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On Plausible Role of Classical Electromagnetic Theory and Submicroscopic Physics to understand and enhance Low Energy Nuclear Reaction (LENR): A Preliminary Review

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On Plausible Role of Classical Electromagnetic Theory and Submicroscopic Physics to understand and enhance Low Energy Nuclear Reaction (LENR): A Preliminary Review

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Abstract

In this paper we will discuss how we can study some effects associated with LENR from the principles of classical electromagnetic theory and also from a very new approach based on the submicroscopic concept of physics. Perhaps our considerations have their own risks because the majority of mainstream physicists consider nuclear fusion rather as a phenomenon associated with tunneling through a Coulomb barrier, which is a pure quantum effect. We will discuss that there are some aspects of Classical electromagnetic theories which may have impact on our understanding on LENR phenomena, including: a. nonlinear electrostatic potential as proposed by Eugen Andreev, b. vortex sound theory of Tsutomu Kambe, c. nonlinear ponderomotive force, and d. submicroscopic consideration.

Introduction

Since Pons & Fleischmann reported their experiments around 1989, many labs in the world tried to replicate their results, but many failed. Thereafter, there was a wave of rejection to their claim that table-top nuclear fusion at room temperature is possible. Some establishment physicists even called "cold fusion" idea as *pathological science*. But many non-mainstream physicists and chemists continued their works in underground manner. And some eminent physicists have taken risks to join this underground movement, including Prof. Hagelstein from MIT.

But the rejection of mainstream physics towards cold fusion/LENR remain strong. Even the famous Prof. Brian Josephson from Cavendish Lab in Cambridge University was denied access from arXiv server because of his endorsement to E. Storm's works. He went on to write a paper suggesting that such a denial of many successful experiments related to cold fusion/LENR can be called "*pathological disbelief*."

In this context, allow us to recall a story that was told to the first author (VC) several times by Dr. Iwan Kurniawan, a nuclear engineer from Indonesia.[1] When he was a doctoral student in a University in Japan around 1990s, his professor invited him to do experiment related to cold fusion in physics lab. After setting all the apparatus properly, they went home. In the morning, they were surprised that all the apparatus was blown up and it damaged the window glasses in lab. Dr. Iwan told VC that since then he concluded that cold fusion does not work as claimed by Pons & Fleischmann.

He is one of my good friends for a long time, and VC and him often discussed many things. But regarding his cold fusion experiment in lab, we got a different opinion: the fact that the apparatus blew the entire lab indicates that there was huge energy in the device, so huge that it damaged the window glasses. The problems appear to come from at least two aspects: a. poorly understood mechanism of the reaction, and b. the reactor failed to work properly. So, it is basically similar to reactor meltdown in a usual fission reactor. We need to learn what makes their cold fusion reactor failed. It is not because there is no energy inside the system, but it is really because there is so huge energy. Reactor shutdown has recently been admitted as one of the real problems in many LENR reactors, and this is a challenge for experimenters and companies who want to design commercial LENR reactors.[8-10]

However, in this paper we will not repeat such debates that have been discussed many times elsewhere. Instead we will discuss how we can study some effects associated with LENR from the principles of classical electromagnetic theory. We are aware that this approach has its own risks, because many physicists consider that nuclear fusion should be associated with tunneling through Coulomb barrier, and this kind of tunneling is a pure quantum effect. Is that true?

We will discuss that there are some aspects of Classical electromagnetic theories which may have impact on our understanding on LENR phenomena, including: a. nonlinear electrostatic potential as proposed by Eugen Andreev, b. vortex sound theory of Tsutomu Kambe, c. nonlinear ponderomotive force, d. submicrosopic consideration. Regarding ponderomotive force, it has been proposed recently by Lundin & Lidgren in order to understand the mechanism of LENR. [13][14]

It is our hope that this paper will motivate young electrical engineers to study LENR phenomena from new perspectives starting from classical electromagnetics theories. In

[1] Special thanks to Dr. Iwan Kurniawan for telling his first-hand experiment with cold fusion. Wishing you will be recovered soon, brother!

short, classical electromagnetic theories still offer many surprises to those who are willing to dig deeper into the hidden mysteries of Nature.

a. Nonlinear electrostatic potential of Eugen Andreev

In modern physics, there is a firm conviction based on the vast empirical material that:

- The electromagnetic and nuclear interactions are of a different nature;
- The field of electric charge (proton, electron) is spherically symmetric;
- The nucleon-nucleon forces depend on the direction.

