

# CLASSICALLY BOUND ELECTRONS

## EVs, Exotic Chemistry & 'Cold Electricity'

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### *Abstract*

At a range of  $10^{-13} m$ , the magnetic field of a classical point-like spinning electron reaches 1 GTesla, which overcomes the electrostatic repulsion of another electron. This allows them to pair into singlet states, dense electronic stringy loops as well as induce an exotic chemistry and nuclear reactions. The resulting electronic strings shrink, convert a fraction of their mass into ionizing radiation, and thereby generate electrical power by the photoelectric effect. Such a state, upon entering an anode, may use the latter's electronic thermal energy to convert itself again into free electrons, creating the effect of 'cold electricity'. A similar process could well be occurring inside conductors. More realistic, fully relativistic semi-classical evaluations are given in the appendix.

In the non-relativistic regime, the potential energy for two classical electrons can be written as

$$[1] \quad \Phi_{ij} \cong \frac{e_i e_j}{4\pi\epsilon_0 r_{ij}} - \frac{g^2 \mu_B}{4\pi r_{ij}^3} \left[ 3(\vec{\mu}_{B_i} \cdot \hat{r}_{ji}) \hat{r}_{ij} - \vec{\mu}_{B_i} \right] \cdot \vec{\mu}_{B_j},$$

where  $\mu_B$  is the orbital magnetic moment of the electron (Bohr's magneton written as an axial vector) and  $g$  its gyromagnetic factor. This energy, while dominated by the electrostatic repulsion at large distances, cancels and becomes attractive at distances below  $\sim 10^{-13} m$ . At such distances however, [1] no longer applies as written, and must be replaced either by the Bargmann-Michel-Telegdi equation, its equivalent in the Vigier-Bohm relativistic hydrodynamic theory in classical mechanics, or by some solution to the Dirac equation. This has consequences in quantum chemistry, as two electrons with opposing spins can form a bound quasi-particle state of charge  $2e$  and mass  $2m$ , as suggested by Animalu, Santilli and Aringazin. Such an entity has an autonomous existence in vacuum, as evidenced by the tunneling of Cooper pairs between superconductors, while its consequences in chemistry are atoms and molecules shrunk beyond the usually recognized ground state associated with single electrons. A ring of  $k$  closely bound electrons has a Bohr radius of  $1/k^2$  and a bonding energy  $k^3$  times that for a single electron about a nucleus. This allows for neutral hydrogen polymers with  $k$  protons. The corresponding bonding, transitional energies and molecular masses may well have been observed by R. Mills in his *Blacklight* process, with particularly strong peaks for  $k = 4$  and  $k = 2$ . The formation of a shrunk negative hydrogen ion (hydrino) can proceed simply with atomic

hydrogen, which provides both an electron and the first energy gap of  $13.6\text{eV}$ , but it is facilitated by a catalyst tuned to the second,  $\sim 81.6\text{eV}$  gap, such as  $\text{Li} \rightarrow \text{Li}^{2+}$ ,  $\text{K} \rightarrow \text{K}^{3+}$ ,  $2\text{Ne}^{\text{II}}$ ,  $2\text{Ar}^{\text{III}}$ ,  $3\text{Rb}^{\text{II}}$ , etc, or having an energy of ionization slightly lower, such as in  $\text{He} \rightarrow \text{He}^{2+}$ , because this liberates more electrons. A hot tungsten, gold or platinum wire is also useful in this respect as it both generates atomic hydrogen and free electrons capable of forming negative ions. The mechanism that allows the two electrons in the  $s$  orbital to bind involves the transient inversion of the 4-velocity and mass of the whole atom, which underlies the latter's quantum evolution, inducing a negative pressure in the electronic gas and a temporary collapse of the electrons near the nucleus, which catalyses the binding in the presence of the necessary element to carry the excess energy away non-radiatively, by collisional transfer. Lord Rayleigh had first discovered this novel source of energy in low pressure gas cells ( $\text{H}$ ,  $\text{N}$ ,  $\text{O}$ ), between 1935 and 1946, and had published his findings in the proceedings of the Royal Society of the Sciences. The energy that can be extracted from a molecule of hydrogen in this way can be as high as  $200\text{eV}$ , which is dozens of times that from its combustion. In the realm of the solid state, a (semi-)conductor carrying a current creates charged loops of magnetic flux near its surface, which organize as bound electronic strings. These experience a centripetal Lorentz pinch, and therefore tend to move just below the surface. A balance between the centrifuge attraction of the charge-depleted surface and the centripetal Lorentz force then establishes itself. The radially opposing Lorentz and electrostatic forces are complemented by longitudinal repulsive forces between the depleted segments of like-charges at the surface, and between two successive electronic loops. When the current is further increased, these longitudinal forces will explode the wire, mostly from its depleted surface lattice, into fragments, or a discharge into 'sausages', which is the well known instability that has prevented the simple pinched fusion schemes that were contemplated in the 1950's to succeed. When a cold cathode is fed with a pulse, the closed magnetic loops cum electrons leave it in the form of metastable electronic vortices, or EVs. These were extensively studied by Kenneth Shoulders and typically contain  $N = 10^8$  electrons in a region of about one and a half micron in radius, at an average distance of  $2\pi R/N \sim 10^{-13}\text{m}$ , which is in the attractive range of the potential [1], while two- or three- dimensional configurations not only fail to reach the critical attractive proximity between electrons by several orders of magnitude, but are problematic in terms of the needed magnetic topology.

