Are Pollack batteries possible?

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Abstract

DoNut Lab has made rather bold claims about a solid state battery that they have developed. It is however difficult to understand how these claims could be consistent with the standard views of solid state physics and chemistry. In the TGD inspired quantum biology, the Pollack effect, involving new quantum physics, plays a central role. It is already known that the addition of water to natrium-vanadium batter could increase its charging capacity by almost a factor 2. Therefore it is interesting to see whether the Pollack effect as an additional element could allow what might be called a Pollack battery, perhaps consistent with the claims of DoNut Lab.

1 Introduction

This article was motivated by the claim of Donut Lab about a breakthrough in battery technology. February 2026, Donut Lab published one of a planned series of independent VTT test reports [D1] (see this) covering fast-charge performance only. All other claimed specifications – energy density (400 Wh/kg), cycle life (100,000 cycles), extreme-temperature tolerance, safety, and cost – remain entirely unverified by any independent party.

Using Claude Cowork Deep Research, Marko Manninen has prepared a report [L25] (see this) and a Youtube video (see this) about the claims related to the Donut battery. The report compares the measured performance of the Donut Lab Solid-State Battery V1 against current lithium-ion technologies and competing solid-state efforts. All Donut Lab figures are derived from VTT test data where available; all competitor figures come from published specifications and third-party reports. Where Donut Lab data is unavailable, scenario analyses and flag assumptions are represented clearly.

What was announced was "Ultra high energy density, the fastest charging time, practically unlimited cycles, extreme safety, and lower price than lithium-ion". The reactions from professional circles have been skeptical. It is indeed difficult to see how the claims about Donut batteries could be consistent with standard condensed matter physics.

1. The claim about very rapid charging time of about 5 minutes is verified in the VTT test. This corresponds to charging rate 11 C, where 1 C corresponds to a charging time of 1 hour.

2. It was found that there is a high heat production during charging. During VTT Test #6, the cell reached ~ 90 °C under 11C charging with passive cooling only, triggering an automatic safety cutoff by the test equipment — the cell itself showed no damage or signs of thermal runaway.

3. The number of life cycles is claimed to be extremely large, about 10^5 cycle times and testing of so many cycles has been claimed to be implausible since it would require years. VTT made only 7 tests meaning 7 cycle times. The strong heating during the loading by ohmic currents is expected to cause damage to the electrode receiving the charge and this reduces the number of cycle times.

4. The claimed energy density of about 400 Wh/kg is very high. Suppose that the system consists of basic units with mass Am_p (m_p is proton mass) having atomic volume a_0^3, where $a_0 = 10^{-10}$ m. This would give an energy density of $dE/dm = 1.4 \times 10^{-10}$, where the unit $c = 1$ is used. This would mean .1 eV per proton mass $m_p \simeq 10^9$ eV.

   The energy density relates closely to the reported energy efficiency related to the counterpart of capacitor charge about 10^5 Coulombs, which is very high but consistent with that for mobile phone batteries. Note that the energy density is proportional to the dielectric constant ϵ of a dielectric possibly used between the positively and negatively charged electrons. It measures how large fraction of energy is stored as chemical energy. For a simple capacitor the energy is mere electrostatic energy.

5. Donut battery is claimed to be a solid state battery cell. VTT did not verify the chemistry of the cell. Donut patent application gives the following information about the battery.

- Cathode with cathode material in particulate form + polymeric binder (polymeric binders are used to bind together battery materials)
- Solid electrolyte with solid electrolyte material + polymeric binder
- Anode with anode material in particulate form + polymeric binder

Module is manufactured *without* use of: Prussian blue ($Fe_4[Fe(CN)_6]_3$), lead, cadmium, cobalt, nickel, mercury, manganese, sulfuric acid, organic solvents, fluorinated compounds, antimony, arsenic, beryllium, thallium, selenium, perfluorinated compounds, polyvinyl chloride, silicon, lithium, neodymium, dysprosium, lanthanum.

The basic problem is what is called trilemma. In the framework of standard condensed matter physics, the conditions for high charging speed, large number of life cycles, and high energy density are mutually conflicting. The high charging rate, which has been verified, requires high energies so that the charging involves ohmic dissipation and large energy and momentum transfer to the electrode causing its deterioration. It is claimed that the momentum transfer during the charging is small.

The following is a kind of private brain storming session about whether TGD based physics could allow the the realization of batteries based on Pollack effect [I2, L1, I5, I3] consider from the TGD view point in [L1, L2, L14, L7, L15, L13]. I am not specialized to battery technologies and these considerations are just speculations and need not have much to do with the Donut Lab battery, except as a thought ignition and framing the energy charging, storage, and dissipation systems. The basic inspiration comes from biological analogies and the charging of the battery is regarded as an analog of photosynthesis.

The notions of field/magnetic body, the hierarchy of effective Planck constants and Pollack effect are the key elements of the model and the following gives a brief summary of h_{eff} hierarchy and Pollack effect.

1.1 Large h_{eff} phases of ordinary matter behaving like dark matter

Large h_{eff} phases of ordinary matter behaving like dark matter are in key role in the TGD inspired quantum biology.

1. In the TGD view of quantum biology, the dark matter at field/magnetic bodies with a large value of h_{eff} is in a central role. The original for the hierarchy of phases of ordinary matter labelled by the values of effective Planck constant $h_{eff} = nh_0$, with estimated to satisfy $h = (7!)^2 h_0$, came from the findings of Blackman [J1] and others about quantal looking physical and behavioral effects of ELF radiation on verterbrate brain occurring at cyclotron frequencies of endogenous magnetic field $B_{end} \simeq .2$ Gauss. h_{eff} measures the scale of quantum coherence identified as the size scale of the space-time surface.

