of fusion.

m) Fusion involving larger atoms tends to be asymmetric with the second reactant being substantially smaller.

Table 2: ZIPP Fusion Reactions (*Unconfirmed*)

Molecular Reactions	**Diatomic Reactions**	**Asymmetric Reactions**
${}_{6}C^{12}\,{}_{8}O^{16} \rightarrow {}_{14}Si^{28}$	$2\,{}_{14}Si^{28} \rightarrow {}_{26}Fe^{56}$ EC	${}_{25}Mn^{55} + {}_{1}H^{1} \rightarrow {}_{26}Fe^{56}$
${}_{6}C^{12}\,{}_{8}O^{16} \rightarrow {}_{13}Al^{27} + H$	$2\,{}_{14}Si^{30} \rightarrow {}_{28}Ni^{60}$	${}_{12}Mg^{24} + {}_{2}He^{4} \rightarrow {}_{14}Si^{28}$
${}_{6}C^{12}\,{}_{8}O^{16}{}_{2} \rightarrow {}_{20}Ca^{42} + 2H$	$2\,{}_{13}Al^{27} \rightarrow {}_{26}Fe^{54}$	${}_{15}P^{31} + H \rightarrow {}_{16}S^{32}$
$2\,{}_{6}C^{12}\,{}_{8}O^{16} \rightarrow {}_{26}Fe^{56}$ EC	$2\,{}_{13}Al^{27} \rightarrow {}_{24}Cr^{52} + 2H$	$2\,{}_{38}Sr^{84} + {}_{20}Ca^{40} \rightarrow {}_{82}Pb^{208}$ EC
$2\,{}_{6}C^{12}\,{}_{8}O^{16} \rightarrow {}_{24}Cr^{52} + 4H$	$2\,{}_{16}S^{32} \rightarrow {}_{29}Cu^{63} + H$ EC	${}_{6}C^{12} \rightarrow {}_{5}B^{11} + H$ (fission)
$2\,{}_{6}C^{12}\,{}_{8}O^{16} \rightarrow {}_{25}Mn^{55} + H$	$2\,{}_{16}S^{32} \rightarrow {}_{30}Zn^{64}$ EC	
$2\,{}_{8}O^{16}{}_{2} \rightarrow {}_{29}Cu^{63} + H$ EC	$2\,{}_{20}Ca^{42} \rightarrow {}_{38}Sr^{84}$ EC	
Atomic Reactions	$2\,{}_{6}C^{12} \rightarrow {}_{12}Mg^{24}$	
${}_{14}Si^{28} + {}_{6}C^{12} \rightarrow {}_{20}Ca^{40}$	$3\,{}_{8}O^{16} \rightarrow {}_{22}Ti^{48}$ EC	
${}_{8}O^{16} + {}_{11}Na^{23} \rightarrow {}_{19}K^{39}$	$2\,{}_{8}O^{16} \rightarrow {}_{16}S^{32}$	
${}_{8}O^{16} + {}_{7}N^{15} \rightarrow {}_{15}P^{31}$	$2\,{}_{8}O^{16} \rightarrow {}_{15}P^{30} + 2H$	
${}_{6}C^{12} + {}_{7}N^{15} \rightarrow {}_{13}Al^{27}$	$2\,{}_{6}C^{12} \rightarrow {}_{11}Na^{23} + H$	
${}_{12}Mg^{24} + {}_{8}O^{16} \rightarrow {}_{20}Ca^{40}$	$2\,{}_{1}H^{2} \rightarrow {}_{2}He^{4}$ (predicted)	

6 Conclusions and Recommendations

This data provides further compelling evidence of the reality of low energy induced nuclear reactions, which in concert with the results obtained by other research groups should by now be regarded as a simple fact despite the lack of theoretical understanding or the contradictions that arise with the existing paradigms in chemistry and nuclear physics. Low energy induced nuclear reactions would appear to occur with surprising abundance under special circumstances. Despite the proven value of Lavoisier's Law to the vast majority of conventional chemistry, it does not apply to these types of reactions, which combine aspects of both chemical and nuclear phenomena.

Low Energy induced nuclear fusion reactions are predictable and should be anticipated to occur in a variety of low energy systems. The primary reason that they are not widely observed and recognized is due to the simple fact that they are considered impossible according to presently accepted and well entrenched theories of both high energy physics and Lavoisier chemistry. The root cause of all such phenomena appears to be coherence of the otherwise random ZPE of the vacuum through resonance, interference and brute radiation pressure from the seething vacuum. The ZPE is in this view responsible for the stability of all matter on a continuous basis.

Existing Atomic theory based in the Bohr model is in obvious need of refinement if any progress is to be made on the theoretical foundations of low energy fusion reactions. Low Energy Fission reactions are also believed achievable provided the nucleus is parted in a concise manner using reversible variations of ZIPP Fusion and other processes.

To continue to describe such reactions as "low energy fusion" may not be appropriate in many instances as well as theoretically misleading. It would seem advisable instead to refer to them as "low energy induced fusion". Adding the qualifying term is proposed in the realization that the energy involved in such reactions may in fact be many orders of magnitude higher than that supplied to initiate the reaction or that which is actually observed. This energy comes predominantly from the active vacuum and remains internal to the process stored as the potential energy of the newly formed nucleus thereby avoiding detection as kinetic or heat energy. If heat energy is desired less efficient fusion configurations would appear preferable.

The effective application of such low energy induced nuclear reactions to the treatment of nuclear waste and a wide variety of other fields is essentially a given that is only limited by the lack of financial commitment and political will. In addition to variations of the ZIPP Fusion process, several other methods are proposed for investigation, some of which have actually progressed to the point of initial industrial application. A sampling of these various methods include:

- PHOTOREMEDIATION, which induces a form of NMR capable of inducing sub-critical fission and greatly accelerated decay rates through resonance of the nucleus using monochromatic gamma and hard X-rays.
- RIPPLE Fission, which utilizes a supersonic, ionized gas to aerosol heat exchanger, to envelope the radwaste aerosol in a vacuum induced plasma vortex, capable of disrupting the matter sustaining ZPF, resulting in production of stable light elements from heavy metals.
- SCALAR Interferometry, which utilizes the interference of scalar EM waves to modify and disrupt the matter stabilizing frequencies of the ZPF in a defined region of space resulting in greatly accelerated nuclear decay to stable end products.
- LENTEC electrolytic cells, which utilize High Density Electron Clusters (HIDEC) to induce nuclear reactions in the electrolyte and electrode materials.

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