Disposing Classical Field Theory, Part V

The Missing Experiments

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Abstract

This paper serves two aims: First, it wraps up the previous parts. Second, it shows that vast areas of particle physics are yet waiting to be explored through relatively inexpensive and small experiments. I divided these into three sections.

It is my hope that a future generation of physicists will rediscover the wealth of experimental simplicity for its own, and not for the pleasure and confirmation of any given physical theory. Experiments document the current state of affairs. They live through their repetition and continuous revision by experts and amateurs. This demands experiments to be cheap, common, and ubiquitously carried out.

1 Introduction: Inversions Revisited

Let us consider a fluid at rest, say, fluid Helium in a bottle. It is a statistical model from ground up, and it is described by a mass density function $\rho : (t, \mathbf{x}) \ni \mathbb{R}^4 \mapsto \rho(t, \mathbf{x}) \in \mathbb{C}$, which is phase-symmetric because of time-inversion symmetry: Given ρ, we can find out, what it looks like in terms of energy and momentum by taking the Fourier transform of ρ in all its four space-time coordinates. (One might object that the stationary, i.e. time-invariant ρ, would not allow for an integration, but this is wrong: It exists as a tempered distribution, see: [3].)

Now observe, that due to time invariance, instead of integrating time from $-\infty$ to $+\infty$, we can equivalently integrate the other way round! In a stationary model there is no way to tell the positive time direction apart from the negative one: they are nothing but equivalent!

But then, Fourier transforming ρ in the opposite time direction will give me a negative result $-\hat{\rho}(p)$, we get the symmetry of energy inversion, and Fourier inverting $\hat{\rho}$ along the energy coordinates in the opposite direction, gives us $-\rho$ in symmetry with ρ.

Now it is time to ask: How can we be sure that ρ is non-negative? We can't:

The sign of ρ depends on the direction of time chosen, which in turn is arbitrary because of time inversion symmetry!

So, the correct way of saying that oxygen atoms weigh more than helium atoms is to say that the absolute value of the rest energy of oxygen is greater than the absolute value of rest energy of helium. And the correct way of dealing with ρ would be to let it be complex and give it a phase symmetry $U(1)$!

Next, let ρ be a stationary charge density. Its energy density is proportional to ρ. But then at rest, charge inversion must be identical to energy inversion. That means, that if we decide upon the sign of a mass of an electron or a proton by a gauge, then we fix the sign of its charge, either!

The question is not, whether negative energies exist at all, because of time-inversion. The question only is, whether particles with negative energy interact with ones of positive energy, and if so, how.

Anyhow, ss long as the Hamiltonian can be diagonalized and commutes with time inversion, we can always restrict to positive energetic particles along a positive time direction and tell the negative energetic ones to be evolving along the negative time-axis. That is nothing but a gauge in its purest sense.

So we can assume that nucleons (along the positive time axis) are positively charged, wheras consequently, the ones along the negative time axis have to be negatively charged.

Summarizing, invariance of energy and charge inversion allow us to make the choice that all nucleons be positively charged, freeing physics from the fear of a gluring anti-world.

That said, let me exploit this paper's previous parts and disprove two claims of last century's quantum physics, namely that $\mathcal{P}$ and $\mathcal{PC}$ were broken symmetries:

According to special relativity every matter has to obey $E^2 = m_0^2 + \vec{p}^2$, where E is the energy, m_0 the rest mass or rest charge, and $\vec{\mathbf{p}}$ is the 3-momentum or 3-current. That equation can be rewritten by means of the Dirac matrices as $\gamma_0 E = m_0 + \vec{\gamma} \cdot \vec{\mathbf{p}}$, which is unique up to transformation of elements of $U(4)$, i.e.: $U(4)$ is its symmetry group. Substituting $m_0 \to \gamma_0 m_0$ and observing that $\vec{\mathbf{p}}$ is proportional to m_0 we can rewrite that into $E = \gamma_0 m_0 + \gamma \cdot \vec{\mathbf{p}}$. Then parity or space inversion $\mathcal{P}$ is defined as inversion which commutes with the 1st summand and anticommutes with the 2nd, so is proportional to γ_0, whereas the charge inversion $\mathcal{C}$ that leaves the 2nd summand invariant and inverts the rest mass/charge. This gives the time/energy inversion $\mathcal{T}$ as the product $\mathcal{T} = \mathcal{CP}$. In other words: Each of the three fundamental inversions $\mathcal{P}$, $\mathcal{T}$, and $\mathcal{C}$ is the product of the other two, and they are not at all all independent from eachother!