   The number theoretic interpretation of h_{eff} as the dimension of algebraic extension of rationals and degree of corresponding Galois group emerged later and means that h_{eff} measures algebraic complexity. In TGD inspired theory of consciousness [L22, L23] h_{eff} serves as a universal "IQ" and the matter at field body behavin like dark matter would naturally control the ordinary biomatter and receives information from it (say by EEG).

2. TGD inspired quantum biology leads to a model of genetic code [K1] [L9, L4, L5, L12] in which A simple model for linear dark proton triplets predicts their states to be in a 1-1 correspondence with DNA, RNA, tRNA, and amino-acids and the numbers of codons coding for given amino-acid are predicted to be the same as for the vertebrate genetic code [K1] [L9, L4, L5, L12].

3. Especially interesting example of very large h_{eff} are phases labelled by gravitational Planck constant [L11, L10], originally introduced by Nottale [E1]. h_{gr} is proportional to the product of the masses of the systems involved. Also the electric Planck constant h_{em} [L13], proportional to the product of the charges of two systems involved, is important. Genes, cell nucleus, cell, central nervous system and its parts, and even the Earth's biosphere form evolutionary hierarchies with increasing h_{eff}. The negatively charge exclusion zones (EZs) created in the Pollack effect creating $h_{eff} = h_{gr}$ phase at the gravitational body, has a large value of h_{em} [L22, L23].

1.2 Pollack effect briefly

In the Pollack effect (PE) [I2, L1, I5, I3] negatively charged exclusion zones (EZs) are induced at the boundary between the gel phase and water by an energy feed such as IR radiation.

1. The Pollack effect would play a key role in the transfer of ordinary particles to dark phases at the field bodies [L1, L14]. p-Adic length scale hypothesis [L18, L24], for which the number theoretic vision provides a justification, makes possible quantitative predictions.

2. The negative charge of EZ is explained as a formation of flux tubes carrying dark protons, which are interpreted as dark nuclei. Every 4^{th} proton should transform to a dark proton transferred to the flux tubes to explain the observations.

   EZs are able to remove impurities from their interior in conflict with the second law of thermodynamics (SL). The TGD based explanation is that the time reversal by BSFR at the level of MB [L6] also induces an effective time reversal in long time scales at the level of ordinary bio-matter.

3. PE explains the occurrence of a charge separation in living matter. DNA has one negative charge per nucleotide, microtubules are negatively charged, the cell is negatively charged, and ATP carries 3 units of negative charge. Therefore ZEO suggests that PE plays a key role in bio-control and macroscopic SFRs play a key role in living matter.

4. Pollack effect is expected to occur at quantum critical temperature $T_P \sim 300$ K for the Pollack effect involved with the transformation of nucleons to their dark counterparts at magnetic flux tubes. Dark nuclei would transformed to ordinary nuclei liberating almost all nuclear binding energy.

   T_P could be near the Hagedorn temperature for gravitational monopole flux tubes (for the TGD view of the notion of gravitational Planck constant. [L11, L10]). At the level of chemistry, the Pollack effect would naturally correspond to the flip of a topological qubit having as its bit values OH and O^- + dark proton [L16] and this means that it has many generalizations.

It has become clear that of Pollack effect can be generalized considerably [L13]. A mechanism providing the energy needed to kick ordinary protons to dark protons at the monopole flux tubes. Photons are one such mechanism but one can imagine large number of mechanisms of this kind. This suggests that Pollack effect is plays a key role in quantum biology [L21, L2, L7, L15, L13, L20].

Also "cold fusion" identified in TGD as dark fusion at the monopole flux tubes of the magnetic body could involve Pollack effect [L17]. One can also speculate with the role of generalized Pollack effect in making possible conscious computers as hybrids of classical and quantum computers [L16, L19].

In the sequel the idea of Pollack battery will be discussed.

2 Could the notion of Pollack battery make sense?

I have considered the possibility that the Pollack effect plays a central role in electrolysis, which is the key effect in the chemistry of batteries. The following is an attempt to build a model for a battery based on the Pollack effect.

2.1 What could Pollack battery mean?

The claimed properties of the Donut battery can be used as guidelines in speculations. Something new making possible the rapid charging and the resolution of the trilemma and Pollack effect could be the missing element. I have discussed its generalization and possible applications to biology [L11, L13] and also to develop some speculative ideas about living computers [L16, L19]. It is best to proceed by inventing objections and be ready to challenge which is believed to be known about batteries and electrolytes.

2.1.1 Evidence for the importance of the Pollack effect in the case of batteries

The recent finding reported in ScienceDaily (see this) that addition of water to a Sodium-Vanadium battery increases its charge capacity almost by a factor 2, suggests that the Pollack effect for water is in an essential role in this case. Note however that the presence of the gel phase would be necessary.

What is nice is that Sodium and Vanadium are not rare metals unlike Li. Researchers found that keeping water inside a key sodium-ion battery material nearly doubled its charge storage. It also charges faster and stays stable for hundreds of cycles. This discovery could make lithium obsolete. The same material can also desalinate seawater into drinking water.

1. Could the Pollack effect occur at the electrode becoming negatively charged or in the counterpart of electrolyte between the electrodes?

2. The Pollack effect generates negatively charged EZs in water. This should also occur in the general case. In the case of the Pollack battery, the negative charge would be generated at the electrode, which provides the dark positive ions. A small value of $\Delta E = E - E_{opp}$ can prevent the transfer of negative charge by ohmic conduction. The value of E could be increased during charging.

   There is evidence for the change of the arrow of time at the electric field body for EZ, which suggests a large value h_{em} [L22, L23]. If also the negative ions are in large $h_{eff} = h_{em}$ phase (proportional to the charge of the electrode), the transfer could occur without dissipation but is prevented if the sign of the $\Delta E = E - E_{opp}$ is wrong.