How are EVs formed ? They most likely result from a runaway magnetization that initiates at the density of matter, from closed flux ring Landau states enclosing a decaying current. Then, a runaway ionization and magnetization ensues that strongly confines and further polarizes the resulting ions magnetically, resulting in denser and denser self-magnetized Landau states. In any material medium, an electric field  $\mathbf{E}$  near the ionizing threshold excites the atoms and results in an increased permittivity  $\epsilon(\mathbf{E})$  that decreases the electrostatic and transverse electromagnetic spin repulsive energy. In a semiconductor such as  $\text{InSb}$ , besides an initial permittivity  $\epsilon \sim 10$ , electrons have very low effective masses ( $m^* = 0.014m_e$ ) that increase their magnetic moment  $g\mu_B^* \sim eh/m^*$  and spin-spin coupling as  $\sim (m/m^*)^2$  while lowering the magnetization needed for Landau states to 0.2 Tesla. Their magnetic field, combined with the electric field at the cathode then induces the runaway ionization and magnetization of neighbouring atoms, which substantially increases  $\mu$  while sending the permittivity  $\epsilon$  to infinity. The atoms are initially as closely spaced as  $0.66\text{\AA}$ . At some point, the runaway begins in which the magnetic field is enhanced from the emptying atomic  $d$  and  $f$  shells polarized by the exchange interaction, whose magnetic binding to the forming  $\text{EV}$  surpasses their initial atomic binding energy. The recently discovered phenomenon of *ballistic magnetoresistance*, which reaches a record 3000% within the atomic-scale nanodomain of a tunnel microscope-like nickel spike contacting a flat surface of the same metal through which flows a substantial current is, I believe, related to a deep-shell atomic magnetism of such Landau states and their related phase transitions. Because of their mass  $2m$  and charge  $2e$ , valence pairs form from the expelled electrons, which penetrate deeper inside the atomic clouds, feel a stronger potential from the nuclei and need only half the momentum and energy of single electrons to remain confined in a given space. It then becomes energetically favourable for half the electrons still in the filled  $d$  and  $f$  shells to leave them and either move to higher empty shells, thereby increasing the magnetic polarization more than twofold, or to form new valence pairs. As the

atoms shrink into ever more magnetized and densely packed ionic states, the free pairs form collectively bound molecular orbitals. Soon the intensity of the magnetic field induces the valence pairs to start breaking too into spin-aligned free electrons, solely bound by the magnetic field in the ring. For each halving of the mean distance between polarized electrons, the magnetic binding energy grows more than eightfold, attracting surrounding atoms from the periphery. As a result, these cluster about the forming EV, their electrons binding themselves magnetically into the ring. This proceeds until most atomic and molecular shells are half empty, longitudinally squeezed and magnetically polarized piled discs. At this point, the critical inter-electronic spacing of  $\sim 10^{-14} \text{ m}$  is reached, whereupon the radiation of the neutral shrinking Landau states expels their nuclear core and makes them switch to the relativistic regime of the self-sustaining charged EV in which the vacuum polarization and mutual magnetization of electrons allows for lower energies, as described in the appendix. All this occurs near the cathode, so that the expelled ions are violently accelerated back into it, where their recombination creates an explosion likely to damage it. Hence the preference for a liquid metal cathode. X-rays should be produced at that point. In order to avoid contaminating the newly-formed EV with ions, K. Shoulders places a drift tube that radiatively stimulates this initial shrinking just after the EVs are produced. One consequence of this mechanism is that a negative pulse is immediately drawn upon the formation of each EV into the cathode from the return of the ions. This must be damped by a resistor. The ions must preferably be of some heavy element, such as Mercury or Xenon, which have ample supplies of electrons in  $d$  and  $f$  shells. The reason why EVs have been thought to be spherical could be related to the traces that they leave upon colliding with the anode and exploding at its surface. Most likely, they form into small tori that bind magnetically into a larger torus.

Such an electronic loop may exist in two states : ferromagnetic with longitudinally aligned spins ( I ), which is how it generally appears in the solid state and when formed in a discharge, or antiferromagnetic with transversely oriented alternate spins ( II ). The decay from ( I ) to ( II ) involves that of the magnetic flux that subtended the initial state. Note that the longitudinal binding is twice as strong, classically, than the transverse.

By virtue of this attractive potential, such loops could, except for the energy associated with their charge, shrink up to an interelectronic spacing of  $\sim 10^{-15} \text{ m}$ , when the magnetic potential (akin to a classical superselection rule) is strong enough to confine the transverse kinetic modes of the electrons into a torus as happens in very thin conductors, while confining the longitudinal modes is taken care of by Pauli's exclusion principle. The energy balance comprises the energy of the electrons' transverse and longitudinal kinetic modes, which increases as  $\sim 1/R^2$  in the initial low energy regime and as  $\sim 1/R$  in the relativistic regime, which is predominant below a scale, if we assume the little radius  $r$  of the torus to scale with the big radius ; the electrostatic energy that increases as  $1/R$  as  $R$  shrinks, so that the overall positive energy, kinetic plus electrostatic, scales as  $+\alpha/R$  below a scale. There is also the longitudinal magnetic potential, which grows increasingly negative as  $-1/R^3$ . The overall energy thus scales as  $\alpha/R - \beta/R^3$  in the relativistic regime, the latter term always dominating at some point. As a result, a stringy EV that shrinks in vacuum loses energy and would convert the entirety of its initial mass (or more if in an external attractive potential well) into energy, were it not for charge conservation and its associated energy. In the process, it emits ionizing radiation, causing it to self-accelerate and zigzag wildly from the recoil, as a 'white EV'. This shrinking is manifestly limited, otherwise the vanishing mass would allow it to reach relativistic velocities, even in modest potentials of  $\sim 10 \text{ KV}$  over sufficiently long paths. Its limit is set by the reduction in the electrostatic and magnetic self-energies from the reduction in magnetic permeability  $\mu_0$  (owing to a huge magnetization) and the increase of the permittivity  $\epsilon_0$  of space under the intense magnetic and electric fields, the latter of which increase the density of electron-positron pairs. This allows for the somewhat lower mass-to-charge ratio at the origin of the  $2 \text{ KeV}$  transitions observed by K. Shoulders, which he believes correspond to the binding energy per electron within an EV. In that case, only the inversion of the dynamics can be contemplated as a plausible explanation for the puzzling, sudden and reversible apparent vanishing of both mass and charge. In most of what follows, I shall assume the charge of EVs to remain

constant.