Because $U(4)$ is a symmetry group on top of the above matrix equation that is connected, contains all of the inversions $\mathcal{P}$, $\mathcal{C}$, and $\mathcal{C}$, and these inversions can be transformed into eachother through elements of $U(4)$, all of these symmetries are broken if and only if a single one of these is broken. Then, because the charge inversion $\mathcal{C}$ is a symmetry (as we experience an overall neutral universe), it follows that $\mathcal{P}$ and $\mathcal{PC}$ must be symmetries as well.

So, what goes wrong with the experiments that claim the broken symmetries?

In case of the Wu experiment (see: [8]), where Co^{60} is β-decaying into Ni^{60} in a strong magnetic external field, the sign of the charge and the parity are already fixed by the electron charge and the external magnetic field, thus determinating the sign of the energy, so the the electrons' motion parallel with the field. (Below, we'll see that there even exist $\mathcal{P}$-invariant models which predict the result of Wu's experiment.)

And the first evident problem with the Cronin-Fitch experiment (see: [1]), which claims even CP-violation, is that it overtly mistakes a sufficient condition for a necessary one: As we saw, a CP-violation is equivalent to a violation of $\mathcal{T}$, meaning that the Hamiltonian of the system must not be a Hermititian operator any more. However, mathematically we can always extend that operator (be ot perhaps by including yet another quark), such that the extended operator is Hermititian/$\mathcal{T}$ invariant again! In order to be able to deduce CP-violation from the Cronin-Fitch experiment, it ought to be shown that no physically reasonable Hermititian extension (or modification) of that Hamiltonian will exist. And that has not been done. In fact, ee not even weren't given the complete Hamiltonian for that system, but only the S-matrix.

But, worst of all, the theory behind that experiment tacitly relies on the non- interactivity of neutral Kaons with eachother (see [6]). However, because by theory Kaons do decay into its anti-Kaons, which themselves do interact with the Kaons, we do have an interaction of Kaons with eachother. And, given that interaction, the chain of arguments for that experiment immediately breaks down.

2 Spin Experiments

As has been shown in the previous parts, given a stationary charge density ρ of electrons, a Lorentz boost to a speed v along the x_3 coordinate axis transforms $\rho\gamma_0$ into $\rho(\gamma_0 + v_3\gamma_3)^{-1}$, where $c \equiv 1$ is understood and γ_0 and γ_3 are Dirac matrices (see: [3] or [4]):

$$\gamma^0 = \begin{pmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & -1 & 0 \\ 0 & 0 & 0 & -1 \end{pmatrix}, \qquad \text{and } \gamma^3 = \begin{pmatrix} 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & -1 \\ -1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \end{pmatrix}.$$

Up to spin-inversion, i.e. parity, the lower two lines of $\rho(\gamma_0 + v_3\gamma_3)^{-1}$ are the time inversions of the the first two lines, and by symmetry we can unitarily transform the lower two lines into phase to the upper two lines. In quantum mechanics, as a convention, the first line is called the spin-up state, the 2^{nd} the spin-down state, the 3^{rd} spin up, and the 4^{th} spin down again. Incidentally the spin gets a neat physical interpretation: For each Lorentz boost $\Lambda(v_3)$ of the inertial space-time coordinate system at rest to the one, which is moving at a constant speed v_3 along the x_3-axis, the spin-up particles increase in charge with the same sign as the rest charge, while the spin-down particles change oppositely, i.e. their net charge appear to decrease. So, $q_e \mapsto q_e\big(1 \pm \frac{v_3}{\sqrt{1-v_3^2}}\big)$ holds with positive sign for spin-up particles and with a negative sign for the spin-down ones, where q_e is the (negative) electronic charge. Because ρ is describing a fluid rather than a dicrete set of particles, there is no means to tell what the individual electrons are doing. But overall we get that the charge density grows electrical dipoles as it is boosted to increasing velocities (along the x_3-axis).