3. The huge dielectric constant ϵ (as large as 10^6) strongly suggests that chemical energy storage dominates over electrostatic energy storage. This storage would naturally occur to the electrolyte serving also the role of the gel phase acting as a catalyst. Note that Pollack effect could be catalyzed also by hydrophilic polymers. The energy storage would be chemical as in biosystems and the electrolyte would take the role of proteins and lipids. This suggests that the solid state electrolyte should be an organic material able to store metabolic energy. Carbon polymers carrying energy in carbon-carbon and carbon-hydrogen bonds is what suggests itself.

2.1.2 Generalized Pollack effect as an explanation for the fast charging?

The fast charging could be understood if the ions are generated by the Pollack effect or its generalization at the second electrode. Protons or perhaps even alkali ions could be generated by the generalized Pollack effect. In the presence of an electric field the positively charged ions would travel to the second electrode in the electric field (note that for static electric fields the voltage is the same along the space-time sheet for ordinary matter and for the magnetic flux tube).

Since the value of h_{eff} is large, dissipation would be small and could be even absent if the analog superconducting is in question. Therefore the travel time would be very short and could make rapid charging possible. In the simplest classical model the particle would experience the analog of free fall in the approximately constant gravitational field of Earth.

What is nice is that in the case of a Pollack capacitor the electrodes could consist of the same material.

2.1.3 Electrolyte in gel phase is needed as a catalyst of Pollack effect

The ordinary Pollack effect for water involves a gel phase bounded with the water. Presumably it acts as a catalyst for the Pollack effect. The electrolyte is a good candidate for a catalyst and should consist of organic matter, some kind of polymer. In ordinary batteries, the electrolyte is believed to act as a storage of chemical energy. Is this condition consistent with the catalyst property?

In standard chemistry it is thought that catalyst provides temporarily the energy needed to overcome the potential wall preventing the reaction to proceed rapidly. Could the electrolyte in gel phase provide temporarily the energy to kick proton the magnetic body? Does the catalyst return to the original state or to an excited state in which case it could store energy chemically, which seems to be necessary? Could this transform the gel phase to ordinary phase so that the battery would age?

2.1.4 How is the energy stored?

1. The simplest Pollack battery would involve electrolyte as a mere catalyst; it would not store energy as chemical energy. This option is unrealistic.

   Ohmic conductivity makes possible the transfer of currents in the electrolyte and the storage of energy as electric energy. Taking into account the contribution of the electric energy means the replacement of the electric energy $CU^2/2$ with electric plus chemical energy $\epsilon_r CU^2/2$. For water the value is in the range 78-80. Doped semiconductors/polymers can have dielectric constant exceeding values 10^6.

   This suggests that the chemical storage of energy dominates over the electrostatic storage so that the charging by Pollack effect should transfer energy to the electrolyte acting also as a catalyst in gel phase (also hydrophilia could be enough for to catalyze Pollack effect). The chemical energy storage to the excited states of the catalyst, gradually destroying the gel phase, is what comes to mind. The ohmic diffusion of protons to the electrolyte could modify the chemisty or the electrolyte and give rise to chemical energy storage.

   Donut LAB claims that their battery is a solid state battery. Also polymers in solid state can act as catalysts. The question is of whether they can catalyze Pollack effect, perhaps by providing monopole flux tubes carrying the dark ion currents making quantum tunnelling possible.

2. Could one consider any other storage mechanisms? Here biology suggests an idea: in the case of DNA and cell, interpreted as stable exclusion zones, the magnetic body serves as a stable storage of dark protons. This is due to the formation of dark nuclei as bound states of dark protons preventing reverse Pollack effect.

   Could it be possible to store the energy of the battery to the magnetic body instead of chemical storage to the electrolyte? Could the very large value of di-electric constant possible for batteries (as high as $\epsilon_r \sim 10^6$) actually reflect the storage of the energy at the magnetic body?

2.1.5 The energy source for the generalized Pollack effect?

1. Photons as energy source needed to kick protons or even alkali ions to the magnetic body are missing now also thermal photons could do this (the efficiency increases temperature range 80-100 °C). The kicking requires energy ΔE_P, which is expected to be not far from .05 eV [L16]. The electrostatic energy in the voltage between electrodes should therefore act as the fundamental energy source during the charging of the battery. This energy could be transformed to chemical energy or possibly some other forms of energy, say at the magnetic body. Could cyclotron states with a large value of h_{eff} be considered?

2. The dark protons should end up to the second electrode, already during the charging or at least when the stored energy is used. If the dark proton behaves classically, it accelerates in the electric field and gains the energy $\Delta E_c = e\Delta V$. The problem is that the dark proton (or alkali ion) could transform to an ordinary proton already before the electrode. When it transforms to an ordinary proton at the electrolyte or electrode it gives its energy $\Delta E_c + \Delta E_P$ and its momentum to the electrode. This is expected to cause heating and degradation of the electrode.

2.1.6 Could Pollack effect occur by quantum tunnelling?

If a long scale quantum coherence is involved, one can ask whether the Pollack effect could take place by quantum tunnelling. Note that biocatalysis requiring a gel phase could be an alternative description for quantum tunnelling.

1. Suppose that the energy gain $e\Delta V$ between the location P of the Pollack effect - either second electrode, call it E_2 or position inside electrolyte - and second electrode, call it $\Delta E_{max} = e\Delta V_{max}(P, E_2)$, equals to the energy ΔE_P needed to transform the proton to dark proton. This gives the condition $\Delta E_{max} = \Delta E_P$.

   This condition does not allow the transformation of the dark proton to ordinary proton before it has reached the second electrode. After this the dark proton can transform to an ordinary proton and gains energy ΔE_P and corresponding momentum. Therefore it causes minimal recoil effects at the electrode. The protons too near to the target electrode cannot reach it and for $e\Delta V_{max}(E_1, E_2) = \Delta E_P$ the protons can be transferred only from E_1 to E_2 only.

