Dark energy is needed for the consistency of quantum electrodynamics
Heisenberg's biggest blunder?

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Abstract

The argument that virtual photons can be globally gauged away I think is spurious. Indeed, the inconsistency with the boson commutation rules in Heisenberg and Pauli's historic 1929 attempt to quantize the electromagnetic field[1] disappears once one uses the recently discovered dark energy density.

The Problem

They then form the momenta conjugate to the ϕ's *and the trouble starts*

$$L \equiv \frac{1}{2}\left(\vec{E}^2 - \vec{B}^2\right)$$
$$\Pi_I = F_{0I} = \partial_0 A_I - \partial_I A_0$$
$$\Pi_{0(real)} = \frac{\partial L}{\partial \dot{\phi}_0} = F_{00} = \partial_0 A_0 - \partial_0 A_0 = 0$$
$$\left(\Pi_1, \Pi_2, \Pi_3\right) = -\vec{\mathrm{E}}$$

… *The vanishing of* Π_0 *is a very serious difficulty since it contradicts the quantum condition*

$$q_0(x)\Pi_0(x') - \Pi_0(x')q_0(x) = ih\delta(x - x')$$

Paraphrase of Dirac's comment on Heisenberg and Pauli's "On the Quantum Dynamics of Wave Fields" 1929 cited by Schweber pp. 39 – 44.

In the fall of 1928 Heisenberg discovered a way to bypass the difficulties engendered by the fact that $\Pi_0 = 0$ *in the* $L = F_{IJ}F^{IJ}/4$ *formulation of the action principle for* <u>*classical*</u> *electrodynamics. He suggested adding a term* $-\varepsilon\left(\partial_I A^I\right)^2/2$ *to the Lagrangian, in which case*

$$\Pi_0 = -\varepsilon\left(\partial_I A^I\right)$$

and the usual method of the canonical quantization scheme became applicable. The limit $\varepsilon \to 0$ *was to be taken at the end of all calculations.*
Schweber p. 41

My original idea in this paper is that ε is finite determined by the dark energy density of virtual photons.

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[1] "QED and The Men Who Made It", Sylvan S. Schweber p. 41 (Princeton, 1994)

$$\varepsilon\left(\partial_I A^I\right)^2/2 \sim \frac{c^4}{8\pi G_{Newton}}\Lambda_{Dark\_Energy} \tag{1.1}$$

The classical equation of motion for the compensating local internal symmetry $U_1(\vec{r},t)$ group gauge connection potentials of the Maxwell electromagnetic field with sources is

$$\left(\partial_J\partial^J\right)A_I = -J_I + \partial_I\left(\partial_J A^J\right) \tag{1.2}$$

Expanding into components[2]

$$\begin{aligned}
&A_I \equiv \left(\vec{A},\phi\right)\\
&J_I \equiv \left(\vec{J}_e,\rho_e\right)\\
&\Box \equiv \vec{\nabla}^2 - \frac{1}{c^2}\partial_t^2 \to \frac{\delta^4(x-x')}{D_{Feynman}(x-x')}\\
&\Box\vec{A} = -\frac{1}{\varepsilon_0 c^2}\vec{J}_e + \vec{\nabla}\left(\nabla\cdot\vec{A} + \frac{1}{c^2}\partial_t\phi\right)\\
&\Box\phi = -\frac{\rho_e}{\varepsilon_0} - \partial_t\left(\nabla\cdot\vec{A} + \frac{1}{c^2}\partial_t\phi\right)
\end{aligned} \tag{1.3}$$

$$\begin{aligned}
&\partial_I A^I = \nabla\cdot\vec{A} + \frac{1}{c^2}\partial_t\phi\\
&\partial_I \equiv \frac{\partial}{\partial x^I} = \left(\partial_t,\vec{\nabla}\right)\\
&A^I \equiv \left(\phi,\vec{A}\right)
\end{aligned} \tag{1.4}$$

The Lorentz term is $\nabla\cdot\vec{A} + \frac{1}{c^2}\partial_t\phi$ with a + sign. It does not vanish for virtual photons. It does vanish only for real photons.