Now we know from Stern-Gerlach experiment that a jet of electrons, moving at a constant speed along an axis, can be split into two parts by means of a strong and inhomogenous magnetical field vertical to the direction of motion, and these parts are associated with the spin-up and spin-down particles. Plus, the two parts cannot be parted again by applying a subsequent inhomogenous field to either spin-up or spin-down particles.

Oddly enough, although the discovery of spin in the Stern-Gerlach experiment is 100 years old and is being considered as a cornerstone for quantum theory, it is vastly unexplored:

The point is that the details of this spin-splitting will tell us about the structural alignment of the electric dipoles. (Note that the ordinary magnetical dipoles in here have been turned into electric dipoles: more on that in the thought experiment below.)

The most important thing to know first place, is at which field strength the electron splitting sets in: When the jet of electrons is hit by a strong electromagnetic field of some strength below this threshhold, then, as it is the well-known quantum mechanical problem of particles in an attractive potential well, we should see a radiation from the electrons of a discrete spectrum. The cumulation point of the radiated spectrum then will be the threshhold energy, at which spin-splitting sets is. (Is the spectrum discrete?) But is this radiation polarized? I don't know. Anyhow, if at all there is an alignment of electrons happening in the jet of electrons, then the polarization should tell us.

Lacking the experimental data as to this, I take the ordinary approach of physics: I make the simplest possible model describing spin alignment and point out what with it should be discoverable: And the simplest is a pairing of electrons side by side with a transfer of dipol charges: one electron becoming more negative, one more positive. With this, there are two immediate predictions: The magnetic field would no longer need to be inhomogenous: any strong homogeneous magnetic or even electric field perpendicular to the electrons' motion should be capable to split the electrons into the two spin parts. (Note that by shaping the north or south poles of a magnet, it is easier to create an inhomogenous field than it is to generate a homogenous one.) And, secondly, the two parts must then be charged at a different level: one part, consisting of spin-up electrons must show an increased net charge, the other one, the spin-down electrons must be less negatively charged, and the voltage drop would be proportional with the speed of the electrons. This should be easy to check experimentally: Just split a beam of electrons into its two parts and have them collide with conducting plates each: there should then be a voltage drop between the two plates, which increases proportionally with the speed of the electrons. Alternatively, a homogenous electric or magnetic field can be applied to the two beams of electrons perpendicular to the electrons' motion. The beams should be accelerated at different rates, and the rate difference again must be proportional to the speed of the electrons.

The truth has to be decided upon by experiment. However, as simple as the above model is, the following confirms it:

3 Thought Experiment 1

Let an observer A set up the Stern-Gerlach experiment in vacuum with just electrons, not ions, moving along the x_3 axis at a constant speed v_3. Let *A'* be another observer moving with the electrons at the same speed v_3. Then *A'* will see an inhomogenous electric field rushing in and out with a speed $-v_3$ that splits the electrons at rest into two parts perpendicular to x_3. Because the electric field is inhomogenous, observer *A'* will deduce that the electrons must be dipoles, and that the electrons in either split part must either be at a different charge or dipoles with a different dipole moment. But, the electrons in either part were dipoles, then each of the split parts could be split again by a successive strong electric field into particles of a different charge. And the Stern-Gerlach experiment just excludes this. So, *A'* concludes that there must be a voltage drop between the two split beams. And this voltage drop is perpendicular to the x_3-axis. So, A and *A'* must measure the same voltage.

4 Thought Experiment 2

Let's proceed with the above experiment and raise a subtle problem: Suppose, observer A would continue the Stern-Gerlach experiment and accelerate one of the two split beams from v_3 to $u_3 > v_3$, that is, the electrons are once again accelerated in their direction of motion to a larger velocity. The direction of motion is the same before and after. But the spin be conserved? The answer is: no. The reason is that for observer *A'* as the the acceleration to velocity u_3 starts, the electrons are accelerated from 0 velocity to $u_3 - v_3$, and by the result of the Stern-Gerland experiment, no matter what the spin was before, after a subsequent acceleration, a strong inhomogenous magnetic field should split the jet of electrons up into spin-up and spin-down electrons again.