While shrinking EVs do not directly convert mass into electrical power, their ionizing radiation can be harnessed to knock off electrons from the cathode or other metallic surfaces at a lower potential than the anode, around the EVs' path, therefore producing an excess of electrical power. This could induce the mysterious drop in potential seen in charged surfaces near EVs. The resulting shrunk state could be the candidate for what K. Shoulders' called 'black EVs', because they do not radiate. Upon colliding with the anode, these may become excited again into disordered electrons by sucking the anode's thermal energy, which could be the cause of the mysterious 'cold electricity', or may catalyse exotic chemical and nuclear reactions. While the extraction of electrical power from exotic electrochemistry or nuclear reactions is exothermic and consumes a fuel, that from 'cold electricity' requires closing the loop (recycling the shrunk electrons in the anode), and therefore supplying the anode with a flow of heat. This endothermic regeneration of free electrons from EVs could be the dominant cause, along with the breaking of the boundary layer by negative ions generally put forth as an explanation, of electrostatic cooling.

K. Shoulders observed that some EVs seem to lose suddenly most of their mass and charge, while keeping their ratio unchanged. One explanation is a temporary inversion of their mass and energy along with a 'gravitational decoherence' from the Machian background at infinite or negative temperatures (related to a partial or total phase transition), in the framework of an induced gravity, with the result that the energy, mass, temporal evolution and thermodynamics of certain substates inverts and that their bound states with counterparts of positive energy see their kinematically measured mass and charge almost vanish while generating puzzling kinematic anomalies. A temporally inverted EV acquires a positive charge and affects its environment accordingly, but behaves kinematically as though it were negative. While the transition to such states is seamless, that of negatively charged EVs to a negative mass, while keeping the charge and the overall temporal evolution unchanged, would involve strange boundary conditions and the emission of electromagnetic or gravitational waves of positive energy in order to conserve momentum, while its reverse requires the absorption of such radiation, or an emission of gravitational radiation with a negative energy. This may then result in the non-conservation of momentum on the scale of an experimental device, although it can be shown that its global dynamics will conserve momentum and energy.

Along a similar line of reasoning, given that the behaviour of quantum objects results from their random walk in space-time, whose temporally reversed paths involve inverted energies, masses and charges adding up to the conjugate wavefunction, and that the dynamics of self-sustaining EVs implies that they are macroscopic coherent quantum states, it then follows that they should exhibit the quantum behaviour expected of the wave-function of an indivisible quantum object, such as an atom or molecule, which may split into several branches upon being partially reflected or scattered. Might then its mass and charge become diluted along its wavefunction so long as it interacts minimally with its surroundings, as for a '*quiet EV*'? Upon interacting, the wavefunction would collapse, and it would then instantaneously localize its mass and charge. Might then the mysterious '*Black EVs*' be the partially scattered wavefunctions of quiet EVs, the tickling of which would make them interact, whereupon they decohere in the quantum mechanical sense and localize? To conserve energy and momentum locally, the vanishing branches of the wavefunction would then emit gravitational waves with positive energy and momentum, while the newly-localized EV radiates gravitational waves with negative energy and momentum, which exist in certain theories of gravity. According to a more plausible view, however, there is no collapse of the wavefunction, which only reflects our incomplete knowledge of reality. In this case, the entire wavefunction arises from the temporal whereabouts of a

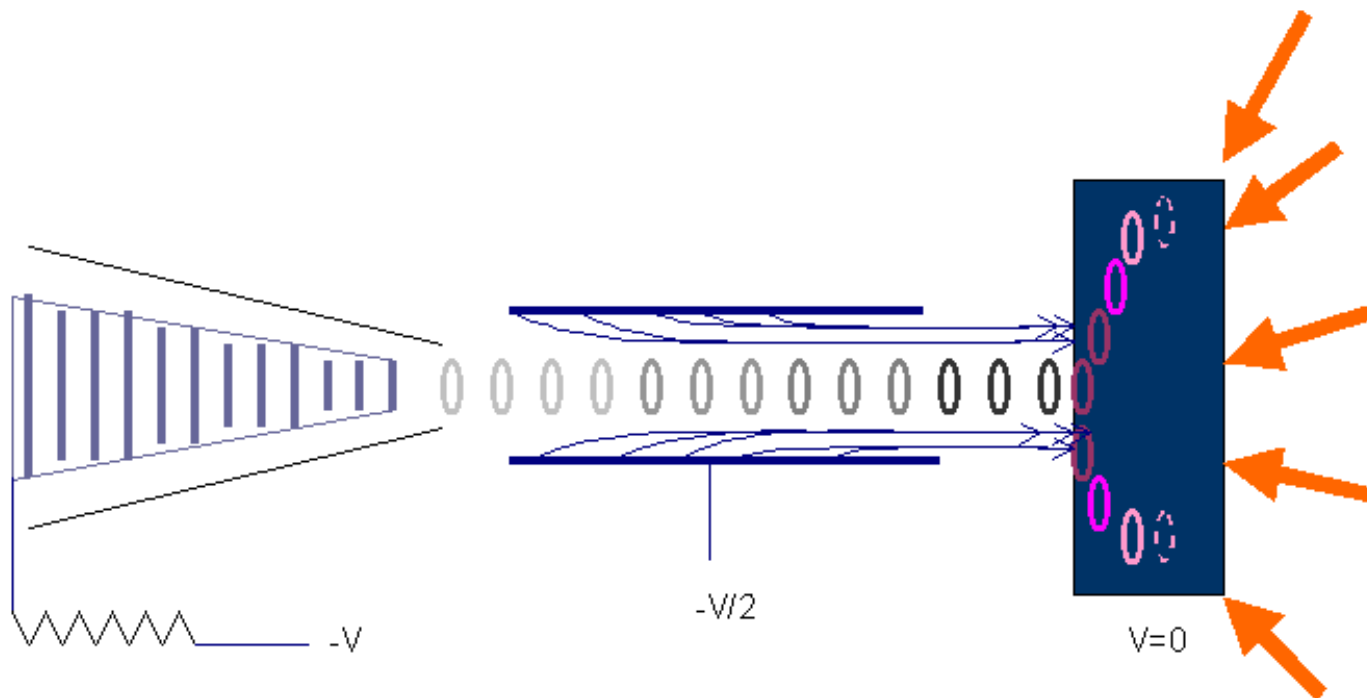
single entity. Only its positive mass, energy and usual charge interacts with some element of its environment at a positive temperature, and when this occurs, the whereabouts of the wavefunction cease, and its unused branches, which exactly combine worldlines of opposing momentum, electric current, mass and charge into pairs amount to nothing. Therefore, the shadow EVs cannot be explained in this way.

