AIAA SciTech Forum
7-11 January 2019, San Diego, California
AIAA Scitech 2019 Forum

10.2514/6.2019-0869

Room Temperature Superconducting System for use on a Hybrid Aerospace-Undersea Craft

Salvatore Cezar Pais[1]
Department of the Navy, NAVAIR/NAWCAD, NAS Patuxent River, MD. 20670

The subject matter of this paper describes the design of an active room temperature superconductor, to be incorporated within the Hybrid Aerospace-Undersea Craft (HAUC), described in a recently published paper - Pais, S., "A Hybrid craft using an inertial mass modification device," AIAA 2017-5343 conference paper, AIAA SPACE Forum, 2017. It is envisioned that the electrically charged outer surfaces of this craft, which under accelerated vibration allow for inertial mass modification of the HAUC craft, are of the room temperature superconducting type. A theoretical argument is presented for achieving room temperature superconductivity (RTSC) in a current-carrying special composite metal wire. This concept enables the transmission of electrical power without any losses, which leads to the design and development of novel energy generation and harvesting devices with important benefits to civilization.

Simply put, RTSC can be enabled in a current carrying special composite metal wire which is abruptly vibrated by mechanical or electrical means. The wire is composed of a bulk (core) insulator with a 'thin' coating of a normal metal (such as Aluminum), of a thickness on the order of the London penetration depth (but possibly much thicker), given an externally applied magnetic field. For the electrically-driven vibration, the wire is coated with lead zirconate titanate (PZT ceramic / poor metal), or any other material in which the Piezoelectric effect can be induced. Since the RTSC supercurrent may be generated along the metal/insulator interface (boundary), this wire configuration may be termed an unconventional superconductor. Current is pulsed through the wire at the resonance vibration frequency.

It is theoretically observed that the superconducting charge carrier mass is inversely proportional to the vibration frequency squared and that the diamagnetism exhibited by the room temperature superconductor is enhanced with increasing frequency of vibration.

I. Introduction

A room-temperature superconductor is a material that is capable of exhibiting superconductivity at operating temperatures of or above 25 deg. C (approx. 300 deg. K). Several materials have been reported to be room-temperature superconductors, although none of these reports has been confirmed nor properly acknowledged by the mainstream condensed matter physics community. However, the concept at hand argues that, instead of concentrating on the chemical structure of such materials which do not utilize any electrical or mechanical manipulation, room temperature superconductivity (RTSC) in a manipulated current-carrying special composite wire may be achieved.

Used for the electrically charged surfaces of the HAUC craft, such room temperature superconductors can give rise to very high Q-factors (namely the ratio of energy stored divided by energy lost is extremely high), which greatly modifies the quantum vacuum state energy density in close proximity to the craft so as to generate the macroscopic quantum coherence effect necessary for inertial mass reduction and hence propulsion of the craft (AIAA 2017-5343).

The fact that no cryogenic fluids need to be carried on the hybrid craft in order to induce superconductivity is highly desirable from a craft weight minimization perspective.

The achievement of room temperature superconductivity (RTSC) represents a highly disruptive technology, capable of a total paradigm change in Science and Technology, rather than just a paradigm shift. Hence, its military and commercial value is considerable.

---

[1] Aerospace Engineer, NAWCAD Air 4.3.5.1, B. 2187 NAS Patuxent River, MD. 20670 - AIAA member

It is important to realize that internal heating within any system enclosure can be greatly reduced by room temperature (300 deg. Kelvin and higher) superconducting wiring, which would allow for lossless transmission of electrical power to its subsystems.

There are three parameters which affect superconductivity, namely temperature, current density, and externally applied magnetic field strength. Physically, these parameters have in common one thing, that is, the interactive motion of electric charges, namely electrons [1].

Control of this motion via vibration and/or spin of charged matter subjected to rapid acceleration transients (highly non-linear in nature) may lead to the achievement of room temperature superconductivity, especially if the charged matter is inhomogeneous.

At the present time, it is believed that the mechanism of superconductivity can be induced either by bipolarons [2, 3] or Cooper pairing [1]. The important realization is that independent of physical mechanism, the key to observed superconductivity is the strong electron-lattice (phonon) coupling [4]. Strong electron-lattice interaction can be obtained from abrupt / accelerated vibration of a wire, thereby providing justification for our argument on the possibility of RTSC enablement.

