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Notes on positrons' extraction from the quantum vacuum

Preamble

This short report is intended exclusively for people of [redacted] already acquainted with the proposal to extract positrons from the vacuum.

BASICS

"Science is science as long as it is able to separate what we know from what we believe" is a modern reformulation of a famous sentence by Confucius. Physics is a typically experimental science: we know experimental facts, we believe in accepted theoretical interpretations.
In Physics, when verified by experimental evidence, we have LAWS, PRINCIPLES, RULES, MODELS
If something happens experimentally, some rule, law or model must allow it to occur; if something does not happen, some rule, law or model must forbid it.
For instance we believe in the ENERGY-MOMENTUM CONSERVATION PRINCIPLE. We believe in the HEISENBERG UNCERTAINTY PRINCIPLE.
So far, we did not observe any process in which neither the ENERGY-MOMENTUM CONSERVATION PRINCIPLE nor the HEISENBERG UNCERTAINTY PRINCIPLE are broken or violated.
In the case of the experiment under discussion I didn't find one theorist who could tell me what fundamental law or principle is broken or violated in our case.

Paradigmatic case N. 1

We know that a photon γ with energy well above the sum of the masses of the electron-positron pair (e^+e^- pair), in spite of the abundant energy available, can not create an e^+e^- pair <u>in vacuum</u>. Such process violates ENERGY-MOMENTUM CONSERVATION: the photon has zero mass, therefore Einstein relation [$E^2 = P^2 + M^2$] for e^+e^- pair production reads:

For the photon: $E(\gamma) = P(\gamma)$

For the e^+ and the e^-: $E^2(\text{electron}) = P^2(\text{electron}) + M^2(\text{electron})$

$E^2(\text{positron}) = P^2(\text{positron}) + M^2(\text{positron})$

Energy momentum conservation read:

$$E(\gamma) = E(\text{electron}) + E(\text{positron}) \quad [a]$$

$\underline{P}(\gamma) = \underline{P}(\text{electron}) + \underline{P}(\text{positron})$ [b] (vector sum)

If [a] is true [b] cannot be true! The photon has to find a way to create the mass of the electron and the mass of the positron.

Then, if an external electromagnetic (EM) field is present (for instance the electric field generated by an hydrogen atom or any material) able to provide a tiny transverse momentum to the e^+e^- virtual pair, the phenomenon is permitted and very common in elementary particle physics.

<u>Another strictly true rule of quantum mechanics is that a spin ½ particle must have the spin rigorously aligned along the direction of the mechanical momentum (its vector velocity).</u>

Since a photon cannot have any transfer component of the total spin (as a zero mass "pseudo"spin s=1 particle) to make a photon, the e^+e^- pair MUST have their spin rigorously parallel so as to result in a state with s=1.

The pair production process in vacuum contradicts the Energy Momentum Conservation Principle; however it occurs in matter because the EM interaction allows the creation of the e^+e^- masses and slightly deviates apart the trajectories of the e^+e^- pair; the two spins are now not RIGOROUSLY PARALLEL anymore and cannot recombine to make a photon (this transverse momentum contribution is neglected in the calculation of all basic quantum theory books)[ref. missing].

The tiny negligible electric field of the surrounding matter pays ONLY for the e^+e^- separation. The atoms, after some oscillation goes back to the original state. If the photon just knoks on an electron of the atom, the so called trident is produced since there is plenty of longitudinal energy. In a trial calculation an hydrogen atom looses in a 2 → 3 EM process an energy that goes to zero when E_γ goes to $E_\gamma=2M_e$. It is the original γ that provides the energy to create the masses of the e^+e^- pair.

<u>Paradigmatic case N. 2</u>

The HEISENBERG UNCERTAINTY PRINCIPLE relevant to the present project reads:

$\Delta E \times \Delta t > \hbar/2$

The Casimir effect is another important case.

You place two small metallic plates one in front of the other, you make the best vacuum you can get; you leave them there without doing anything and go to drink a beer. The two plates attract each other. Now an easy question arises: WHO PAYS FOR THE ATTARCTING FORCE acting between the two plates? The quantum vacuum.

The quantum vacuum and the uncertainty principle allows for fluctuations fields and of non-zero energy in the ground state of systems with finite as well as infinite degrees of freedom. Observable effects are well known at the microscopic level, such as the Lamb shift and the value of (g-2)e at low energy and the radiative corrections in EM physics at high energy. However these effects are not well tested at the macroscopic level.