2. The positive electrode generates an opposing electric field E_{opp} causing a gradually increasing opposing electric force. It is enough to have a gradually increasing electric field ΔE, which exceeds this opposing electric field. The dark positive ions would experience the force $\Delta E = E - E_{opp}$. This would save energy in charging and minimize the effects caused at the positive electrode. The positive ions could be transferred with minimal energy and momentum transfer to the positive electrode. ΔE could be much weaker than the electric field E_{opp} between the electrodes defining the voltage of the battery. This would minimize the damage to the electrode.

2.1.7 How to maximize the capacity of the battery?

A large charge for the capacitor-like system is required. One can consider two options.

1. The surface areas of the separate electrodes could be maximized by folding to form an accordion-like structure. There would be a continuous separator, which enhances efficiency, increases safety, and manages volume changes better than winding. It seems that this is not the case now.

2. Biology suggests a different solution to the problem. Folder the entire capacitor. In the cell, the interior and exterior are analogous to the plates of the capacitor. Cell membrane is a highly folded connected structure consisting of two lipid layers to which one could assign the opposite charges.

   Interestingly, the cortex is also highly folded, which supports the idea that the surface area and the associated charge are maximized for both cells and cortex to increase the value of the total charge. This ensures maximum value of electric Planck constant h_{em} proportional to the total charge of the bilayer and serving as a universal IQ in TGD inspired theory of conscious experience [L22, L23].

   The idea is that the standard capacitor plate is replaced with a very thin, highly folded bilayer with layers taking the role of oppositely charged capacitor plates. These bilayers are insulated from each other by using a polymer so that dielectric breakdowns do not occur between the electrodes. The polymer could serve as the electrolyte and and as catalyst when in gel phase.

2.1.8 So: what could the Pollack battery look like?

The first guess for the structure of the Pollack battery would be as follows.

1. Both electrodes would be of the same material allowing Pollack effect. The battery would be a highly folded membrane like structure analogous to a cell membrane.

2. The electrolyte between the electrodes would be partially in gel phase and act as a catalyst for the Pollack effect. It would also store energy to the excited states of the catalyst. Presumably this would spoil the gel phase property and lead to the aging of the catalyst.

3. Charging by Pollack effect could involve quantum tunneling between the electric field used for the charging. This could be a counterpart for the description in terms of a catalyst providing temporarily the energy needed to overcome the potential barrier for the Pollack effect.

2.2 Biosystems as role models for Pollack batteries

Could one take biological systems as role models in attempts to guess what the Pollack battery could look like? Pollack effect plays a key role in the TGD inspired quantum biology and occurs for cells and DNA/RNA. Membrane bounded biological structures act as batteries. Also the charge separation for DNA-magnetic body pairs defines a charge separation and therefore a battery in an abstract sense. Water is essential for the Pollack effect in the living system. Is it needed? As already noticed, the addition of water can almost double the charge capacity of Na-Va batteries.

1. The positive electrode and electrolyte should allow the Pollack effect in which alkali ions are transformed to dark ions at the magnetic body of the system. Cell membrane is a battery and many alkali ions are involved (H^+, Li^+, Na^+, K^+, Ca^{2+}, Mg^{2+},..) [J1]

2. An energy source replacing photons is needed and the voltage used to charge the battery could do the job. The cell membrane potential is analogous to the voltage of the battery and the generation of nerve pulse is analogous to discharging followed by charging.

   The dark alkali ions, such as Li^+, could flow in the charging voltage from the cathode and electrolyte to the opposite electrode with very small ohmic resistance. This would be essential for rapid charging.

3. Gel phase is needed for the Pollack effect in water. In the case of cell membranes, gel-sol phase transition creates gel phases. This suggests that the organic polymer forming the electrolyte should be in gel phase, at least during the charging. Also the other electrode or both of them could be organic polymers.

4. Intriguingly, DNA/RNA nucleotides involve negatively charged phosphate giving DNA and RNA constant negative charge density. In this case the dark phase is stable and the proposal is that binding energy of the dark nuclei formed from dark protons (binding energy is much smaller than for ordinary nuclei) guarantees the stability. These dark nuclei would be essential for "cold fusion" [L8, L17]. The interpretation could be in terms of the exclusion zone (EZ) characterized by a large electric Planck constant h_{em} proportional to the charge of the codon or gene. This predicts a hierarchy of phases with increasingly longer quantum coherence length and h_{em} serving as a measure of algebraic complexity and defining a universal "IQ". Similar hierarchy is predicted also for membrane like structures enclosing negative charged interior (cell organelles such as mitochondria, cell nucleus, cell, neutron,...) [L22, L23].

2.3 Some brave guesses

Just for fun, one can make brave amateurish guesses about the actualization of the Pollack battery.

2.3.1 Polymer based batteries as Pollack batteries

1. There exists a large class of polymer based batteries (see this). Lithium polymer battery serves as a representative example (see this). In this case, the cathode providing positive alkali is Lithium Iron Phosphate $LiFePO_4$. It is not clear whether the Donut battery involves Lithium or not. One could however also consider other alkali atoms instead of Li.

   Also DNA and RNA have one negatively charged phosphate ion per nucleotide. The finding that the addition of phosphates increases the otherwise pure conductivity of the system, suggests that dark Li^+ ions associated with EZ can act as current carriers.

2. The electrolyte could consist of polyethylene oxide polymer, $LiCF_3SO_3$ salt, and silane-treated Al_2O_3 (Al_2O_3-ST) ceramic filler. Polyethylene (plastic) is a simple hydrocarbon of form ...-(CH_2)-... Its oxide contains oxygen atom periodically to give -C-O-C-....One can also consider other alkali atoms instead of Li and also the possibility that the electrolyte involves Li atoms but Li ions are not charge carriers.

