The Particle Annihilation Paradigma

Hans Detlef Hüttenbach

To my daughter

Abstract. The aim of this article is to show that the annihilation paradigma in Standard Theory does not reconcile with classical electrodynamics, which in turn predicts the existence of electromagnetically opaque matter.

1. Preliminaries

Particle annihilation is defined as the process of collision of particle and antiparticle which results into an electromagnetic radiation of energy that is equal to the total sum of energy of the colliding particles. So, the evident conclusion is that, since the energies match, the particles must have been converted into photons.

2. The Problem

As to electrons and positrons, this annihilation process has been measured many times. However, the detection of the electromagnetic radiation takes place over meters, not within nanometers. So, the electromagnetic radiation is a macroscopic event, therefore at least partly falling into the realm of classical electrodynamics. And classical electrodynamics is governed by Maxwell's equations. Hence, annihilation should reconcile with Maxwell's equations. (It should be said that this large scaled particle annihilation has not been observed directly for massier charged particles like protons or pions, which "almost instantly" decay into other particles and would leave the annihilation into an electromagnetic field, if at all, as a short ranged intermediary.)

3. The Classical Side of Annihilation

For that reason I am mainly focussing on electrons/positrons colliding overhead, but the argumentation will apply to any charged particle/antiparticles that upon collision decay into photons.

Irrespective of their opposite charges, both, particle and antiparticle have a positive nonzero (equal) mass, because of the force of inertia,w hich is opposite to the acceleration. So, both have a positive free energy, which is defined as the geometric mean of rest mass and momentum (with $c := 1$, where c is the velocity of light).

Now, Maxwell's equations are given in covariant form as $\Box A = j$, where left and right hand side are 4-vectors, and their forward propagating solution is - modulo plane waves - given by

$A(x_0, \mathbf{x}) = \int \frac{\delta(x_0' + |\mathbf{x}-\mathbf{x}'| - x_0)}{|\mathbf{x}-\mathbf{x}'|} j(x_0', \mathbf{x}') dx_0' d^3\mathbf{x}'$,

in which δ is the (1-dimensional) Dirac distribution. This is nothing but the relativistic form of Poisson's equation and its solution: Applying Gauß theorem along with $\nabla^2 \frac{1}{|\mathbf{x}|} = 4\pi\delta(\mathbf{x})$ on each of of the 4 components of the above equation gives for a 2-dimensional sphere S surrounding a ball $B(r)$ of radius $r > 0$ in the 3-dimensional space at time x_0:

$$\iint_S \nabla A^\mu(x_0, \cdot) \cdot \mathbf{n} \mathrm{d}S = 4\pi \iiint_{B(r)} j^\mu(x_0 - dist(\mathbf{x}, S), \mathbf{x}) d^3x, (0 \leq \mu \leq 3),$$

where $dist(\mathbf{x}, Br)$ is the (Euclidian) distance of $\mathbf{x}$ to the sphere S.

That is: The flux of A^μ through a sphere S at a given time x^0 is the integral of the flux $j^\mu(x)$ in the interior of S at the retarded local time. I denote this by $Q^\mu(x^0)$. Therefore, the total flux of energy radiated by A through a sphere at time x_0 is given by

$$\sqrt{\sum_\mu |\iint_S \nabla A^\mu(x_0, \cdot) \cdot \mathbf{n} \mathrm{d}S|^2} = \sqrt{|Q^0(x_0)|^2 + \cdots + |Q^3(x_0)|^2},$$

which can be stated to be the free, retarded electrical energy of the charges within the interior of S. (It should be noticed that this statement is scale-invariant w.r.t. r: it simply holds for all $r > 0$, which makes it hard to correct for a "quantum mechanically relevant" length scale.)

Considering a charged particle and antiparticle on their overhead collision course, their free electrical energy add, and due to the decrease of their attracting potential energy, as they approach, their free electrical energy strictly increases, until at collision time it reaches their maximum $E_{collision}$, each. The problem now is that following Maxwell's theory, there will be an electromagnetic wave radiating the enegry $E_{collision}$, only if we have a source of that energy at collision point, in other words: the matter cannot purely dissolve into electromagnetic energy: Either Maxwell's theory does not hold as to particle-antiparticle annihilation and standard theory falls short of a replacing alternative, or standard theory is falling short of the energy $2E_{collision}$.

The good thing about that problem is that it can be experimentally decided upon:

Assuming that Maxwell's theory holds, the particle-antiparticle will result into a massive, neutral particle of rest mass of at least $2E_{collision}$. (At least $2E_{collision}$, because the charged particle might have an additional neutral mass which the electrical charge does not account for.)

That mass must have observable garvitational effects on electromagnetically active matter like charges or atoms. Further, protons/antiprotons are more than 180 heavier than electrons/positrons, their electrical charges however are the same. Whereas Maxwell's theory, which is dependent only on charges, would imply that upon particle-antiparticle annihilation the radiated field would be the same for electrons/positrons as for protons/antiprotons, a total conversion of protons/antiprotons into electromagnmetic radiation should result into a higher radiation for protons/antiprotons than for electrons/positrons due to their higher rest mass energy.

The race between both theories is open. What speaks in favour of Maxwell's theory is that it is well-settled and checked, plus it may readily explain for large parts the missing dark matter as well as the nature of black holes as matter composed of particle-antparticle pairs.

Hans Detlef Hüttenbach
Im Rheingarten 6
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