What if all you need to do, in order to make a special composite metallic wire be superconductive (SC) at room temperature, is to make it abruptly vibrate, while running a pulsed current through it, just like ‘plucking’ a guitar string, intermittently. The current must be pulsed for maximum effect, moreover the current is pulsed through the wire at the resonant vibration frequency.

II. Hybrid Aerospace-Undersea Craft (HAUC)

As described in paper AIAA 2017-5343, it is possible to envision a hybrid aerospace-undersea craft (HAUC), which can function as a submersible craft capable of extreme underwater speeds (lack of water-skin friction) and enhanced aerial / underwater stealth capabilities (non-linear scattering of RF and sonar signals). This hybrid craft would move with great ease through the air/space/water mediums, by being enclosed in a Vacuum /plasma bubble/sheath, due to the coupled effects of EM field-induced air/water particles repulsion and Vacuum energy polarization. The HAUC is conical in configuration, with an elliptical cross-section, similar in geometry to a hypersonic glide vehicle / dart.

Controlled motion of electrically charged matter (from solid to plasma) via accelerated spin and/or accelerated vibration under rapid (yet smooth) acceleration-deceleration-acceleration transients can result in high intensity electromagnetic energy flux, which can modify the energy density of the vacuum energy state in close proximity to the hybrid craft, resulting in local vacuum modification, and hence inertial mass reduction of the moving craft. The HAUC utilizes microwave-induced vibration within a resonant annular cavity, whose outer surface is electrically charged while being vibrated.

The manner and effectiveness with which the microwave energy couples with the resonant cavity wall is called the cavity Q-factor. This parameter can be written as the (Energy stored / Energy lost) ratio and is in the range of 10^4 to 10^9 (and beyond), depending on whether ordinary metal (Aluminum or Copper at room temperature) or cryogenically cooled superconducting material (Yttrium Barium Copper Oxide or Niobium Germanium) is used for the resonant cavity wall and outside mold line skin of the aerospace vehicle. In the present paper RTSC wiring is the superconductor of choice, with no need for cryogenic cooling.

Optimal vibration of the hybrid craft’s electrically charged outer surface (skin) can be achieved by using high EM energy emitters operating at 100 Terahertz (and higher) frequencies – think confined Photoelectric effect. Moreover, the HAUC skin can have imbedded polycrystalline materials which strongly exhibit the Piezoelectric effect (namely mechanical deformations of an oscillatory nature) when an electrical current is passed through them, such as PZT or Barium Strontium Titanate. Alternatively, the hybrid craft’s charged skin can be vibrated with high frequency sound generators.

The high energy/high frequency electromagnetic radiation responsible for the inertial mass reduction effect produces a repulsive EM energy field while in earth’s atmosphere, thereby repelling air molecules in the path of the hybrid craft’s ascent/flight. Consequently, once in orbital space, due to local vacuum polarization, a repulsive gravity effect (recall the negative pressure (-P) of the polarized vacuum condition, which can be readily observed from a First Law of Thermodynamics treatment: dE = TdS – PdV; standard textbook nomenclature), would permit swift movement of the HAUC beyond our Solar System. As discussed in AIAA 2017-5343, a plurality of microwave antennas (high radio frequency emitter sources) in the electromagnetic (EM) spectrum range of 300 Megahertz to 300 Gigahertz can be arranged within the annular duct - resonant cavity (surrounding the crew compartment and powerplant system, which would be guarded by a Faraday-type cage, against all EM radiation effects).

An auxiliary propulsion unit (possibly Plasma Compression Fusion-generated), would provide the initial HAUC thrust and electrical power generation. Furthermore, if the annular resonant cavity duct is filled with a noble gas such as Xenon (possibly seeded with ferro-electric particulates such as Barium Titanate), the microwave energy collision with the gas/solid particulates will induce a plasma state of matter (further augmenting the oscillatory vibrations experienced by the resonant cavity inner wall), thereby creating a highly non-linear environment (phase transitions / abrupt changes of state from gas to plasma, which induce symmetry breaking) which will intensify the Prigogine effect (“Order from Chaos”) [11]. This will enable the coherence of physical vacuum fluctuations in the proximity of the outer mold line skin (electrically charged, RTSC-type) of the hybrid craft, in this manner assuring a high degree of vacuum polarization.