An equivalent way to see this is to take into account the lower two lines of the matrix-transformation: The matrix γ_0 does not commute with γ_3. This is where the time inverted solutions come into play and no more can be neglected by saying that because of time invariance the negative energetic solutions would have to be irrelevant.

5 Experiments on weak decay

It is well-known that free neutrons, i.e. when they are knocked out of the atomic nucleus, do decay into a proton, an electron, and an anti-neutrino with a recently corrected mean-lifetime of $881.5 \pm 1.5s$ (see: [7] or [5]). What is interesting is that this number in all publications I know, all come without the specificating environmental parameters, namely temperature and pressure. In [5] it can be seen that the rates had been measured from $-30°$C to $+30°$C, which still is a very small range, but the pressure appears to have been always the normal atmospheric pressure.

As to temperature, the interesting region is temerature near absolute zero, and here is why: We know that the necessary minimal energy that triggers the β-decay must be small, if not zero. The only interesting aspect to find out as to temperature is, whether a lower energy threshhold > 0 exists. That will be nice to know, but that will mean to take a very high effort compared to the relevance of knowing that. If however we'd know about the decay rate at low pressure, then we would know whether a neutron will stably exist by itself and whether or not a collision with some other particles is needed to trigger the β-decay.

And again, because apart from the Wu experiment (see: [8]) and the continuity of the spectrum of the electron emission very little is known bout what is going on in β-decay, let's take the simplest possible model of β-decay and derive some predictions:

I assume that the β-decay needs a considerable amount of collisional energy in order to trigger. When it happens, the neutron converts into a proton, an electron, and an anti-neutrino, and the first problem is that the electron will need some amount of kinetical energy in order to leave the proton, and because the proton is 2000 times heavier than the electron, that could happen by successive collisions with other atoms or nucleons. But, when a neutron collides with such a particle, it will be very likely that the neutron will bind and stick to the other neutron(s) and/or protons. So, I assume that the β-decay does involve 2 neutrons, and not just one. The outcome will be a system of two protons paired with a pair of electrons. That pair of electrons will be of opposite spin, surronding the nucleons, and likewise the two protons that evolved from the neutrons must have opposite apin: it is the only constellation, in which two charged particles with the same sign of charge have a constant net charge upon acceleration. (Note that by the same reason, two oppositely charged particles will align, such that their spin point to the same direction, either both spin-up or both spin-down.)

Ihe basic symmetry model in here is not a translational, but a rotational one. With the substitution of the translational flux $\mathbf{j} := (j^1, j^{,} j^3)$ into the "angular momentum flux" $\mathbf{I}(x)\omega(x) := \mathbf{r} \times \mathbf{j}(x)$, where ω is the angular velocity and $\mathbf{I}$ the moment of inertia. And irrespective of I being an axial pseudovector and not a "normal" vector, Lorentz covariance demands that $E_{rot}^2(x) = \rho^2(x) + \|\mathbf{I}(x)\|^2\omega^2(x)$ holds. So again, as in the translational model, $\gamma_0 E_{rot} = \rho + \gamma_1 I_1\omega + \cdots + \gamma_3 I_3\omega$ is the solution of this equation (defined modulo U(4)). In this rotational context the first and third row are often associated as "right-handed" spin (Instead of spin-up), the 2^{nd} and 4^{th} row with a "left-handed" spin (instead of spin-down). I'll stick to the spin-up/ down terminology.

The problem is, whether or not the pairs of Cobalt atoms will preferrably pair with opposite or parallel nuclear spin. In the Wu experiment all nuclear spins are lined up, and at least in this constellation we know that the β-decay takes place. So, in this case, the pairs of Cobalt nucleons are of the same spin. And this determines which of the two paired electrons within the nucleon pair is going to leave the nucleons: the electron remaining with the nucleons must have a spin parallel to the overall positive nucleons.

I note that the above still just touches the surface of the problem, how β-decay is really taking place. If we'd knew, then we'll be able to predict the decay rates of atomic nucleons, which currently we do not really understand. One particular question is how the rotational, angular spin of the electron, which is leaving the nucleons, is related to the translational one as it leaves the nucleon. Could it be circularly polarized?