In his paper, Andreev [1] suggested a hypothesis that the notion of the nuclear interaction could be interpreted as a nonlinear distribution of the electrostatic potential, which manifests itself at the Fermi scale. An analytical form of the potential of the proton is proposed, which coincides with conventional forms used in the nuclear physics at a short scale, but becomes the usual Coulomb potential at a large scale.

The model potential possesses a set of properties that could be called "*nuclear van der Waals forces*."

Coulomb's law can be written in integral form as follows:[1]

$$\varphi(x,y,z)=\frac{k\varphi}{R}=-k\iiint_{v}\frac{div(\nabla\varphi(x,y,z))dV}{\sqrt{(x^2+y^2+z^2)}} \tag{1}$$

If we replace R with R_{dd}, which is defined as follows:

$$R_{dd}=\sqrt{x^2+y^2+\beta^2 z^2+r_o{}^2} \tag{2}$$

Then we will have a two parameter field potential: [1]

$$\phi(x,y,x,\beta,r_0)=\frac{\phi}{R+r_0}, \tag{3}$$

Or

$$\phi(x,y,z,\beta,r_0)=[\varphi].\left(\frac{k_1}{R_{dd}}+\frac{k_2}{|R_{dd}|^2}\right) \tag{4}$$

As a result, we have obtained an explicit analytic form of the *electronuclea*r potential of a proton:[1]

$$\phi_{(proton)}=\frac{r_0}{\sqrt{(x^2+y^2+2z^2+r_o^2)}}+\frac{dz.r_0^2}{(x^2+y^2+2z^2+r_o^2)} \tag{5}$$

Thus, the general form of the potential well, due to the specific distribution of the charge density inside the proton, reminds us to the *van der Waals interaction*.

The above result is quite significant, because it explained Coulomb barrier suppression starting from classical electromagnetics theory. Furthermore, Andreev has shown that PP potential as described above can be compared with:[1]

- Lennard-Jones potential (resulting from the van der Waals interaction):

$$V_{LJ}=\frac{0.01}{r^{12}}-\frac{1}{r^{5}} \tag{6}$$

- Reed potential:

$$V_{Reed}=-10\frac{e^{-r}}{r}-1650\frac{e^{-4r}}{r}+6484\frac{e^{-7r}}{r} \tag{7}$$

b. Vortex sound theory of Tsutomu Kambe [2][3][4]

The above electronuclear potential starts with electrostatics/Maxwell equations. Now it is very interesting to remark here that Prof. T. Kambe from University of Tokyo has made connection between equation of vortex sound and fluid Maxwell equations.

He wrote that it would be no exaggeration to say that any vortex motion excites acoustic waves.

He considers the equation of vortex sound of the form: [2]

$$\frac{1}{c}\partial_t^2 p-\nabla^2 p=\rho_0\nabla.L=\rho_0 div(\omega\times v) \tag{8}$$

He also wrote that dipolar emission by the vortex-body interaction is:[3]

$$p(x,t)=-\frac{P_0}{4\pi c}\pi_i(t-\frac{x}{c})\frac{x_c}{x^2} \tag{9}$$

Then he obtained an expression of fluid Maxwell equations as follows:

$$\begin{aligned}&\nabla\cdot H=0\\&\nabla\cdot E=q\\&\nabla\times E+\partial_t H=0\\&a_0^2\nabla\times H-\partial_t E=J\end{aligned} \tag{10}$$

Where :

a_0 denotes the sound speed, and

$$
\begin{aligned}
q &= -\partial_t(\nabla \cdot u) - \nabla \hbar, \\
J &= \partial_t^2 v + \nabla \partial_t h + a_o^2 \nabla \times (\nabla \times v)
\end{aligned} \tag{11}
$$

To our opinion, this new expression of fluid Maxwell equations suggests that there is deep connection between vortex sound and electromagnetic fields. Therefore, it may offer new ways to alter the form of electronuclear potential as described in the previous section.

For octonic formulation of fluid Maxwell equations, see [15]. For alternative hydrodynamics expression of electromagnetic fields, see [16].

c. Nonlinear ponderomotive force

According to Brechet et al. [6], a ponderomotive force results from the response of inhomogeneous matter fields to the presence of electromagnetic fields. Ponderomotive forces are generally overlooked since the electromagnetic community is not much concerned with continuum mechanics and the continuum mechanics community is not dealing usually with electromagnetic systems.

The nonrelativistic ponderomotive force as proposed by Miller (1958) is as follows: [7]

$$F = m\bar{\ddot{r}} = -\frac{q^2}{4m\omega^2}\nabla\left|\vec{E}(r,t)\right|^2 \tag{12}$$

Equation (12) can obviously be derived from the ponderomotive potential:

$$\phi_{(p)}(r,t) = \frac{q^2}{4m\omega^2}\left|\vec{E}(r,t)\right|^2 \tag{13}$$

Other than Miller's force, there are other types of ponderomotive forces ee: [5]

- Abraham force (1903),
- Barlow (1958),
- Lundin & Hultqvist (1989),
- Bolotovsky & Serov (2003).