In summary, HAUC alters the local vacuum energy density in the vicinity of its electrified vibrating skin, thus modifying the local Spacetime fabric at the microscopic / discrete quantum level, This foundational concept brings to life the profound statement made by John Archibald Wheeler in regard to Einstein's Relativity Theory which now evolves into: ***Energy Density tells Spacetime how to fluctuate, and Spacetime tells Energy Density how to propagate.***

III. Proposed Room Temperature Superconductor (RTSC)

The special composite metal wire is composed of a bulk (core) insulator (such as Teflon, or any other non-conductive polymer) with a ‘thin’ coating of a normal or poor metal (such as Aluminum (Al) or PZT ceramic), of a thickness on the order of the London penetration depth (but possibly much thicker, based on experiments to be performed), given an externally applied magnetic field. Arguably, this wire configuration may be termed an unconventional superconductor, since the RTSC supercurrent may be generated along the interface (boundary) between the normal metal and the insulator portions of the wire.

This is due to the abrupt change in state between the normal metal portion of the wire and the insulator section, analogous to an abrupt phase transition occurring along the metal/insulator interface, which spontaneously breaks symmetry and thereby induces superconductivity [5]. This abrupt change in state (phase transition) occurs as the wire is abruptly vibrated and occurs at the boundary between the metal and the insulator portions of the wire, as various states of charged (metal) and non-charged (insulator) matter are thrown into a state of coherent superposition.

The expression for the London penetration depth ($\boldsymbol{\lambda}_L$) can be written as:

$$\boldsymbol{\lambda}_L = [m_S / (\mu_0 n_S q_S^2)]^{1/2} \tag{1}$$

Given that the superconducting charge carriers (of mass m_S, where μ_0 is the magnetic permeability of free space) are electrons ($q_S = e$, electron charge), with a number density of superconducting charge carriers (n_S) on the order of 10^{20} / cm^3 (endemic of unconventional superconductors such as YBCO), the London penetration depth, and hence the thickness of the metallic (coating) portion of the wire is on the order of micron(s), however this thickness could be much greater, as possibly determined by experiments to be performed in order to verify the RTSC concept at hand. As discussed in reference 14, the London penetration depth would be (much) greater than the coherence length (size of Cooper pairs) for high temperature superconductors, hence the chosen (possible) thickness of the ‘metal’ coating for our unconventional (topological) RTSC wire.

Consider an experimental set-up at standard room temperature and pressure, where the current carrying Al-coated wire (in a cylindrical configuration) is mechanically vibrated in an abrupt / accelerated manner, by being struck with a non-conductive element, such as a Teflon pick, in order to generate accelerated vibrations.

A more effective means of vibrating a wire in tension is by use of an electromagnetic (EM) plucking coil located in close proximity to the wire [6, 7]. The coil is rapidly energized and de-energized using either DC or AC current. The magnetic flux couples with the wire which is composed of a magnetically permeable material, such as steel. In our case, the composite wire coating can be doped with ferrite inclusions, such as but not limited to iron or steel.

For the composite wire, the Al-coating can be doped with sub-micron sized ferrite particles so that is becomes highly responsive to the EM forces exerted by the plucking coil. However, this EM method of vibration may not be conducive to RTSC, since the mechanically-plucked AL-coated composite wire may fail the Meissner effect test for superconductivity, and not be able to expel the flux lines of the externally applied magnetic field.

Further consider the electrically-driven vibration version of this idea, whereby a non-Al coated wire is abruptly vibrated by having an electrical potential difference applied along its lead zirconate titanate (PZT) coating, thus inducing wire vibration via the piezoelectric effect. Coupling of both mechanical and non-mechanical vibrations in an accelerated vibration mode subjected to rapid acceleration transients can be considered for possible amplification of system non-linarities.

Moreover, it has been shown that micrometer-size PZT thin film deposits can excite high vibration frequencies, exceeding 100 MHz [8], which would generate high EM fluxes in an outward direction, from the surface of the current-carrying composite wire. This method of vibration would be greatly conducive to superconductivity, since enablement of the Meissner effect would be possible. The current through the wire can be pulsed for maximum effect.