3. It is found that the charging capacity of the Donut battery is best in the range 80-100 ^{circ}C (350-370 K) [L25]. At this temperature the thermal energy is .035-.037 eV and of the same order of magnitude as the electrostatic energy of the cell membrane. This suggests that thermal photons also contribute to the Pollack effect.

4. What is fascinating is that the performance of a given Donut battery is reported to improve in repeated tests. Could the Donut batteries share with biology also the possibility of self organization and evolution. Evolution is predicted to occur in all scales in the TGD Universe [L22, L23].

5. In water bounded by a gel for which Pollack effect certainly occurs. As already noticed, the addition of water to Sodium-Vanadium battery increases the charge storage capacity by a factor of almost 2 and also the charging becomes faster (see this). The addition of water between bilayers of a folded capacitor-like system consisting of a catalyst in a partial gel phase could be considered.

2.3.2 Could a modification of Carbon Nanotube serve as the electrode material?

The claim that Li ions are not involved as charge carriers, inspires the consideration of more exotic options. There is a claim (see this) that chemical batteries cannot have the claimed similar behavior at 30 °C and 80 °C (Arrhenius equation) (see this).

A further claim is that Donut Lab uses Spintronic Nanocarbon, which also has magnetic structure, which would naturally relate to the needed monopole magnetic flux tubes as charge carriers. Spintronic nanocarbons utilize carbon-based materials like graphene and nanotubes for manipulating electron spin, offering low-power, high-speed, and durable computing alternatives to traditional electronics.

1. Could a modification of CNT (see this) serve as a building block of the second electrode or even both electrodes of the Pollack battery? For the latter option the battery would be a completely symmetric structure, a kind of flip-flop.

2. What about electrolyte (say polyethylene oxide polymer, $LiCF_3SO_3$ salt, and silane-treated Al_2O_3 (Al_2O_3-ST) ceramic filler)? Could it take only the role of the gel phase? This would conform with the claim that Li ions are not charge carriers.

CNT has an aromatic ring with six C atoms as a basic building block. Each C atom has a double bond with one of the neighboring 3 carbons associated with an aromatic ring.

1. It is known that -OH groups can be added to the defects (C=C is replaced with C-C) associated with the aromatic rings and the surface of CNTs so that they could serve as seats of Pollack effect in TGD Universe [L3]. The Pollack effect as transformation -OH→ -O^- + dark proton. If this occurs at the first electrode E_1 it becomes negatively charged and one obtains a capacitor like system. Its capacitance could be made large by multi-folding of CNTs.

2. If the electrolyte consists of CNTs, there is a problem. How to get the negative charge of $-(C-O^-)-C$ produced in the Pollack effect to the E_1? Could one imagine that the reaction $-(C-O^-)-C \rightarrow -C = C + O^-$ removing the defect takes place first and after that O^- is transferred to E_1 in the electric field? Or can one think that O^- is transformed to $O + e^-$ (this however requires energy) and dark electron e^- is transferred to E_1. Could also this process occur by quantum tunnelling in the same way as the transfer of the proton.

   If this problem cannot be overcome, only the electrode E_1 can consist of CNTs with -OH side groups. The electrolyte could consist of some organic polymers able to provide dark protons by Pollack effect and allowing the negative ion to donate the electron. Clearly, a fine tuning of the voltage would be required to make the charging maximally effective.

2.3.3 It is enough that polymer is hydrophilic

The problematic assumption that a gel phase for electrolyte is needed turned out to be too strong as I learned from Esa-Juhani Ruoho whose sent an excellent article by Thomas Brown [I4] discussing the relationship between icosahedral geometry and Pollack effect. In the usual Pollack effect, it is actually enough to have a hydrophilic polymer instead of a gel, and there are many of these. Hydrophilic polymers are possible also in the solid state as Google says.

1. Hydrophilicity favors certain amino acids on the surface of the protein that borders on water. Roughly one half of the amino acids are hydrophilic. When proteins fold, proteins arrange themselves in water in such a way that hydrophobic amino acids border the cavities inside and hydrophilic amino acids face the water.

2. There are 11 key hydrophilic amino acids.

   - 6 polar uncharged: Serine (Ser, S), Threonine (Thr, T), Asparagine (Asn, N), Glutamine (Gln, Q), Tyrosine (Tyr, Y), and Cysteine (Cys, C).
   - 3 positively charged (basic) : Lysine (Lys, K), Arginine (Arg, R), Histidine (His, H).
   - 2 negatively charged (acidic): Aspartic acid (Asp, D), Glutamic acid (Glu, E).

3. Their key properties are as follows.

   - They are highly soluble in water because their side chains can form hydrogen bonds.
   - Protein Structure: They are typically found on the surface of globular proteins, interacting with the aqueous environment.
   - Catalysis: Charged hydrophilic amino acids (like His, Asp, Glu, Lys) are crucial in the active sites of enzymes, facilitating chemical reactions.
   - They are "water-loving" in contrast to hydrophobic amino acids (like Val, Leu, Ile, Phe, Trp) which prefer to be inside the protein, away from water.

Does a nanotube with -OH inserts at the defects of the nanotube at which C=C bond is transformed to a C-C bond make it a water-like compound as far as Pollack effect is considered? If so, the Pollack effect would correspond to a transition -OH →O^- + dark proton at the flux tube also in this case.

Could hydrogen bonds form between the hydrogens of the nanotube and some atoms of the solid state polymer? Hydrogen bonds form between a hydrogen atom covalently bonded to a highly electronegative atom (typically Nitrogen, Oxygen, or Fluorine) and another electronegative N, O, or F atom on a nearby molecule. This suggests that the solid state polymer should contain N, O or F. N and O look the most plausible. All above mentioned polymer candidates, i.e. polyethylene oxide polymer, $LiCF_3SO_3$ salt, and silane-treated Al_2O_3 (Al_2O_3-ST) ceramic filler) contain oxygen atoms.