It can be noted here that the Miller force is independent of wave frequency for $\omega^2 << \Omega^2$ and **attractive** for the entire frequency range below resonance. The Miller force is **repulsive** at frequencies above resonance, but decays strongly at higher frequencies.

Ponderomotive forcing by electromagnetic waves is capable of causing attraction of solid bodies.

Brechet et al. [6] discuss electromagnetic force density of magnetoelectric ponderomotive force, which is different from Miller's force.

In a recent paper, Lundin & Lidgren proposed that Miller ponderomotive force may offer an explanation to nuclear spallation as observed in some LENR experiments. Although their study is not yet conclusive, it opens an entirely new way to discuss LENR from purely classical electromagnetic theory.

d. Submicroscopic consideration

In monograph [11] it was presented a detailed structure of physical space (or a vacuum, ether), which is based on pure mathematical principles – set theory, topology and fractal geometry. The study shows that matter appears from a primary substrate that has a structure of a mathematical lattice named the tessellattice. Thus all massive particles as well as electrically charged particles emerge from the tessellattice as local distortions of its cells. At the motion such anamorphosis has to interact with the tessellattice, which is neglected in quantum mechanical, quantum field and electromagnetic theories. The bulk fractal deformation of a cell of the tessellattice is associated with the notion of mass; thought the surface deformation of a cell is related to the electric charge. Hence two kinds of equations should appear: one system of equations describes the behavior of a massive particle and one more system of equations depicts the behavior of the electric charge. The first system is quite new and presented in book [11] and it is related to the quantum mechanical formalism; the other system is reduced to the conventional Maxwell equations, which is also illustrated in book [11].

It has been demonstrated [11] that the interaction of a moving particle with the tessellattice results in the generation of a new kind of quasi-particles named 'inertons'. These inertons are carriers of massive properties of particles and they play in some sense the role of hidden variables introduced in physics by de Broglie, Bohm and Vigier. Inertons exchange by mass, speed and hence momentum and kinetic energy with the particle that generates them. A section of space known as the particle's de Broglie wavelength λ is the spatial amplitude of the particle. it is a section, in which the particle initially generates inertons and passing the whole kinetic energy to the generated cloud of inertons finally stops; then in the next section λ inertons guide the particle passing on to it their velocity, mass, momentum and kinetic energy.

The particle's inerton cloud together with the particle, which exist in the real space, are projected to the quantum mechanical formalism, which was developed in a phase space, as the particle's wave ψ-function. Thus, in a solid each atom is surrounded with its inerton cloud; the same for each free electron, proton or another canonical particle.

In the recent experiment [12] in a chamber filled with a gas a discharge has been generated. Positive ions of the gas reached the cathode where they interacted with atoms of the electrode made of tungsten. If the gas is hydrogen, discharges produce free protons in it. Reaching the cathode, protons interact with a metal matrix in such a way, that at the resonance conditions, i.e. when the momenta of the interacting atom and proton are coincide by the absolute value and have opposite directions, i.e. the proton impacts the tungsten atom being in antiphase oscillating in its site of the crystal lattice, both particles must stop, $m_{\mathrm{p}}\vec{u}_{\mathrm{p}} + m_{\mathrm{W}}\vec{u}_{\mathrm{W}} = 0$. This condition means that the proton knocks out the tungsten's atom inerton cloud.

One of free electrons available at the surface of the electrode absorbs the tungsten atom's inerton cloud and also traps a proton. The merging of the heavy electron with the proton results in the creation of a super heavy hydrogen atom. In this system the reduced mass of the proton and the electron is almost equal to m_{p} (in fact $1/m_{\mathrm{p}} + 1/(m_{\mathrm{e}} + m_{\mathrm{W}}) \cong 1/m_{\mathrm{p}}$). Therefore the proton starts to rotate around the heavy electron; the Bohr radius for the rotating proton is

$$r_{\text{p-e}} = \frac{4\pi\varepsilon_0 \hbar^2 n^2}{e^2 m_{\mathrm{p}}} = 2.88 \times 10^{-14}\ \mathrm{m}, \tag{14}$$

where we put $n = 1$. Though the electron orbit (14) deeply penetrates into the middle of the proton, the electron still does not reach the critical distance of 2×10^{-14} m that characterizes the quark orbit inside the proton [11]. If we put $n = 2,\ 3$, the radius (14) will be larger but still in the order of femtometers.