There are three characteristics that a material must possess in order to be superconductive, a state of matter which constitutes a macroscopic quantum phenomenon, thus occupying a unique place in condensed matter physics. These are perfect diamagnetism (the Meissner effect), perfect electrical conductivity (zero electrical resistance) and macroscopic quantum coherence, namely the ability of all the constituent particles in a superconductor to fall into lock step and move in an organized orderly fashion, in other words to form a giant matter wave [9].

IV. Mathematical Formalism of RTSC Concept

Consider the fact, that in a superconductor, the introduction of an electric field will accelerate the superconducting charge carriers (electrons). This can be represented by the phenomenological London theory, by using a simple Newtonian formalism, which can be expressed as:

$$d\mathbf{J} / dt = [(n_s q_s^2)/m_s]\, \mathbf{E} \tag{2}$$

, where **J** is the current density, and **E** is the applied electric field.

Since we can write $\mathbf{J} = n_s q_s \mathbf{v}$, where **v** is the velocity of the electrons, given the fact that for accelerated vibration we have $(dv/dt)_{max} = R_\omega \omega^2$, where R_ω is the vibration amplitude and ω is the angular frequency of vibration (given a simple harmonic motion treatment).

Therefore, from equation 2, we obtain the relation:

$$m_s \sim q_s^2 / \omega^2 \tag{3}$$

This expression indicates that if the superconducting wire is vibrated then the superconducting charge carrier mass is inversely proportional to the vibration frequency squared. Thus as the vibration frequency is increased the mass of the SC carriers will decrease, which means that the electron transport through the ion lattice is facilitated to a very high degree as the wire is accelerated in vibration. It can be argued that for high vibration frequencies this is analogous to zero electrical resistance.

Furthermore, combining equation 2 with Faraday's Law written as [curl **E** = (- d**B**/dt)], where **B** is an externally applied magnetic field, we obtain:

$$[m_s / (n_s q_s^2)] \; \text{curl } \mathbf{J} + \mathbf{B} = 0 \tag{4}$$

Taking into consideration expression 3 and the fact that (curl **J** ~ ω) since (**v** ~ R_ω ω), we can argue that the diamagnetism exhibited by the room temperature superconductor is enhanced with increasing frequency of wire vibration. In other words, the magnetic flux which the superconductor generates in order to expel the magnetic field lines of an externally applied **B**-field, is inversely proportional with the vibration frequency, namely you need a smaller generated flux to combat the applied magnetic field, with increased vibration. Thus the first two requirements for superconductivity, namely zero electrical resistance and the Meissner effect are met by accelerated vibration of a wire which exhibits a voltage potential difference along it, namely is subjected to an applied electric field.

The third requirement for superconductivity, namely the enablement of macroscopic quantum coherence is best described by the conventional BCS (Bardeen, Cooper, and Schrieffer) theory, as follows. As the current courses along the wire, the lattice ionic vibrations (phonon interactions) will create an attractive force between electrons (of opposite spin and momentum), which normally want to repel one another (Coulomb interaction). Thus electron pairs, named Cooper pairs will be formed which will subsequently condense into a single quantum mechanical state, represented by a unique wave function. This is equivalent with macroscopic quantum coherence and can be further exemplified by the creation of the 'supercurrent' in the 'gap' material of a Josephson junction.

In our case, under room temperature conditions the thermal agitations (fluctuations)-induced lattice vibrations will couple with the artificially induced (by purely mechanical or piezoelectric means) vibrations of the lattice ions, produced by the abrupt (accelerated) vibration of the wire, to generate a virtual 'soup' of fluctuations, a highly non-linear, far-from-equilibrium environment in the metal portion of the wire.

It is a well-known facet of quantum field theory that everything can be described in quantum mechanical terms. The complex interactions between a physical system and its surroundings (environment), disrupt the quantum mechanical nature of a system and render it classical under ordinary observation. This process is known as decoherence [10].

However, it is argued that we can retard (delay) decoherence (and possibly even suppress it – namely decouple a physical system from the environment) by accelerated spin and/or accelerated vibration of electrically charged matter under rapid acceleration transients. This may be the very condition to achieve a state of macroscopic quantum coherence, the idea being that we never let the system achieve thermodynamic equilibrium, by constantly delaying the onset of relaxation to equilibrium (hence the production of maximal entropy is delayed). The system may "violently" react by generating "anomalous" emergent phenomena, such as room temperature superconductivity.