Nuclear reactions can be induced by EVs' carrying and accelerating nuclei to relativistic velocities in vacuum, by their screening the Coulomb potential between fusing nuclei, and, most interestingly, by their modifying the alpha tunneling probability of heavy elements and thereby hastening their natural alpha decay, which is environmentally friendly, as no radioactive waste is produced. While these processes may release energy in the short span of time when an EV collides with the anode and decays, the second and the third may also occur continuously below the surface of a current-carrying element. The current would preferably be in the form of short, unidirectional pulses, at such frequencies as to maximize the formation of coherent ferromagnetic loops below the conductor's surface, while avoiding its explosion. Fusion may occur in the solid state, in deuterium loaded Palladium, in other systems, while alpha fission may be contemplated with heavy elements such as Tungsten, Uranium or Thorium. A reactor would typically consist of a wire at the centre of a conducting pipe. The induced fission would occur inside the wire, heating it so that power is extracted by hot electron emission.

A possibility that does not involve nuclear reactions is to consider the exotic chemical reactions that such coherent electronic states may induce in various materials, such as those in low pressure gas cells, ordinary batteries, conductors or magnetic materials subjected to certain unidirectional pulses. These will be transformed into atomic isomers with a higher binding energy, as found in the Rayleigh process. Before making claims of free energy, the detailed examination and analysis of the materials that are involved in the devices should be performed, so as to detect any structural change, whether of a molecular, atomic or nuclear nature.

Is the Second Law of Thermodynamics about to lose its standing of one century and a half, seeing as several open quantum systems are now known that explicitly violate it ? These are unidirectional open systems in which the reverse transition channels are closed owing to destructive quantum interference. This allows such phenomena as rectified Brownian motion and anti-Stokes Lasing without an externally induced population inversion. The phenomenon of cold electricity manifestly belongs in this category. Because such processes involve negative temperatures, they must correspond to negative energies, masses and a reversed temporal evolution, according to E.C. G. Stueckelberg, which enforces the second law of thermodynamics... at the cost of the expected temporal ordering in such states.

Below are some processes of this kind that involve EVs.



One of K. Shoulder's devices. EVs are produced from the tip of a whet metallic cathode at  $V \sim 4\text{KV}$ , connected through a  $\sim 500\Omega$  resistor so as to stabilize their formation. As they radiate  $2\text{KeV}$  photons, they appear as white EVs, pass through a metallic tube at an intermediate voltage  $V/2$ , where their ionizing radiation induces electrons to be knocked off from the photoelectric effect. It also accelerates the EVs' shrinking through stimulated emission in this cavity where other EVs are radiating their energy away. This is the source of the electrical power that is produced. When they exit the tube, they have radiated off most of their binding mass-energy and have become black EVs. While the drawing illustrates single EVs, it seems that EVs may be formed into toroidal clusters. The reason could be that in the presence of short pulses in an axial magnetic field, the current feeding the cathode has an initial axial vorticity. As the pulse reaches the tip, the angular velocity increases, and a toroidal plasmoid carrying a small vortical loop of current is formed that also has a toroidal vorticity, as in a smoke ring, owing to the mechanism of its formation. The magnetic field at the tip then decays, subjecting the newly formed toroidal vortex to a poloidal induction, forming on it equidistant shrinking EVs. The same mechanism of EV formation by the decay of loop plasmoid currents may proceed in electrodeless discharges. Their radiation then dissipate the plasma, and only the EVs remain in the shape of the skeleton of a torus held together by magnetic and Casimir forces (which is possible if each EV is a rigid superconducting loop). This leaves bead-like traces upon their decay on an anode. I once remember EVs being put forth for exciting phosphors in flat CRTs. One problem was their variability. Interestingly, IBM recently announced that their new flat CRT had its cathode tips embedded in a sheet magnet, which probably solves the problem, as the exact dynamics of the pulse becomes less critical in a strong field. In this case, the plasma involves a noble gas rather than a whet cathode. EVs may also penetrate the anode transversely and decay, leaving two holes, as seen in some of K. Shoulder's photographs. Once in the anode, these aggregates use the thermal energy of the conduction electrons to be restored back into free electrons, so that the electrical circuit can be closed if heat is supplied from the outside to that effect. This would clearly be an endothermic process which, I now realize, should not violate the second law of thermodynamics. Its efficiency is improved by feeding the heat generated in the midsection to the anode. Note the similarity with EV Gray's and Moray's tubes. Other configurations can form such entities in the solid state and induce exothermic electrochemical or nuclear exotic reactions. Since the EVs may emit electrons and antineutrinos as they shrink, to the photoelectric showers that are shown could be added those from the EVs themselves.

An intriguing question is whether a similar process could occur within the confines of a (semi)conductor. Several experimenters report an unusually strong back emf from switched coils with a ferromagnetic core polarized by a permanent magnet. Examples of such devices are Bearden's MEG and Floyd Sweet's device. I am thankful to William Alek for sharing with me the results of his experiments with his Motionless Shock Charger, which uses the back emf to charge a battery. He notices that a permanent magnet substantially increases the efficiency of his device. I shall assume that the current organizes itself as progressing vortical magnetic rings surrounding the wire, just below its surface. These are similar in nature to EVs in a vacuum or rarefied medium, though of a lower density and electrostatic energy.

1/ The current flows against the magnetic field and prevents the ferrite core from being magnetized. We may assume the total magnetic field to be small at the centre of the coil. The advancing vortical magnetic rings of Landau states are initially in equilibrium just below the surface and have a small negative binding energy. They are built from the half-empty, unidirectionally moving upper Fermi levels of conduction, and may reside within a semiconducting layer that surrounds the conductor.