Vacuum is plenty of energy; vacuum fluctuations of the EM field result in radiation pressure on macroscopic bodies. The force (pressure) is very tiny but it is there. The ground state is not inviolable and it can release fluctuating energy arising as a consequence of the HEISENBERG INCERTAINTY PRINCIPLE $\Delta E \times \Delta t > \hbar/2$.

The pressure between 2 plane surfaces is

$F_C = \pi\ h\ c/480 = 1.3 \times 10^{-27}\ Nm^2$

$[h = 6.63 \times 10^{-34}$ joule.s]; $[\hbar/2 = 6.63/12.56 \times 10^{-34} = 5.3 \times 10^{-35}$ joule.s]

<u>Paradigmatic case N. 3</u>

The quantum vacuum is full of particle-antiparticle pairs too. You may extract antiprotons, anti-deuterons, anti-helium nuclei and, if you want it, anti-uranium nuclei too. The three first antimatter particles have been produced (in particle-antiparticle pairs) and discovered in the laboratories. Emilio Segré and Owen Chamberlain got the Nobel Prize in 1959 for the discovery of the antiproton. The point is simply to provide enough energy to extract antimatter from the vacuum. To do that for the antiproton they had to build a proper accelerator (the Bevatron at Berkeley-California) to provide the mass energy of 2 protons (about 2 GeV in the center of mass) and smash an intense beam of 6 GeV protons onto a nuclear target at a non negligible cost. The proton-antiproton pair is made of nuclear particles, thus we need a nuclear field to create them. The e^+e^- pair is made of EM particles and we need an electromagnetic field to create them. Here then, the HEISENBERG UNCERTAINTY PRINCIPLE allows for fluctuations providing, at no cost, photons with energy large enough to produce the mass of 2 electrons (about 1 Mev).

<u>Our situation</u>

We asked the trivial question of which is the lightest particle beyond the photon (excluding the neutrino which is, for our purposes, so to speak, a "useless" particle). The answer is: the positron. The problem is coming from the UNCERTAINTY PRINCIPLE $\Delta E \times \Delta t > \hbar/2$. This is true only for a very short time interval!

Now: the time interval Δt must be shorter than $\hbar/2\Delta E$ to preserve the UNCERTAINTY PRINCIPLE.

The mass of 2 electrons is M=1.022 MeV; 1.022 MeV = $1.022 \times 10^6 \times 1.9 \times 10^{-19}$ j = $= 1.94 \times 10^{-13}$ j.

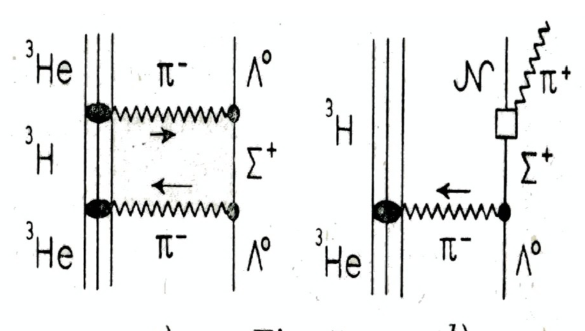
Assuming as a tiny extra energy, i.e. 2×10^{-13} j for the mass of the e^+e^- pair, the time interval is $\Delta t < 5.3 \times 10^{-35}/1.94 \times 10^{-35} = 2.73 \times 10^{-22}$ s. Thus we have to act in less than about 10^{-22} seconds!

This is the crucial point. In a time interval $\Delta t \approx 2 \times 10^{-22}$ s an EM field may propagate for a distance d = 6×10^{-14}m = 60 fermi (fm), a very long distance for point-like particles.

<u>Therefore a photon with $E_\gamma > 2M_e$ can be thought as an electric dipole</u>.

The QED Feynman diagram of a photon is a sequence of $\gamma \to e^+e^- \to \gamma \to e^+e^- \to \gamma \to e^+e^-$...... and the situation is such that the spin orientations are perfectly conserved.

