PHOTON LOCALIZATION and DARK ENERGY
by Norman Albers

Light must exist in wave packets or not much energy would fall on any one atom to complete its absorption. The quantum of energy exchanged is determined by the stable states of the atom, and is the difference between a ground and an exited state. We can use Maxwell's equations and extent them, allowing non-zero charge and current terms on the right-hand side where we used to put zero for what we thought was a vacuum. Simply by stating mathematically that there exists such a packet we imply the existence of what amounts to a diffuse sheath acting like a phased-array antenna to keep the energy from spreading out. This is what an optical mirror does: it responds in phase and so radiates the incoming light. Also the walls of a waveguide are simply good conductors reflecting energy back inside. “Inhomogeneous fields” comprise such a response accompanying the propagation of a photon, and I investigate their characteristics.

Rather than supporting our current understanding of quanta, it seems that any size of light packet can exist, even fractional values less than the “h-nu” energy required for exchange with a particle. Like pennies in a coin machine that takes only nickels or more, smaller packets cannot be absorbed and so can be called dark energy with respect to electromagnetic interaction. Neither can they be emitted so we cannot yet explain their origin without further theory. This will involve interaction with quantized photons, or creation at an early epoch in the big bang before condensing particles decoupled a more unified field.

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Part I: PHOTON LOCALIZATION,

Photons are represented as quasi-monochromatic wave packets, where a helical, transverse magnetic-vector potential has an exponential falloff in three dimensions. The currents implied by such a limiting sheath are describable as a fundamental contribution from the virtual background, plus net charge regions responding to the potential. The latter is expressed as momentum $(\rho\, \boldsymbol{A})$ multiplied by a pertinent “q/m” of $\dfrac{\rho c^2}{\rho U}$.

Our treatment of angular momentum in the electromagnetic field is confused by the assumption of sufficient localization that surface integrals far away may be dismissed; yet we admit no mechanism for transverse fields to fall off, implying divergence, as in $\partial A_y/\partial y$ for a photon in x. We may investigate such a possible physics by analyzing a diffuse, quasi-monochromatic wave packet defined as an exponential bubble:

$$A_y = \cos(kX)\exp(-a^2(X^2 + y^2 + z^2)),$$

$$A_z = \sin(kX)\exp(-a^2(X^2 + y^2 + z^2)),$$

where X is $(x - ct)$, and k a few magnitudes larger than a.

If we take the divergence of **A** (in y and z), the assumption of Lorentz gauge defines scalar potential, U:

$$\partial U/\partial t = -c^2 \operatorname{div}(\mathbf{A}).$$

To express U we must do a series of integrations by parts, as the time coordinate appears twice in X. This yields an expansion (hereinafter with the exponent omitted) in orders of (a/k), which is assumed to be small:

$$U(k/2a^2) = (-y\sin(kX) + z\cos(kX))(1 - 2(a^2/k^2)(1 - 2a^2X^2)) +$$

$$2(a^2/k)\,\mathrm{X}(y\cos(kX) + z\sin(kX))(1 - 2(a^2/k^2)(3 - 2a^2X^2)).$$

Charge is defined as the d'Alembertian of U. Of more immediate interest is current, expressed as the d'Alembertian of **A**. Since the wave moves in $+x$, all contributions from $\left(\partial_x^2 - c^{-2}\partial_t^2\right)$ vanish, and:

$$-\rho = \left(\partial_y^2 + \partial_z^2\right)U,$$

$$-j_y = \left(\partial_y^2 + \partial_z^2\right)A_y,$$

and so forth, with permittivity and speed-of-light unity. Current is:

$$-j_y = 4a^2\cos(kX)(1 - a^2(y^2 + z^2))\exp(-a^2(X^2 + y^2 + z^2).$$

I propose that we can see physics here by writing current as:

$$j_y = -\lambda^2 A_y + (\rho/U)A_y,$$

with $\lambda = 2a$, and charge as:

$$\rho = \lambda^2 U + (j_y/A_y)U.$$

To first order:

$$U = 2\frac{a^2}{k}(-y\sin(kX) + z\cos(kX)),$$

$$\rho = 8\frac{a^4}{k}(-y\sin(kX) + z\cos(kX))(2 - a^2(y^2 + z^2)),$$

so one can see that this is successful at this level in $O(a/k)$.