Enter the Prigogine effect, as described in reference 11, on page 316. The Prigogine effect teaches us that under three conditions, a chaotic system – the aforementioned 'soup' of fluctuations, can self-organize into an orderly state, equivalent to the state of macroscopic quantum coherence. These conditions are the existence of a highly non-linear medium, an abrupt departure far-from-thermodynamic equilibrium, and last but not least, an energy flux (caused by the intermittent abrupt vibration of the wire) to maintain the process of self-organization (Order from Chaos). All three conditions are met in our current application, thus it can be argued that a path toward room temperature superconductivity is herein established and possibly enabled.

It may be possible that the key to superconductivity (and especially RTSC) is the enablement of local macroscopic quantum coherence, namely the ability of a macroscopic object to act as if quantum mechanical in nature exhibiting such phenomena as superposition, entanglement, tunneling.

In summary, one can argue that the 'synthesis' of three physical mechanisms, namely the Meissner effect, the Cooper effect (or bipolaron formation), and the Prigogine effect leads directly to the possibility of room temperature superconductivity, at least in a special composite metal wire. Therefore, it can be argued that the RTSC super-current may be generated along the interface (boundary) between the normal or poor metal and the insulator portions of the wire.

To enforce our argument from an experimental perspective, a recently published paper [12], shows that "by exciting metallic K_3C_{60} (potassium doped fullerene) with mid-infrared optical pulses, we induce a large increase in carrier mobility, accompanied by the opening of a gap in the optical conductivity"; thus showing the importance of non-equilibrium phenomena in effecting high T_c superconductivity (T_c being the ctritical temperature below which superconductivity occurs).

Even though Fullerene is not a normal or poor metal, the pulsed light induced high T_c superconductivity is shown to be a direct result of the driving non-equilibrium dynamics, which our argument considers as essential for achievement of RTSC. Experimentally, we may replace the normal metal portion (coating) of the wire with Graphene, and observe under what conditions, if at all, RTSC is obtained.

V. Novel Interpretation of E = mc^2

In another order of ideas, if we consider the ubiquitous equation ($E_T = mc^2$), where E_T is the total energy associated with an object of mass m and c is the speed of light in free space (vacuum), then coupling this relationship with a Maxwellian electrodynamics formalism, we can write:

$$m / E_T = \{[\mu_0 \mu H^2] [\varepsilon_0 \varepsilon E^2]\} / (E^2 H^2) \qquad (5)$$

, where [$c^2 = 1 / (\mu_0 \mu \varepsilon_0 \varepsilon)$], such that μ_0 and μ are the vacuum and non-vacuum magnetic permeabilities and ε_0 and ε are the vacuum and non-vacuum (dielectric constant) electric permitivities, respectively; in this case c is the speed of light in a non-vacuum medium (that is μ and ε are not equal to 1).

Given the fact that (S = EH), where S is the magnitude of the Poynting vector (EM energy flux), E and H are the electric and magnetic field strength respectively, and further taking into consideration that S is directly proportional to the angular frequency of spin or vibration (ω), as depicted in equation 1 of reference 11, then we can write:

$$m / E_T \sim 1 / \omega^2 \qquad (6)$$

which reinforces the finding of equation 3, namely that the mass of an object is inversely proportional with the object's spin or vibration frequency squared.

Since the numerator of equation 5 is the total electromagnetic energy density (stored in the locality of the object of mass m) squared, and the denominator is the total electro-magnetic energy flux (out of the locality of the object of mass m) squared, then Einstein's (originally Poincare's) famous equation for electromagnetic mass takes on a very special representation of an object's total mass, as related to the non-linear flux of electromagnetic energy from the total electromagnetic energy density stored in the object's spatio-temporal locality.

VI. Enablement of Inventive Concept

Electron pairing is the keystone of superconductivity, without which its physical mechanism cannot stand. At high temperatures it is only the moderately strong non-linear electron-phonon (lattice vibrations) interactions that can induce electron pairing [14]. Arguably, given the fact that a superconducting condensate is an electrically charged superfluid and that the foundational structure of the Cosmos (the vacuum energy state) is superfluid in nature [13], it may be possible to render ordinary matter as superconducting via electrodynamic manipulation.