2.3.4 What about the second electrode and what happens when the battery is used?

The discharging of the battery must occur slowly, unlike charging. The battery must behave classically during its use (Ohmic currents) and quantally during its charging.

1. Assume that electrodes E1 and E2 are in the initial state nanotubes prepared making different modifications of double bonds =C

   E1 : =C → -(C-OH) : addition of OH

   E2: =C → -(C=O) : addition of O

   The open question is whether the oxygenation is possible energetically without energy feed.

2. What happens in charging?

   (a) Pollack effect for E1 ocurrs and inducing the modification
   -(C-OH) → -(C-O^-) + dark proton at flux tube

   (b) Dark proton is transferred to E2 and suffers reverse Pollack effect. At E2 one has
   -(C=O) +p, where p is ordinary proton.

3. What happens when the battery is used?

   (a) Pollack effect at E2 is not possible (no -OH groups)! The battery voltage generated in charging induces an ohmic electron current from E1 to E2. The Ohmic current is not quantal and the discharging is slow.

(b) Electron leaves E1 and the transition -(C-O$^-$)-C→-(C=O)-C occurs and e$^-$ is transferred to E2 ohmically.

(c) At E2 e$^-$ combines with a proton to form H. After that the H combines with C=O to give
-(C=0)-C +H -→ -(C-OH)-C
The roles of E1 and E2 are changed!

The next charging must use an opposite loading voltage inducing Pollack effect at E2.

The model is very general. What is essential is that one has a lattice type structure in =X-type units are replaced with -(X-OH)- and -(X=O)- type units for the two electrodes. For instance, carbon nanotubes could be replaced with silicon nanotubes (SiNT), which indeed do exist. Silicon nanotubes, the tubes are not smooth but wrinkled: this would increase the capacity to load charge.

The objection against the proposal is that the energy difference between states -C-(C=O)-C + e$^-$ and -(C-O$^-$)-C is large and of wrong sign so that e$^-$ is tightly bound to -(C-O$^-$)-C and Ohmic current cannot be generated. I am not a chemist but I am able to use Google, which answers as follows.

"The energy difference between a neutral carbonyl group plus a free electron $(-C-(C=O)-C+e^-)$ *and the resulting radical anion* $(-C-(C-O^{\bullet -})-C)$ *is characterized by the electron affinity (EA) of the carbonyl compound. For simple aliphatic ketones like acetone, the energy difference is* ≈ 0.0 *to* $-0.5\ eV$ *(approximately* 0 *to* 12 *kcal/mol). This indicates that the formation of the radical anion is typically isothermic or slightly endothermic in the gas phase."*

This would suggest that the liberation of e$^-$ to become a carrier of ohmic current does not require energy or occurs even spontaneously and is made possible so that the electric field of the battery generates ohmic current.

2.3.5 Objections

The basic counter-arguments against the notion of Pollack battery relate to dynamics.

1. The number of dark protons matters. According to the findings of Pollack, every fourth proton in the water in the EZ region is transferred to the magnetic body. This is quite a large number. This provides an order of magnitude estimate of the maximum amount of charge transferred via quantum tunnelling followed by the reverse Pollack effect. If the electrodes are wrinkled, as would happen for the ase of SiNT, the area of the electrodes increases and so does the maximal number of dark protons.

2. The time scale for the lifetime of $(H_3O_2)^-$ phase is attosecond in water. The large fraction of dark protons would give reason for optimism. In the case of DNA, RNA, and cell membrane the region with negative charge is stable and formation of dark nuclei from dark protons should imply the stability against the reverse Pollack effect.

3. At what speed does the transfer to the opposite electrode by quantum tunnelling occur? The tunneling probability could be estimated based on the existing formula for quantum tunnelling by simply replacing Planck constant h with h_{eff}. The tunnelling rate is an exponent $exp(-X)$ of a term X proportional to $1/\hbar$.

   The intuitive expectation is that for ordinary Planck constant X is very large in the scales considered so that tunnelling probability is essentially zero. However, the replacement $\hbar \rightarrow \hbar_{gr,E} = GM_e m_p/\beta_0 \sim 10^{13}$ for a proton could make $X \propto 1/\hbar_{gr}$ small enough. An additional parameter possibly needed as a multiplicative factor is the amplitude for OH → O$^-$ + dark proton decay. The optimistic first guess is that this parameter is of order 1.

Consider now an estimate for the tunnelling amplitude A, whose modulus squared gives the tunnelling probability.

1. Apart from the numerical factor of order one, the amplitude A can be written as an exponent and represents the value of a wave function at point L at E_2. In the classically forbidden region $0 < x < L$ the wave function is an exponentially decreasing function. $\int_0^y k(x)dx$ is

analogous to a plane wave $exp(iky)$ with imaginary momentum. By using the relationship $k(x) = p(x)/\hbar$ and $p(x) = \sqrt{2m(E - V(x))}$ between wave vector and momentum, one obtains

$$\begin{array}{ll} A = exp(-X) & X = \frac{1}{h_{eff}} \int_0^L p(x)dx \ . \\ p(x) = \sqrt{2m(E - V(x))} \ , & \end{array}$$

In the recent case, $V(x)$ is Coulomb energy $V(x) = eE_0x$ for the proton and m is proton mass. In the Earth's gravitational field one has $h_{eff} = \hbar_{gr,E} = GM_Em_p/\beta_0 = r_s(E)m_p/2\beta_0$, $r_s(E) \simeq 1$ cm. The velocity parameter $\beta_0 = v_0/c \leq 1$ has a spectrum of values but there are arguments supporting $\beta_0 \simeq 1$ as the most plausible value for the Earth. For the Sun the value $\beta_0 \simeq 2^{-11}$ is favored.