We can interpret a Meissner-type component as the first term in j_y, as well as what we would expect from a net charge in **A**: momentum is ρ**A**, and we multiply by a q/m of $c^2\rho/(\rho U)$, or U^{-1}.

The response of λ derives from a uniformly available virtual sea of dipole manifestation, more like a plasma than bound, polarizable units. Vacuum fluctuations produce a mean-square dipole measure just as they do a mean-square electric field. This quantum-mechanical concept is thus shown to be necessary and sufficient to describe an understandable mechanism for localization. Either charge of a local dipole pair contributes similar current as an **A**-field comes and goes. The first current term is a dipolar contribution attributable to a local polarization change or bilateral current; the second is monopolar, from net gathering of charge. We should beware the tendency to ascribe phenomena and “natures of space”. Somehow an increasing A-field produces dipolar current which bunches up in an inhomogeneous charge field. We can understand “little charges” being accelerated in a B-field, but that does not mean they are there! Mathematically I am allowing the field to be smoothly inhomogeneous..Thus a neutral background of Lorentz-transformable nature but of local dipole availability must be the nature of what we called the vacuum, and serves to localize photons.

PART II: PHOTON ANGULAR MOMENTUM,

Calculating wave packet totals

Given the wave packet discussed in my first paper, $A_{y,z}=A_o e^{[ikX-a^2(X^2+y^2+z^2)]}$, with , $\mathbf{X}\equiv(\mathbf{x}-\mathbf{ct})$ we may calculate angular momentum components including the inhomogeneous parts. We are accustomed to terms of $(\mathbf{E}\times\mathbf{A})$ where **E** has contributions from $-\partial\mathbf{A}/\partial\mathbf{t}$ and $-\nabla U$. Present also are charge fields, ρ , and given that linear momentum is $\rho\mathbf{A}$, angular momentum is $\mathbf{r}\times\rho\,\mathbf{A}$. Thus the total angular momentum density is: $\mathbf{A}\times(\dot{\mathbf{A}}+\nabla\,\mathbf{U}-\rho\,\mathbf{r})$. If we integrate these totals over space, it is clear that each of the first two terms yields one-fourth the total. This total, which is Planck's constant, can be figured from integration of the energy density, either by squaring the fields or by constructing ρU . (The magnetic contribution should be the same.) Total energy of the packet, divided by angular frequency, is that constant. The other one-half comes from the charge-field terms. This I offer as an inductive conclusion, though we should expect totals from source-term integrations to equal those from fields (squared).

This is where we lost our nerve in electrodynamics! Such vacuum manifestations were not considered, and without them there cannot be localization, as that depends upon transverse divergence, i.e., inhomogeneous fields. The magnitude of Planck's constant varies as *(k/a)*, and also as the square of (A_o/a) . It is not apparent that there is physical process in the field *per se* to render quantization, and we may hypothesize the opposite: it is only emitters and absorbers that obey quantum rules. Only bound states are quantized; a string uncut and unstrung has no note! Treating space as a "ficticious oscillator" becomes a fiction of which we can well be rid. A new accounting of vacuum fluctuations will liberate us from the extreme results offered by current interpretation. Perhaps we can couple the uncertainty principle with statistical mechanics to produce a more reasonable result.

PART III: MANIFESTO

Quantization and Planck's Constant

The photoelectric effect shows interaction of the light field with a bound state, by which I refer to the electron “particle” itself, as well as its disposition in a material. The latter is represented by the “work function” of the material. Beyond that we see the exchange of energy between the field and bound state being proportional to light frequency. It is a mistake of psychological projection to say that this quantum of energy existed in the field, per se. What is known is that an interaction scales to frequency; the root of this phenomenology may be seen as determined by the characteristics of the bound state and not of the field!