2/ The current is interrupted and the vortices stop moving. Besides the far effect of decelerating charges in the coil upon other charges in some localized region, there will be an effect from decelerating charges upon neighbouring charges in that region. Standard theory says that when the circular field lines surrounding the wire decay, the electrons inside the wire feel a back emf  $\text{Curl } \mathbf{E} = -\partial_t \mathbf{B}$ . But since these field lines may consist of Landau vortices, there is another possibility. They start shrinking toward the centre of the wire, contributing to the back emf inside the volume they enclose (as inside a shrinking toroidal coil, from the motional electric field  $-\partial_t \mathbf{A}$ ), while gaining a negative binding energy. Such loops do not shrink in a flowing current : not only are they in equilibrium between the centripetal Lorentz pinch and the charge-depleted surface, but their shrinking is prevented so long as the current itself is maintained. Upon shrinking, they drive the back emf by their electrons falling into one another's magnetic potential. Outside the shrinking tori, the wire should be poorly conducting, since it is depleted in normal conducting electrons of a high enough energy. But the radiation from the shrinking vortices lifts electrons of lower energies into the conducting band. These electrons, along with those that the evolving shrinking EVs themselves may emit towards the periphery, which cannot feel the effects of the closed shrinking field lines within the wire, react to the increasing external magnetic field by also contributing to the back emf. In so doing, they convert some of the random radiation of the shrinking states into usable electric power. This explains why a magnet improves the efficiency of the process, since without it the radiation would be entirely turned into heat. In short, the shrinking electronic vortices also drive the back emf by converting some of their mass into energy.

3/ The shrunk vortices now have a highly negative binding energy while the interaction with their medium increase their disorder and make them transition to the antiferromagnetic state. Then, they need to suck up heat and perhaps electrons from their surroundings to be restored into usable free electrons. The coil cools, and heat must be supplied to bring the shrunk states back to their initial condition. Otherwise, the resistance of the wire would increase, being depleted in conducting electrons.

In the case of apparent overunity, the noticeable temperature drops in the coil would be part of a thermal cycle having an external heat flow, while exotic chemical/nuclear effects are exothermic.

The main problem I see is that since everything happens within the confines of a wire, a higher portion of the radiation from the shrinking electronic tori may be turned into heat than in a Shoulders/Gray tube, thereby shorting the thermodynamic cycle. William Alek seems to support this view, noticing that thinner wires dissipate heat and lower the efficiency of his devices substantially in comparison with heavier gauged wires. Also, some of these shrunk states may end up altering the copper in the long run, but the same problem would potentially affect any other such devices.

To conclude, while a perpetuum mobile of the second kind is improbable, the existence of exotic forms of matter involving bound electrons represents a new source of atomic and nuclear energy that has already been tapped by several researchers in a reproducible way since Lord Rayleigh's pioneering experiments. It is well documented and expected to lead to industrial applications likely to answer our needs for reliable, new and clean sources of energy.

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## APPENDIX

The Barut-Dirac equation with anomalous electromagnetic coupling

**[A1]**

$$\left( c\boldsymbol{\alpha} \cdot \boldsymbol{p} - \left( E - \frac{\epsilon e^2}{r} \right) + \beta mc^2 \right) \psi = - \frac{\epsilon \alpha \hbar e^2}{4\pi mc^2 r^2} i\beta \alpha, \psi$$

gives the following system of equations in spherical coordinates

[A2]

$$\dot{\mathbf{g}}_+ = \left( \frac{\kappa-1}{r} + \frac{A}{r^2} \right) \mathbf{g}_+ + \frac{\mathbf{G}_+ \mathbf{g}_-}{\hbar} \quad , \quad \dot{\mathbf{g}}_- = - \left( \frac{\kappa-1}{r} + \frac{A}{r^2} \right) \mathbf{g}_- + \frac{\mathbf{G}_- \mathbf{g}_+}{\hbar}$$

$$G_{\pm} = \mu c \mp \left( \frac{E}{c} - \frac{B}{r} \right) \quad , \quad A = \frac{\epsilon \alpha e^2}{2\pi m c^2} \quad , \quad B = \frac{\epsilon e^2}{c}$$

where  $\mu$  is the reduced mass,  $\alpha$  the fine structure constant and  $\epsilon$  the relative sign of the charges. By setting  $u_{\pm} = r g_{\pm}$ , eliminating the other variable, and then taking  $f_{\pm} = u_{\pm} \sqrt{G_{\pm}}$ , the following equation is obtained

[A3]

$$\left( \frac{d^2}{dr^2} - (V(r) + \Lambda^2) \right) f_{\pm} = 0$$

$$(V(r) + \Lambda^2)_{\pm} = \frac{\kappa(\kappa \mp 1)}{r^2} + \frac{2A(\kappa \mp 1)}{r^3} + \frac{A^2}{r^4} - \frac{\dot{G}_{\pm}}{G_{\pm}} \left( \frac{\kappa}{r} + \frac{A}{r^2} \right) + \frac{\mathbf{G}_+ \mathbf{G}_-}{\hbar^2} - \frac{1}{2G_{\pm}} \left( G_{\pm}'' - \frac{3G_{\pm}'^2}{2G_{\pm}} \right) \quad ,$$

$$\kappa = j + s = \pm 1, \pm 2, \pm 3, \dots$$

There are bound states between electrons ( $\epsilon = 1$ ) with negative  $\kappa$  only for  $f_-$ . With  $E = m_e c^2 - 2 \text{ KeV}$  and  $\kappa = \pm 1$ , the  $f_+$  solution has a positive minimum at about  $3 \times 10^{-13} \text{ cm}$ , between the singular peak at the origin and a sharp wall at  $5.7 \times 10^{-13} \text{ cm}$ , across which the states within the false minimum may tunnel out. These distances can be significantly increased by form factors. The equation [A1] has several problems : the energy of the ground state of the hydrogen atom would be tachyonic for  $\kappa = 0$ , as is the case when  $Z \geq \alpha$ . Its mass being fixed, no bound states are allowed in principle. And because it is not invariant under time inversions, the interpretation of the negative energy states is dubious.