In classical vacuum where $J_I = 0$, insert the plane wave solution into the classical equation of motion for the electromagnetic field potentials

$$A_I = \xi_I e^{i\frac{p_J x^J}{\hbar}} \tag{1.5}$$

where ξ_I is the polarization (spin 1) 4-vector to get the constraints

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[2] Note the bare spin 0 Feynman propagator $D_{Feynman}$

$$\left(p_J p^J\right)\xi_I = \left(p^J \xi_J\right) p_I \tag{1.6}$$

There are two kinds of solutions. First[3] we have the micro-quantum effect of virtual photons that are off the classical light cone. They can be inside with positive effective rest mass or outside with imaginary effective rest mass. *Randomly fluctuating* spin 1virtual photons[4] *anti-gravitate as dark energy* repelling all masses because they have negative pressure that is 3x their positive zero point energy density in 3D + 1 spacetime. This is required by Einstein's equivalence principle plus Lorentz invariance as shown on pp 25-26 of John Peacock's "Cosmological Physics" (Cambridge). Therefore, for the virtual photon zero point vacuum fluctuations[5], the classical field equations of motion demands the virtual photon solution for consistency with the boson commutation rules when quantizing. This *anti-gravitating dark energy virtual photon solution* is

$$\begin{aligned}
&p_J p^J \neq 0 \\
&\xi_{I(virtual)} = \frac{\left(p^J \xi_{J(virtual)}\right)}{\left(p_J p^J\right)_{(virtual)}} p_{I(virtual)} \\
&A_{I(virtual)} \equiv \varsigma p_{I(virtual)} e^{i\frac{p_J x^J}{\hbar}}
\end{aligned} \tag{1.7}$$

The argument that these virtual photons can be globally gauged away I think is spurious.

Indeed, the inconsistency with the boson commutation rules in Heisenberg and Pauli's historic 1929 attempt to quantize the electromagnetic field[6] disappears once one uses the recently discovered dark energy density

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[3] For real photons of course the "mass shell" pole of the bare photon propagator in the complex energy plane (Fourier transform of the classical light cone in this case) $p_I p^I \sim -c^2\omega^2 + \vec{k}^2 = 0$ and only the two transverse polarizations propagate energy into the far field.

[4] Boson commutation rules in 2nd quantized creation and destruction non-Hermitian operators. In contrast, virtual electron-positron pairs with fermion anti-commutation rules (only none or one quantum per normal mode Pauli exclusion principle) have opposite zero point vacuum energy density and pressure. Therefore, randomly fluctuating virtual electron-positron pairs gravitate as dark matter! The virtual photons spread out. The virtual electron-positron pairs clump just like w = 0 Cold Dark Matter (CDM) even though all virtual quanta have w = -1 where w is the ratio of pressure to energy density.

[5] As well as the non-random coherent states of virtual photons that form the non-propagating near electromagnetic field with all three polarizations seen in electrostatics, magnetostatics, inside the wave zone in transformers, dynamos, motors etc. e.g, the electrostatic Coulomb field of a stationary point charge is a macro-quantum coherent state of spacelike virtual photons outside the light cone with zero energy and all possible finite linear momenta with a continuum of effective imaginary masses.

[6] "QED and The Men Who Made It", Sylvan S. Schweber p. 41 (Princeton, 1994)

$$\Pi_0(\vec{r},t) \sim \partial_J A^J_{(virtual)}(\vec{r},t) \sim \int d^4 p \varsigma p^J_{(virtual)} p_{J(virtual)} e^{i\frac{\vec{p}\cdot\vec{r}-Et}{\hbar}} \sim \int d^4 p \varsigma\left(m^2_{virtual}\right) m^2_{virtual} e^{i\frac{\vec{p}\cdot\vec{r}-Et}{\hbar}}$$
$$\sim \sqrt{\Lambda_{dark\_energy}} \sim \frac{1}{R_{future\_event\_horizon\_retrocausal\_hologram}} \qquad (1.8)$$