But: Where are the neutrinos in the above model? Answer: They are not needed in here, because due to the pairing of the nucleons the energy spectrum of the emitted electrons will be continuous. Plus, in here we don't have a spin problem: two fermionic nucleons decay into a fermionic nucleon-pair (with an additional electron) and a (fermionic) electon, which is emitted.

But, hasn't the existence of neutrinos been proved anyway by F. Reines and R. Cowan by showing that a neutrino collision can convert a proton into a neutron and a free positron? Well, not quite: what was shown is that incoming particles may convert a proton into a neutron and a positron within big containers shielded from the outside by massive walls of steel (or water basins deep underneath the earth's surface), which exclude nucleons and electrons to have intruded from the outside. The decisive, unproven claim now is that the only particle capable to trespass the walls of steal and earth was the neutrino. This however completely disregards the possibilty of particle-antiparticle pairs to either be able to do so, in particular electron-positron pairs, which, if strongly coupled, will not interact with electromagnetic fields any more. They would appear to be dark matter, only subjected to the gravitational force, and therefore they will even accumulate where the surrounding mass is high.

That introduces

6 Experiments on Particle-Antiparticle Annihilation and Creation

As has been shown in the previous parts, according to the covariant Maxwell equations, the electromagnetic field does not contribute anything to the mass or energy of its particle sources it comes from. So, as long as these equations hold true, the outcome of a particle-antiparticle annihilation must be a massive particle itself. The first question is what does really happen in this annihilation process. And one of the questions is whether the spectrum of electron-positron annihilation is continuous or discrete.

To check that, one would need (controllable) electron and positron sources in a vacuum chamber in which a tuneable electric field controls the speed of the colliding particles. If the spectrum was discrete, electron-positron annihilation would occur only at a specific speed of collision. Both results will challenge quantum theory: In case of a continuous spectrum, that process would not be comprehensible as an interaction of two particles, and a discrete spectrum will support the model that, what is conceived to be the ground state is not "vacuum", but a physically existing particle pair.

The next experiment is to prove or disprove that the probability of electon-positron annihilation is equal to the probability of electron-positron creation: For this, one would need a closed cavity with an attached gas pump to adjust pressure, and a source of positrons and a source of electrons at either side that collide one by one, and finally a set of electromagnetic detectors. Presuming the current opinion that the electron and positron transfer into a photon, because of time inversion symmetry, at any time after the photon creation there is a 50% chance that the photon decays into an electron and a positron again, the positron would annihilate again at the next collision with an electron with opposite spin, and so forth. In other words, the particle-antiparticle annihilation should cascade into a sequence of annihilation and creation processes, detectable by rapidly succeeding flashes by photons. By lowering the pressure within the cavity, the mean free path length between two collisions is increased, and therefore, which must be detectable as a sequence of double flashes that decreases in frequency as the pressure decreases: the 2nd flash would spring from particle creation, which likewise sheds an electomagnetic field. Nothing the like has been reported sofar. Still, it should decided upon through experiment. A negative result will show that an electromagnetic field by itself cannot create matter.

As I showed in the previous parts, classical electrodynamics predicts the existence of electron-positron pairs. These must be tightly coupled, hence vastly do not react to electrodynamic fields any more. Because of this, they should be able to pass through atomic matter, but otherwise behave like gas. It will need the scattering with a high energetic photon to split this particle pair apart. This would be the particle antiparticle creation process. But as a gas, the density of the electron-positron pairs must follow the Boltzmann distribution $\Psi(r) = e^{\frac{gmr}{kT}}$, where r is the distance from the center of the earth, m the mass of the electron-positron pair, g the gravitational acceleration, k the Boltzmann constant,and

T the mean kinetical energy of the pairs (see e.g. [2, Vol.I, 40-2]). Hence, by setting up the same experiment at sea level and in the mountains, shooting high energetic photons into a cavity, and observe the number of electron-positron creation processes over the frequency of the photons, the number of observed creation events for a fixed period of time should be observed as decreasing exponentially with the altitude.

There then will be other interesting questions to be answered. One of them is, to what degree the number of creation events will depend on pressure and temperature: For, if not, then this will mean that an electron-positron pair will pass through the nucleons without interaction.

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