Moreover, it may be possible that the electron pairing mechanism is not caused by an electron-phonon (phononic) coupling but by an electron-electron (electronic) coupling, which does not use phonon mediation to induce attraction between electrons. It is of particular interest to note that such a purely electronic coupling was proposed to explain the superconductivity mechanism in a thin (a few atomic layers thick) metallic film deposited on a dielectric (insulator) substrate [15, 16]. Moreover, a hybrid coupling, both electronic and phononic in nature was suggested for explaining experimentally observed indications of near-room temperature superconductivity (313 deg. K) in the interface between a thin Aluminum film deposited on a PZT substrate [17].

Along with electron pairing, it is the existence of spin fluctuations which induces long range phase coherence in solids, thereby giving rise to superconductivity [14].

It is herein argued that in order to generate and amplify both non-linear electron-phonon interactions and spin fluctuations in superconducting solids at room or higher temperatures, we must produce strong electron-lattice interactions which may be achieved by abrupt vibration of a composite metallic wire, through which a current is abruptly pulsed.

With these ideas in mind, consider the preferred embodiment of the inventive concept, namely a composite metallic wire composed of an insulator core overlaid with a thin coating of lead zirconate titanate (PZT) piezoelectric ceramic, through which a current is flowing using a pulsed current source, as portrayed in figure 1. The PZT coating is deposited on the insulator substrate by using a vacuum evaporation method [17].

The insulator core can be made from Teflon or any other flexible polymer, which displays non-conductive properties. Instead of PZT for the wire coating we can use Barium Strontium Titanate (toxicity must be considered) or any other poor metallic/ceramic material which displays good piezoelectric characteristics (mechanical deformation under applied electrical potential difference).

It is important for the PZT coating to undergo a polarizing (poling) treatment prior to RTSC enablement, so that optimal domain alignment is obtained within the ceramic coating, by subjecting the coating to a strong dc current electric field, slightly below the Curie temperature (approx.200 ^{0}C, but possibly as high as 360 ^{0}C, depending on PZT ceramic composition). Furthermore, to increase the probability of vibration in one particular direction, as well as to alleviate the brittle nature of the ceramic material, it may be necessary to make the 'metallic' wire coating out of a composite PZT and highly conductive polymer, such as p-Terphenyl [4]. Another option is to sandwich the PZT ceramic in between two layers of aluminum, resulting in a wire design which may be planar rather than cylindrical in nature. This composite coating design would amplify piezoelectrically-induced vibrations and possibly render them unidirectional.

Figure 2 shows another embodiment of the concept, which depicts a composite wire coating made from aluminum, possibly doped with PZT and/or ferrite species, for amplification of spin fluctuations (non-linear magnetic effects).

A helical coil is wound around the special composite metallic wire, in such a manner as to induce a strong time-variant magnetic field in the wire, while current is being pulsed through the wire, as well as through the coil at different frequencies. This excites highly non-linear modes of vibration in the wire, thereby amplifying spin fluctuations within the composite metallic coating, which mediate long-range phase coherence, and may give rise to room temperature superconductivity [14].

The helical coil can be made from the same material as the special composite metallic wire, so that it can also become room temperature superconductive as current is pulsed through it.