What is interesting, these small atoms named subatoms [12] behave like neutrons, namely, neutron detectors measured the presence of neutrons in the experiment conducted. We [12] were able to generate subatoms, such as subhydrogen and subhelium (in a helium atmosphere), which were perceived by the neutron detector as real neutrons. The intensity of the measured "neutron" radiation was rather significant; the maximum value measured by the detector was 3×10^5 neutrons/($\mathrm{cm}^2 \cdot$min). Nevertheless, the real intensity could even be 5 orders higher. Besides, analyzing our experiments, we came to the conclusion about the existence of other tiny systems: subdeuterium, neutral {deuteron + subhydrogen} pair, and neutral {deuteron + subhelium} pair.

Many other researchers reported about similar very small stable atoms, or combined particles, though were unable to explain their structure and properties.

All these nuclear systems had the size around several units of 10^{-14} nm. They can be generated artificially in a chamber filled with a gas. When in the chamber a discharge is generated, positive ions of the gas reaches the cathode where they interact with atoms of the electrode, typically made of tungsten.

When we launch the production of subatoms and the mentioned nuclear pairs, at the high intensity of these entities we are able to anticipate the real transformation of nuclei in the system studied. Indeed, tiny subatoms and nuclear pairs (with the size $\le 5 \cdot 10^{-14}$ m) can easy to penetrate a shell of electrons around each atom, which have a size around 10^{-10} m.

In other words, a subatom or nuclear pair moving to the nucleus of the atom studied will pierce the electron shell similarly to a spaceship that is travelling in our solar system. Any electron of the electron shell cannot experience this pinhole because of the incommensurability of the sizes of tiny particles and electron orbits.

Approaching a nucleus, a subatom or nuclear par starts interacting with nuclides: a subatom brings to the nucleus a thermal proton (deuteron or α particle), the inerton cloud and electron. The electron will be getting away from the nucleus because it does not participate in nuclear reactions. But the proton (deuteron or α particle) will bring an additional interaction inside the nucleus, which has to result in its mutation.

In fact, studying samples of iron and samples of water contaminated with Cesium-137 we [11] revealed significant mutations in iron (in which emerged such elements, as Co, Ni, Ca, Hf, Cs) and decrease in radioactivity of the water sample up to 30-40% at the application of an inerton field. It seems in those experiments initially subatoms had formed that then influenced nuclei of Fe (in samples of iron) and nuclei of Cs-137 (in samples of water contaminated with radioactive cesium).

Discussion & Concluding Remarks

We have discussed a new expression of electronuclear potential starting from electrostatics law. This explains Coulomb barrier suppression from purely classical origin, without the use of nuclear potential such as Woods-Saxon potential. The model potential possesses a set of properties that could be called "*nuclear van der Waals forces*." In our opinion, this is a quite surprising result that offers a novel way to explain low energy nuclear reaction (LENR) from Classical Electromagnetic theories.

Moreover, Kambe's new expression of fluid Maxwell equations suggests that there is deep connection between vortex sound and electromagnetic fields. Therefore, this result may offer a new insight on how to alter the electronuclear potential using vortex sound equation. This requires further investigations.

In a recent paper, Lundin & Lidgren proposed that Miller ponderomotive force might offer an explanation to nuclear spallation as observed in LENR experiments. Although their study is not yet conclusive, it opens an entirely new way to discuss LENR from purely classical electromagnetic theories.

The electrostatic/electronuclear potentials, fluid Maxwell equations and ponderomotive force have been proposed as an alternative to tunneling effects that could occur at a quantum mechanical consideration of LENR. However, in section d we have shown that the tunneling effect itself can be considered in deeper terms, namely from the submicroscopic point view. This is a quite new approach to the description of physical phenomena, which however, promise a lot in both our understanding of mysterious phenomena of nature and the modeling of some crucial experiments, such LENR or similar.

As follows from the submicroscopic concept, LENR can be possible only in the case when subatoms or nuclear pairs emerge in the system studied. An efficiency of LENR is directly proportional to the quantity of generated subatoms and nuclear pairs. That is why it seems to reach the highest efficiency in LENR can be possible at the following two main conditions: (i) in a reaction chamber one has to increase the number of subatoms and nuclear pairs to the value of no less than 10^{12}; at this quantity of deuterons in a macroscopic sample reactions $d + d =$ He produces heat comparative to a room temperature; (ii) there should be invented a mechanism(s) that would stimulate collisions of subatoms and nuclear pairs with potential targets and between themselves.

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