There exists alternatives to [A1] that address these issues, in which the external potentials appear through  $m \rightarrow m + A_{\mu} J^{\mu} / c^2$  in the equation for the free electron. Taking  $A_{\mu} J^{\mu} \rightarrow e A_{\mu} v^{\mu} \rightarrow e A_{\mu} \gamma^{\mu} = e V$ ; where  $V$  is a space-time scalar for *stationary* states in a Coulomb potential (its vector counterpart and the speed represent random fluctuations owing to Zitterbewegung that average out to zero), [A1] becomes

[A4]

$$\left( c\boldsymbol{\alpha} \cdot \mathbf{p} - E + \beta \left( mc^2 + \frac{\epsilon e^2}{r} \right) \right) \psi = - \frac{\epsilon \alpha \hbar e^2}{4\pi mc^2 r^2} i\beta \boldsymbol{\alpha} \cdot \mathbf{p} \psi$$

The solutions are as in [A3], except for

$$[A5] \quad G_{\pm} = \mu c + \frac{B}{r} \mp \frac{E}{c} \quad .$$

Note that the latter quantity is an invariant, so that the spectrum is symmetric for positive and negative energy states. Now, there are bound states between electrons ( $\epsilon = 1$ ) for  $\kappa \leq 0$ . With  $E = m_e c^2 - 2 \text{ KeV}$  and  $\kappa = -1$ , there is a narrow negative well from  $8 \times 10^{-17} \text{ cm}$  to  $6 \times 10^{-16} \text{ cm}$ , between a positive metastable hilltop at  $1.2 \times 10^{-15} \text{ cm}$  and the singular peak at the origin. For  $\kappa = 0$ , the wider well remains negative, bounded from below and monotonically increasing from its sharp minimum at  $1.7 \times 10^{-16} \text{ cm}$  to  $1.7 \times 10^{-13} \text{ cm}$ , then peaks on a very narrow potential wall at  $5.74 \times 10^{-13} \text{ cm}$ , after which it remains positive and slowly decreasing until it vanishes at infinity. Again, form factors may substantially increase these distances, reflecting a reduction in the repulsion owing to a finite size distribution or decrease in the permittivity in the polarized space at short range. Other factors to take into consideration for obtaining the  $10^{-11} \text{ cm}$  scale are Casimir forces between stationary electronic states akin to a conductive electronic fluid. Otherwise, the bonding of electrons occurs at the strong scale.

The main result here is the symmetry between positive and negative energy states. Only with the appropriate form factors can the corresponding two-body solutions explain the new bound states between two electrons with opposing spins at  $\sim 10^{-11} \text{ cm}$  in the central potential of a hydrogen or helium nucleus as originally found by R.M. Santilli. The same is true for the hydrogen atom : [A4] allows at least one new bound state for  $\kappa = 0$  within a wide negative potential well between a sharp minimum at  $9 \times 10^{-16} \text{ cm}$  and a sharp positive wall at  $3.5 \times 10^{-12} \text{ cm}$ , which here again can be modified by form factors. The asymmetry between positive and negative energy solutions now vanishes. With the appropriate form factors, this allows for an electronic toric string with millions of electrons, which is the obvious collective configuration since the binding interaction is magnetic. Such form factors can be derived from Wei Min Jin's nonlinear theory, which is nonrenormalizable, from which the linearized left hand of [A4] can be deduced in principle (while the right hand would be different), the action at first order is

$$[A6] \quad L = \bar{\Psi} \left\{ \gamma^\mu \left( i \partial_\mu - \frac{1}{2} A_\mu^T \right) - m - \frac{1}{8} F_{\mu\nu} F^{\mu\nu} \right\} \Psi \quad , \quad A_\mu^T = \bar{\Psi} \Psi A_\mu \quad .$$

Varying relative to  $\delta A_\mu$  gives

$$\partial^\nu (F_{\mu\nu} \bar{\Psi} \Psi) = e \bar{\Psi} \gamma_\mu \Psi (\bar{\Psi} \Psi) \quad , \quad \partial^\nu (\bar{\Psi} \Psi) \sim 0$$

which amounts to  $*d*F = J$ . An interesting consequence of [A6] is

$$\partial_\rho \partial^\rho A_\mu^T = \bar{\Psi} \Psi J_\mu^{\text{ext}} + 2 \partial_\rho (\bar{\Psi} \Psi) \partial^\rho A_\mu \quad ,$$

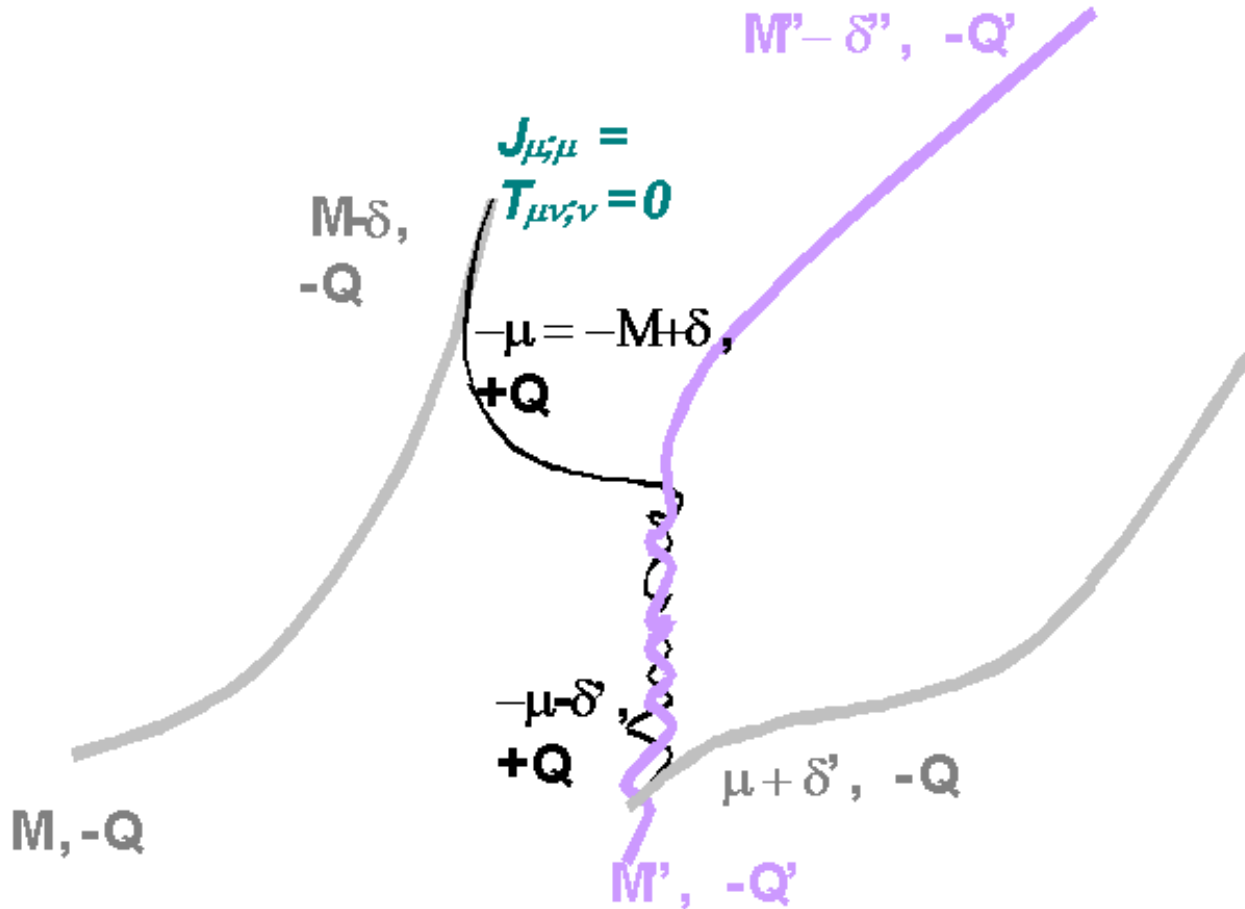
$$\partial_\rho (\bar{\Psi} \Psi) = \varepsilon_\rho(x) \quad , \quad \partial^\rho A_\mu = \kappa^\rho(x) \quad ,$$