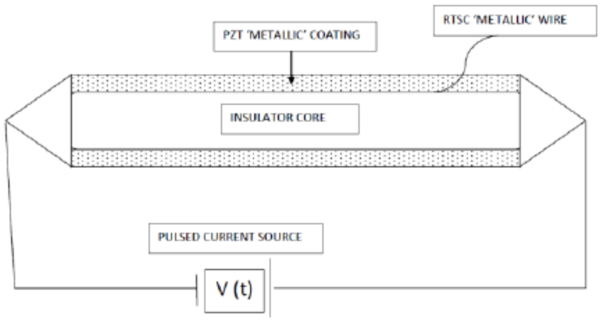

FIGURE 1 - CROSS-SECTIONAL VIEW OF RTSC WIRE

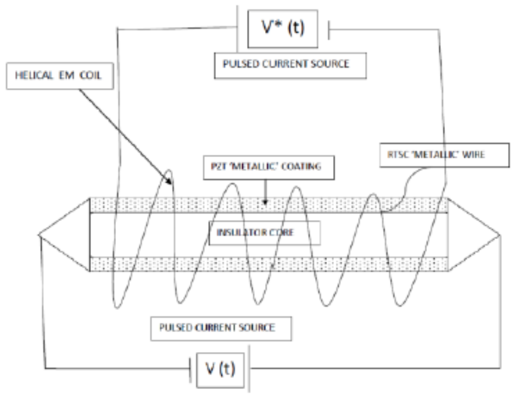

FIGURE 2 – ALTERNATIVE CROSS-SECTIONAL CONFIGURATION OF RTSC WIRE

It is of interest to consider the Isotope effect in superconductors [18], for which the critical temperature T_c can be scaled with (M^{-a}), where the exponent (a) can be higher than 0.5 for unconventional superconductors (high T_c superconductors such as YBCO); for the sake of simplicity we have a = 1, where M is the ionic mass.

Considering a classical Newtonian second law expression using the Lorentz electromagnetic force (under accelerating vibration of frequency Ω), we can relate the vibrating mass (M) with its vibrating charge (Q), in that (M) becomes directly proportional to the square of the ratio (Q / Ω).

Therefore, it can be observed that the value of T_c can be directly proportional with the square of the vibrational frequency of the ionic mass, indicative of high T_c enablement, and hence RTSC possibility with accelerating vibration of the wire.

VII. Conclusion / Electron Pairing Mechanism

Imagine the ionic crystal lattice of the composite metallic wire, featuring a matrix of two rows and multiple columns of positive ions. Through this matrix, two fast electrons (pulsed current) move horizontally, a front electron and a rear electron.

Recall that the current is abruptly pulsed through the metallic portion of the wire, while the wire is abruptly vibrated. This means that the lattice ions will be moving furiously toward each other, in the direction of wire vibration which for the sake of simplicity, say that is vertical in motion (the frequency of pulsed current may be higher than the frequency of wire vibration). It is important to realize that for high frequencies of wire vibration (>10^{12} Hz), the thermal energy given by the Boltzmann relation (E = kT), where k is the Boltzmann constant (8.62×10^{-5} eV/^{0}K) and T is room temperature (300 deg. K), is far exceeded by the vibration energy of the wire. This means that the most important fluctuations are those of the lattice ions themselves, induced by the wire vibration. Further imagine that as the top and bottom lattice ions approach each other vigorously, they just as strongly rebound due to the Coulomb repulsion force acting between them.

Think of the front electron as it approaches the gap between the two ions. Since the electron speed is determined by the pulsed current, the front electron is fast enough to pass through the ion gap and not collide with the lattice. However, as the two lattice ions approach each other (letting the front electron through), an enhanced positive charge region is formed between them.

It is this enhanced positive charge region which decelerates the front electron while accelerating the rear electron toward it. As the two electrons approach each other, they pair up, however at much higher energies than Cooper pair formation (10^{-3} eV).

Along this line of thought, the condition for the vibration energy to exceed the thermal energy and thus ensure that the coherence timescale is far higher than the decoherence timescale (possibly ensuring that macroscopic quantum coherence occurs), can be expressed as:

$$h^* \omega >> k\,T \tag{7}$$

, where h^* is Planck's constant divided by 2π and ω is the wire vibration frequency. However, a threshold ω on the order of 1 Terahertz is extremely difficult to obtain by physically vibrating the wire, unless we account for acceleration of vibration, in which case the characteristic vibration frequency (ω_c) can be written as in equation 2 in reference 11, namely:

$$\omega_c \sim \omega^2\, t_{op} \tag{8}$$

, where t_{op} is the total operational time for which the wire is vibrated at maximum acceleration, following a simple harmonic motion formalism. In other words, by accelerating in vibration and/or spin we can obtain a vibration /spin frequency amplification effect (observed by replacing ω with ω_c in equation 7). Moreover, acceleration of electrons through the wire can be achieved by pulsing the current at the resonance frequency (f_p) for an LC oscillator (hence at zero electrical resistance), namely:

$$f_p = (1/2\pi) / (LC)^{1/2} \tag{9}$$

, where L and C are the inductance and capacitance, respectively, of the SC electric circuit.