The alternating configurations of virtual states are very common in quantum mechanics. An example (in nuclear physic though) come form an experiment I did way back in 1962/63. An $_\Lambda He^4$ hyper-fragment has a neutron replaced by a Λ° hyperon it can also be thought as a state in which an hyperon Σ^+ replaces a proton. The two configurations are generated by the pion exchange mechanism: $\Lambda^\circ\ p \to \Sigma^+\ n \to \Lambda^\circ\ p \to \Sigma^+\ n \to$ .... The process is sketched in the figure named fig. 7a,b and the nuclear event $K^- + {}_\Lambda He^4 \to {}_\Lambda He^4 + \pi^-$; ${}_\Lambda He^4 \to H^4 + \pi^+$ produced by a stopping K^- beam in a He^4 bubble chamber is shown in fig. 7c.



a) Fig. 7. b)

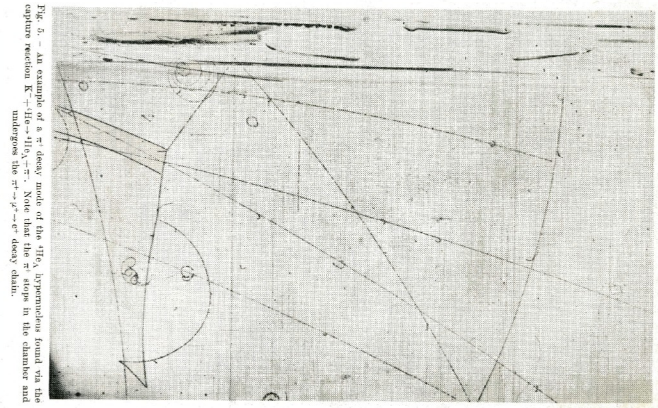


Fig. 7c

One can see the stopping K^- entering the chamber from the upper left; the interaction at rest $K^- + He^4 \to {}_\Lambda He^4 + \pi^-$ after few centimeters (the ${}_\Lambda He^4$ is

collinear to the pion track going upwards; the H^4 is the dark stub from the interaction point stopping after a short range; finally the π^+ undergoes the full decay chain. It travel about 10 cm downwards to rest, it decays into a muon which goes also to rest and decays into a positron that makes about half a circle. The two neutrinos are obviously undetected).
The example supports the idea that one can turn from one configuration the other if the sequence is broken by an external interaction. In the case of the hyper-fragment it is the weak interaction that makes the hyperon (either Λ^o or Σ^+) decay. In our case it is the combined action of external EM and gravitational interactions. In our case the Feynman diagrams replaces the pion exchange process responsible of many observed nuclear phenomena.

The fundamentals of the experiment

In a cubic centimeter there are as many $N=1/\hbar^3$ photons; $N=1.5 \times 10^{107}$ photons. As tiny as it can be the tail of photons with $E_\gamma > 2M_e$, there will be plenty.
We produce a steady translating electric field **E** and a steady translating magnetic field **B** by means of permanent electretes and permanent magnets moved by stepping motors. Furthermore, we generate a gravito-magnetic field by means of rotating liquid heavy material (mercury drops). All stepping motors are driven by means of a 12 volt DC battery and this is essentially the energy we need.
The e^+ and the e^- are at rest and the **E** and **B** move. This is equivalent to having **E** and **B** fixed and the electric charges moving. Thus the Lorentz vectorial force $\underline{F_L}=\pm e\underline{v}x\underline{B}$ and the electric vectorial force $\underline{F_E}=\pm e\underline{E}$ on e^- are rigorously opposite to the Lorentz force and the electric force on e^+. On the contrary, the gravito-magnetic force $\underline{F_G}$ is identical on both e^- and e^+. Therefore the net resulting forces $\underline{R}= \underline{F_L} + \underline{F_E} + \underline{F_G}$, acting on e^- and on e^+ cannot be rigorously parallel and the e^-e^+ pair cannot recombine to form a photon the same way as it is in the e^+e^- pair photoproduction process. (It is worth mentioning that Tajmar and de Matos of ESA [http://www.esa.int/esaMI/GSP/ SEM0L6OVGJE_0.html or http://www.earthtech.org/experiments/tajmar/GM_field/index.html] produced and measured gravito-magnetic fields in the laboratory).
The same DC battery feed a solenoid that through a large impulse extract finally the positrons driving them into a magnetic channel. From here on the problems are of engineering type.

I assume that the pictures of the effects obtained and shown in a CD in our hands are genuine and constitute the knowledge we have so far. We intend to verify and confirm the same results.
I hope the description is clear enough to be useful. Details and technicalities are reported in other documents.

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