2. The boundary condition is that the proton, kicked by Pollack effect from the electrode E_1, arrives at rest to the electrode E_2. This gives

$$E = V(L) = eE_0L = eV_0$$

where E_0 is a constant electric field of the battery and V_0 the voltage between E_1 and E_2. This gives

$$p(x) = \sqrt{2m_p(V(L) - V(x))} = \sqrt{2m_pV_0}\sqrt{1 - x/L}$$

The integral appearing in the definition of X can be calculated analytically and one obtains

$$X = \frac{4\sqrt{2}}{3}\sqrt{\frac{eV_0}{m_p}\frac{L}{r_s(E)}} \ .$$

3. An order of magnitude estimate is obtained by assuming $eV_0 = 1$ eV implying $eV_0/m_p \simeq 10^{-9}$, $L = 10$ cm. For $\beta_0 = 1$, this gives

$$X \simeq 6 \times 10^{-4} \ .$$

The value happens to be quite near to the value of $\beta_0 \simeq 2^{-11}$ for the Sun. The value of X is so small that $exp(-X) \simeq 1$ is true in a good approximation.

The conclusion is that, unless the additional coefficient possibly present is very small, the tunnelling probability can be large enough.

2.3.6 Pollack battery is not the water battery of Pollack

One should not confuse the water battery (see this) proposed by Pollack to Pollack battery. The water battery of Pollack corresponds to the voltage difference that arises between the EZ and the environment due to irradiation. It is not a battery except in a figurative sense.

1. In the TGD version, the Pollack battery is charged using an external voltage that supplies energy to kick protons into a magnetic body and instead of water there is, for example, a nanotube and the electrodes are connected by -OH and =O insertion into double bonds. In this way, a rechargeable battery is obtained.

2. Another fundamental difference is that Pollack interprets the Pollack effect without assuming a magnetic body and only assumes that by some unknown mechanism the protons end up outside the EZ. Such a mechanism has not been found in standard chemistry. Pollack's water battery is based on the Pollack effect in its basic form.

   Therefore there is no assumption of large h_{eff} phases, which are essential in the TGD model and the associated dissipation-free acceleration by magnetic flux tubes. These phases also explain why cold plasma appears in electrolytes. They also explain cold fusion. As well as the relativistic energies for electrons associated with lightning.

2.3.7 Are there indications that Donut battery contains water consistent with the Pollack battery property?

The most recent test by VTT studied the Donut battery for which the plastic pouch containing the battery was degraded at temperature near 100 degrees Celsius [L25]. According to the VTT raport, vacuum was lost in the high temperature test test and agglutinations have contained a hole or a hole has appeared during the test.

1. The expansion of the popped battery by 17 percent has been used as a counter argument to the claim that the counterpart of electrolyte is in a solid state.

   The temperature of 100 degrees indicates that water was present and evaporated at this temperature. Water expands dramatically in evaporation. During the preparation of the paste UV drying is applied and if this drying has failed to be complete, the battery could have contained water. In TGD framework one can ask whether water was somehow created by the Pollack effect.

2. Water, which has been traditionally considered a battery poison, was found a few years ago to increase the charge storage capacity by a factor of two. Did the boiling of the water present from the beginning or the water created in the system cause the pop? Could the water give an additional contribution to the Pollack effect and improve the Pollack battery in some aspects, at least at temperatures near the physiological temperature, which could be optimal for the Pollack effect? Or is the effect opposite?

3. How could water have been created if it was not present originally? Let's assume a Pollack battery based on nanotube electrodes. The addition of -OH groups induce the transformations C=C $\rightarrow$ C-(C-OH). This is necessary for the occurrence of the Pollack effect as a transition -OH$\rightarrow$ O^- + dark proton at the flux tube. Did dehydration of the hydrated nanotube, resulting in the formation of H_2O molecules, occur? The water created in this way would have evaporated at 100 degrees and induced the expansion of the battery.

4. How would dehydration have occurred?

   (a) Assuming that 2 -OH groups at adjacent hexagonal rings of nanotube (defects in the nanotube) have been transformed by the Pollack effect into the state -O^- + dark proton H^+ on the magnetic body.

   (b) Assume that two dark protons drop back from the magnetic body by the reverse Pollack effect and attach to the second O^- so that H_2O^+ ion is formed. Suppose that after this the second O^- donates its electron for H_2O^+ ion so that H_2O and =O are formed so that one -OH defect of the nanotube disappears. The reverse Pollack effect would therefore produce dehydration of the electrode. The rates for the Pollack effect and its reversal by the dropping of two dark protons would determine the fraction of water present in equilibrium state.

2.4 Cell, neuron and ordinary battery as Pollack batteries?

Could it be thought that the second electrode of a Pollack battery and perhaps even a regular battery would be identified as its magnetic body!

1. Let's assume that charging occurs by quantum tunneling so that at the end the external charging voltage is set to zero. What happens? Does conservation of energy force the formation of bound states as dark nuclei on the magnetic body of the second electrode as assumed. It would fit the "cold fusion" model [L8, L17].

2. What happens when an external load, which slightly reduces the battery voltage, is connected to the battery? Current should start flowing as electrons through the load and cause the reverse Pollack effect. How would that happen? If negatively charged nanotube based electrode contains -C-O^- as charge carriers would donate electrons that would travel to the positively charged electrode, where positive dark protons associated with dark nuclei would form atoms (proton $\rightarrow$ H) and drop down onto the electrode as ordinary hydrogen atoms.

The charge of the magnetic body would and the voltage would gradually decrease. If cold fusion occurs, the dark nucleus transforms to ordinary nucleus rather than ordinary hydrogen atoms.