$$(\partial_\rho \partial^\rho + \mu_\gamma^2) A_\mu^T = J_\mu^{\text{ext}} \quad , \quad \mu_\gamma^2(x) = -2 \varepsilon_\rho(x) \kappa^\rho(x) \quad .$$

That is, the photon acquires a mass  $\mu_\gamma(x)$  in the presence of high electronic and field density and gradients, so that the electrostatic repulsion for the  $f_+$  states is reduced by terms of the form  $\exp[-r/r_o]$  when  $\mu_\gamma(x)$  is real. The typical result is a Yukawa-type potential. This precisely corresponds to the form factors often used by Barut, which generally decrease the energy at which bound states occur. Classically,  $\varepsilon_\rho(x)$  is a polarizability that increases the permittivity of a charged medium in relation to its charge and reduces the electric field, inducing a confining force towards the greatest gradients, while  $\kappa_\rho(x)$  has the same effect from polarizing fields. A classical analysis of this has been done by Arne Bergström. This is yet another reason why a thin ring is favoured, as it allows the corresponding gradients to be maximal.

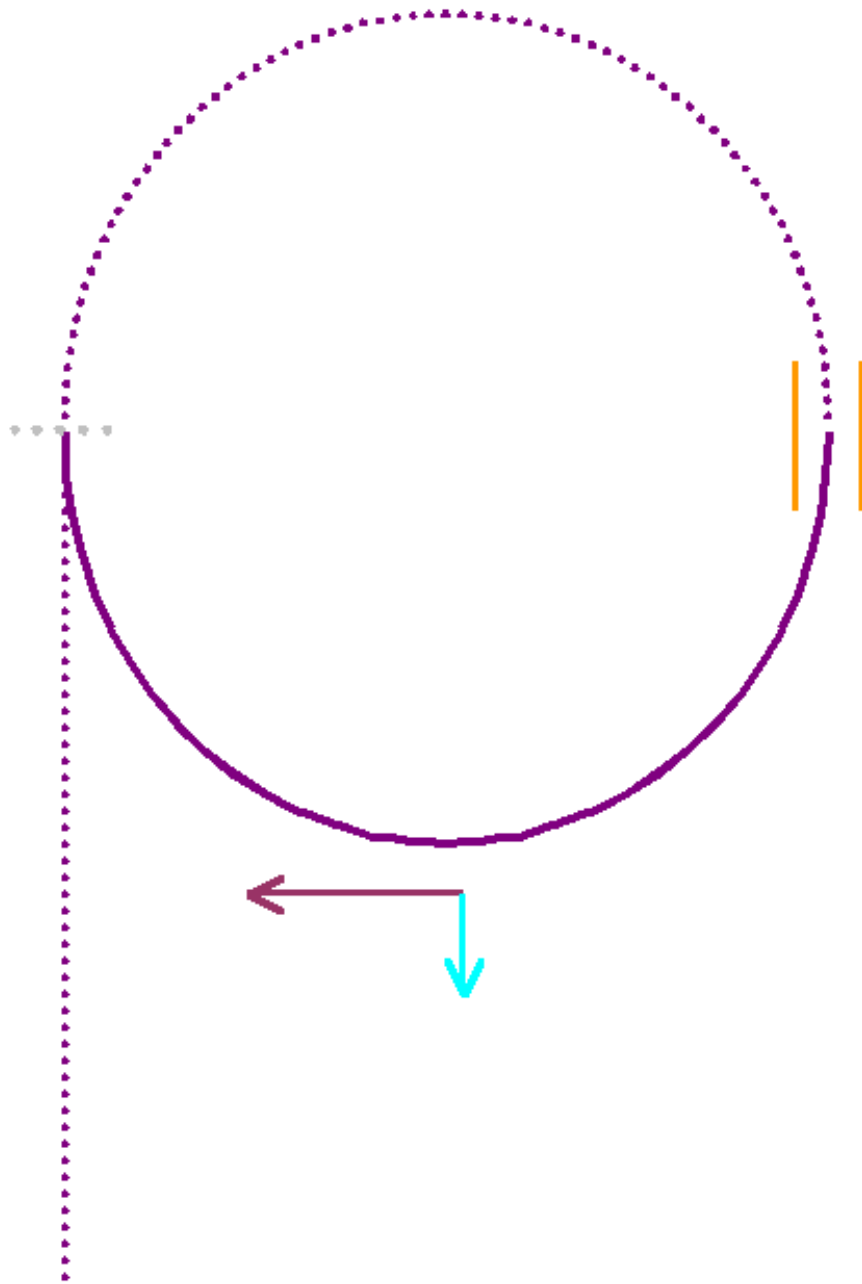
The stability of an EV against the tunneling out of its individual electrons arises from its state being a coherent vortex, akin to an internally relativistic smoke ring, where the intensity of its magnetic field, in the TeraTesla range, induces a transition of its permeability to a lower one, and therefore contributes to an internal reflection of its matter waves from the modified metric. The empirical picture is that of an EV with a charge to mass ratio  $1/256$  lower than that of free electrons, with a lowering of its permeability and increase of its permittivity. As for its most puzzling behaviour, I would assign it to the temporal inversion from the negative energy solutions, and to the radiative uncoupling from the Machian background. When an