In conclusion, of possible interest, is the fact that a notice of allowance on US Patent Application Number 2017/0025935A1 has been received for "ELECTROMAGNETIC FIELD GENERATOR AND METHOD TO GENERATE AN ELECTROMAGNETIC FIELD", which was developed by the author in-house, under the acknowledged NISE-supported project. The developed technology can lead to the enablement of Macroscopic Quantum Coherence (the engineering of macroscopic states to behave as if quantum mechanical in nature - enabling superposition, entanglement, tunneling, and teleportation). This gives rise to emerging technology breakthroughs in Controlled Plasma Dynamics for Hypersonics Research, Advanced Electronic Warfare, Tactical High Energy Lasers, Wireless Power Transmission, Advanced Field Propulsion (hybrid aerospace-undersea craft and power plants), High Temperature (Room Temperature) Superconductivity and Quantum Technologies, such as Spintronics, Magnonics, Quantum Computing / Neuromorphic (Resonance) Computing (AGI / Singularity), and Quantum Sensing (Quantum Radar and possibly Quantum Sonar).

Furthermore, this technology has National Security importance in leading to the generation of Thermonuclear Fusion Ignition Energy with commercial as well as military application potential, in ensuring National Energy Dominance.

Acknowledgments

Funding for this work was provided by the Naval Innovative Science & Engineering (NISE) –Basic & Applied Research (BAR) program, under the project name "The High Energy Electromagnetic Field Generator (HEEMFG)", project number 219BAR-17-009. I wish to thank Dr. James Sheehy, Chief Technology Officer, Naval Aviation Enterprise, for the many hours of thought-provoking discussions on the concept at hand.

References

1. J. Bardeen, L.N. Cooper, and J.R. Schrieffer, Theory of Superconductivity, Phys. Rev., **108**, 1175 (1957).
2. B.K. Chakraverty, J. Physique, **42**, 1351 (1981).
3. A. Alexandrov and J. Ranninger, Phys. Rev. B, **24**, 1164 (1981).
4. R.S Wang et al., Superconductivity in p-Terphenyl, arXiv:1703.05803v1 [cond-mat.supr-con], 16 Mar. 2017.
5. J. Van Wezel and J. van den Brink, Spontaneous symmetry breaking and decoherence in superconductors, Phys. Rev. B **77**, 064523 (2008).
6. R. K. Harris et al., Vibratory-wire strain gage, United States Patent 4,074,565, Feb. 21, 1978.
7. M.J. Hamel, Wireless vibrating strain gage, United States Patent 7,591,187 B2, Sep.22, 2009.
8. K.K. Shung et al., Piezoelectric materials for high frequency medical imaging applications: A review, J. Electroceram (2007) 19:139-145.
9. S. A. Kivelson and B. Spivak, Macroscopic character of composite high-temperature superconducting wires, Phys. Rev. B **92**, 184502 - published 3 November 2015.
10. A.D. O'Connell et al., Quantum ground state and single-phonon control of a mechanical resonator, Nature 464, 697-703, April 1, 2010.
11. S.C. Pais, The high energy electromagnetic field generator, Int. J. Space Science and Engineering, Vol.3, No. 4, 2015 pp.312-317.
12. M. Mitrano et al., Possible light-induced superconductivity in K_3C_{60} at high temperature, Nature 530, 461–464, 25 February 2016.
13. K. Huang, A superfluid universe, World Scientific Publishing, 2016.
14. A. Mourachkine, Room temperature superconductivity, chapter 10, pp. 293-294, Cambridge International Science Publishing, first published 2004.
15. V.L. Ginzburg, Soviet Physics - JETP **20**, 1549 (1965).
16. V.L. Ginzburg, Contemporary Physics **9** , 355 (1968).
17. D. D. Gupta, Indications of room-temperature superconductivity at a metal - PZT interface, arXiv:1007.2736v1 [cond-mat.supr-con] 16 Jul 2010.
18. A. Bill, V.Z. Kresin and S.A. Wolf, The isotope effect in superconductors, arXiv:cond-mat/9801222v1 [cond-mat.supr-con] 21 Jan 1998.