3. Also a normal cell would be a Pollack battery. Now there would be many different alkali ions involved. The magnetic body of mitochondria would mainly contain protons. In energy metabolism producing ATP from ADP, the electrons energized by the chemical energy of sugars would release energy as they pass through the cell membrane and fuse with dark protons to form hydrogen atoms that would then flow through the cell membrane back and provide their energy to form ATP from ADP in a nano-machinery analogous to a rotating shaft of power plant.

4. What about neurons and nerve pulses? Nerve pulse would correspond to the discharging and recharging of a Pollack battery taking place in milli-second time scale. This would happen when the voltage falls below a critical voltage, not when it exceeds it (dielectric breakdown), as common sense suggests. Why is this so? I have tried to understand this and made suggestions.

   Is this related to the system being formed by tunneling? What happens if the voltage decreases? The Coulomb energy of positive charges decreases. Does the conservation of energy also now force a current that collapses the voltage very rapidly? There would be a catastrophically fast battery discharge followed by a recharging. Is the charging by quantum tunneling related to this? Wouldn't it be possible to get to an energetically possible state and decreasing the voltage would only make the situation worse?

5. How is the normal battery discharged? How it can be made to happen very quickly. Is a high compensating voltage needed? Going to Google led to a surprising discovery: all batteries are characterized by a phenomenon known as self discharge! They spontaneously discharge when the voltage is below a certain value (see this).

2.5 A classical model for the charging by Pollack effect

The following purely classical model for the charging of the Pollack battery is very simple but might give some idea about orders of magnitude. It has already become clear that quantum tunnelling seems to be a more realistic model. For simplicity one can consider a piece of the Pollack battery looking like an ordinary capacitor. The batteries with large values of charges of order 10^5 C involve a multiple folded pair of electrodes.

The transversal dimensions of the batteries used in mobile phones are of order $l \sim 10$ cm and the thickness is $d = 2$ millimeters. The total length of the folded bilayer is of order $L = 1$ m. The thickness of the bilayer varies in the range $h = 20 - 25$ μm. This would allow the bilayer to fold in the vertical dimension $N < d/h \sim 10^2$ times $N \sim 10$ would give a length of 1 meter.

One must solve Newton's equations for the motion of charge in the constant net electric field $\Delta E = E - E_{opp}$ associated with the pair of electrets. One can require that $\Delta E = e\Delta U/h$ is time independent and has the correct sign (for clarity voltage is denoted as U). For proton (mas m_p), the solution can be written as

$$h = \frac{e\Delta U \tau^2}{2hm_p} \quad .$$

Here τ is the time taken to travel the distance h between the electrodes. This gives

$$\frac{\Delta U}{V} \times \frac{eV}{2m_p} = (\frac{h}{c\tau})^2 \quad .$$

Note that ΔU is invariant under the scaling $h \rightarrow h$ and $\tau \rightarrow x\tau$.Using $eV/m_pc^2 \simeq 10^{-9}$ this gives

$$\frac{\Delta U}{V} = 2 \times 10^9 \times (\frac{h}{c\tau})^2 \quad .$$

From this one obtains τ if h and ΔU are given.

$$\tau = \frac{h}{c}\sqrt{\frac{1}{\Delta U/V}} \times \sqrt{2} \times 10^{4+1/2} \quad .$$

$\Delta U = 1$ V and $h = 20$ μm gives

$$\tau = \frac{h}{c}\sqrt{2} \times 10^{4+1/2} = (2\sqrt{2}/3) \times 10^{-1/2}\ ms \simeq .2\ ms \quad .$$

The scaling of $\Delta U/V$ by a factor 10^{-6} would give $\tau \simeq .2$ s. The scaling of $e\Delta U$ to the voltage .04 eV assignable to cell membrane which corresponds roughly to the thermal energy at room temperature gives $\tau \simeq 4\ ms$ which is the time scale assignable to nerve pulses.

It seems that the time scale is much faster than the charging time scale so one can ask whether the Donut battery could be modelled as a Pollack capacitor. In fact, the TGD view of dielecrets quite generally involves dark ions travelling at monopole flux tubes and also the generalized Pollack effect.

2.6 Charge capacity and energy density

The value $Q = 26$ Ah= 10^5 C of the charge capacity claimed by Donut [L25] measures the total charge of the battery. This value is reached also in mobile phone batteries. The number N of folds ranges for the bilayered folded capacitors in the range $10^3 - 10^4$. The thickness of bilayer varies in the range 10 nm to 10 1.3 μm.

One can make a rough estimate about the charge density associated with the layers of the bilayer from, $Q = N\sigma S_{fold}$, where N is the number of folds, S_{fold} is the area of a single fold and σ is surface charge density.

One can write σ as $\sigma = \rho h$, where ρ is the 3-D charge density and h is the thickness of the layer. This gives the estimate $Q = N\rho h S_{fold}$ giving the estimate $\rho = Q/NhS_{fold}$ for the charge density. The numerical value for $h = 20$ μm and $S_{fold} = 10^{-2}$ m^2 is $\rho = 10^{-2}e/\AA^3$. Roughly every everyone hundredth atomic volume of $\AA^3$, would be charged.

The claimed value of energy density 400 Wh/kg $\sim 1.3 \times 10^6$ J/kg. The amount of energy per proton rest energy m_pc^2 is $E/m_pc^2 = 1.4 \times 10^{-11}$ and corresponds to .014 eV and roughly one half of thermal energy at room temperature. This makes $0.014A\ eV/\AA^3$ if there are A protons per this volume. Note that the energy scale for membrane potential is 50 meV: $A \simeq 5$ would give this value. The difference for the energies of the states -O$^-$ + dark proton and -OH is in the same energy range [L16], which suggests that Pollack effect is involved.

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