EV transitions collectively and coherently, we are in the presence of a negative temperature that amounts to a negative mass, according to Stueckelberg. Such transitional states can be identified with the smooth and wide negative potential wells for components of negative energy that appear in [A4].



Two EVs interacting, one of which flips twice its temporal orientation from an induced uncoupling from the Machian background, becoming a black EV in between, with a reversed momentum, mass, charge and thermodynamics that dynamically sustains its retrochronicity from a shrinking negative mass, as viewed in our time, by its absorbing ambient photons. Therefore, the electric and momentum-energy currents are strictly conserved. The negative mass and reversed dynamics of black EVs can be used for inertial propulsion, since they have runaway bound states with ordinary matter. This behaviour of negative mass was researched by R. Forward. For instance, the wiggly orbit between a black and a white EV displays just such a runaway with a reduced apparent mass and charge, although no net propulsive effect results in the overall system. A similar diagram could be drawn for a spaceship on a two-way interstellar travel that uses its own return trip negative momentum-energy to accelerate and brake itself to its destination, so that it arrives back at about the time that it leaves, and could choose to visit the star either a few years in the past or in the future. Its inversion in time would use mechanical stresses in its surrounding structure and transitions from white to black EVs, the latter also providing its propulsion relative to its isochronous twin.

This is a scheme similar to Miguel Alcubierre's and Robert Forward's. As for the causal temporal paradoxes, I leave them to the reader as an amusing exercise.



This illustrates why an inertial thruster based upon the macroscopic quantum behaviour of a beam of EVs cannot work. The EV macrostates orbit in a cyclotron orbit in a magnetic field. The wavefunctions are almost totally reflected downwards with no absorption or radiative interaction, while the transmitted portion of their wave continues on its orbit. This, a priori, constitutes the 'Shadow Beam'. The shadow EVs then

thoroughly interact with radiation in the cavity on the right, where they ‘localize’, while they apparently delocalize from the end of the reflected branch, downwards. The process does not create a recoil locally, because, under the effect of the interaction, the vanishing reflected portion is canceled back in time, whereupon the beam, as far as the localizing states are concerned, has retroactively ceased to be a shadow beam ! This is similar to the two-hole diffraction experiment in which a detector is placed in front of one of the two beams, making the interference pattern vanish. That is, the interacting state has been entirely guided by its quantum potential to the upper half so that it has no presence in the downward reflected beam.

The standard view draws an analogy between charged particles, the mouths of Rosen wormholes and sunspots. The annihilation of positrons and electrons corresponds to the release of the energy in the underlying magnetic vortices of sunspots, when they are destroyed in pairs at the end of each half solar cycle of eleven years, after having moved from the poles, connected by a thread deep in the solar interior, to the solar equator, with the connecting thread just below the surface and about to burst into a magnetic storm.

Stückelberg and Feynmann showed that incoming positrons with positive energies can be equated with outgoing electrons with negative energies, inverted momenta and temporal orientation, so that the transition from the one to the other releases twice the electron’s energy. The dynamics of the interaction is well understood. If, instead of transitioning to a state of negative energy, the electron *merged* with one, both would vanish and no energy or charge would be released or lost. This corresponds to folding its worldline into a kink. The phenomenon may be so widespread as to remain largely unnoticed, being at the root of the very quantum evolution of particles, the wave being built from the orthochronous path segments and its conjugate from those having a reversed 4-velocity, mass and charge.

What may matter in the transition is the anharmonicity that allows an entity to decohere from (or anticohere relative to) the Machian background. The frequency of oscillation of a single quantum particle is equal to its energy divided by the Planck constant. It would therefore be expected that the anharmonic oscillation needed to achieve its de- or anti-coherence requires a frequency, and therefore an energy, similar to its own, that is, of order  $mc$ . Similarly, a composite quantum state such as that of a complex atom or molecule has a quantum behaviour, with frequency proportional to its mass. This is because the frequencies of its component stationary states can add. However, this property can be upset far more easily than that of an elementary entity with a similar mass. Statistically, the typical variance from the mean is proportional to the square root of the number of components. To be spontaneously established within a state of free randomness, coherency requires moving harmonically a number of participants equal to the square root of the population. In the reverse, decoherence should follow the same law, and could be driven by a squeezed anharmonic signal of the same order. But simple decoherence would here result in a shadow electron, or neutrino state that would violate the conservation of charge, unless it is transferred to another body in the process. The full inversion may involve twice the mass of the electron. An EV with  $10^{12}$  electrons may thus require only one  $TeV$ , divided between all its electrons, so that one  $eV$  per electron may suffice. This can be provided by an intense and highly squeezed laser beam, by another EV making the transition or simply by

jolting the EV so that some of its internal energy is radiated in the process. The energies involved in the dynamic temporal inversion of EVs in their decoherence within the Machian background would therefore be orders of magnitude smaller than those involved in antimatter annihilation. What happens when this temporal inversion occurs? Just before it happened, the object and its observer had a single worldline. When it began moving backwards in time, there appeared a parallel worldline with the retrochronous object. In order to conserve charge, mass, energy and momentum, the two worldlines must interact and modify themselves so that the dynamics remains self-consistent. In other words, the resulting synthetic trajectory involves history rewritten.

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