It is clear that the field energy must be localized, or interaction would not be of sufficient intensity at the atomic scale. The necessary characteristics of the exchange are set by the well-understood quantum mechanics of electrons, and it is reasonable to say, “A field at some frequency and sufficient energy will impart kinetic energy to the (bound state) electron, equal to Planck's constant times frequency, minus the material work function.” We understand that correctly identified quantum oscillators have particular stable states and rules of transition between them involving absorption and emission. Here is the essence of Planck's constant: it is the characteristic of electromagnetic energy in a bound state. We understand atoms as bound electrons, and we must go further and admit that particles are bound light. The laws of this are accessible with inhomogeneous electrodynamics. When we witnessed the exchange of photons, namely, field energy of quantized proportions, we chose to ascribe the quantization to the field. I hypothesize that we will find it more useful to consider the field as not necessarily quantized on scales larger than the Planck length. There are surely many predictable photons but the native characteristic of the field is of arbitrary magnitude relative to frequency. This argument is most persuasive if we consider resonant emission and absorption. Photoemission has resonance in the work function interaction, but the physics is complicated by the excess energy of higher frequency photons. Any light source emits quantized photons so maybe the argument is mute, but we know that after the electron is freed it can no longer absorb radiation. Thus we can say that the exchange was mediated by the bound electron. On the basis of fractional wave packets we shall refigure our mathematics of vacuum fluctuations, although I hesitate to say anything here, as interpretation may require a fresh attitude. I offer for consideration the Wien blackbody law which fundamentally combines electromagnetic energy density with thermodynamic probability in a manner appropriate for non-quantum state space. It is this sort of approach we will need if it is correct to manifest uncertainty in the local field. Perhaps not even this is what we are coming to, but at least it may give similar results at "low" frequencies. Whatever the characterization, it must answer to the need for homogeneous charge and current fields.

PART IV: DARK ENERGY and IT'S SPECTRUM

The Gaussian wave packet , $A = A_o e^{[ikX - a^2(X^2 + y^2 + z^2)]}$, implies a linear, inhomogeneous response of charge and current as part of the lightfield. It is understood that atoms emit photons according to their angular momentum selection rule, and thus generate quantized radiations. The field mechanism itself is not sensitive to the total angular momentum of the packet, and we may thus theorize disturbances of arbitrary fractional magnitude. Such field components will not interact with atoms except with their integer part. The fractional energy must therefore be dark with respect to spectral electromagnetic interaction with matter. Leaving quantum statistics to have fully accounted for the integer, or quantized photons, let us consider the population of fractional states between <0,1>, or fractional photons, at whatever total field level. We justify this because they do not interact with mass by absorption. Construction of a luminous energy density curve considers mode structure available, and energy likely to exist in each mode. Rather than adding possible multiple integer energy states weighted by the Boltzmann factor:

$$\bar{\epsilon}=\hbar\omega e^{(-\hbar\omega/KT)}+2\hbar\omega^{-(2\hbar\omega/KT)}+\ldots \quad ,$$

we shall integrate possible fractional states of wave packet angular momentum:

$$\bar{\epsilon}=\int_0^1 ds(s\hbar\omega)e^{-(s\hbar\omega/KT)} \quad ,$$

weighted statistically at this point. Define: $\hbar\omega/KT\equiv a$, so that:

$$\bar{\epsilon}=aKT\int_0^1 ds(s)e^{-as} \quad .$$

Integrating by parts $\bar{\epsilon}=(KT)^2(\hbar\omega)^{-1}[1-(1+a)e^{-a}]$.

Normalize this, dividing by: $\int_0^1 e^{-as}ds=a^{-1}(1-e^{-a})$, to get:

$$\bar{\epsilon}_k=KT[1-(1+a)e^{-a}][1-e^{-a}]^{-1}$$

Now we have an expression in a, or energy available at frequency ω

The usual mode analysis accounting for isotropic distribution gives:

$$dn=(k/\pi)^2 dk \quad .$$

Now I propose to put these two terms together with an overall statistical exponent. Quantum theory blindly posits quantization to these fields and equal likelihood that high energies will manifest a half-quantum. I posit an earlier, or even current state of equilibrium statistical mechanics here, and write:

$$d\Psi/dk=KT(k/\pi)^2[1-(1+a)e^{-a}][1-e^{-a}]^{-1}e^{-a}\text{, with } a=\hbar ck/KT.$$

`The quantity in brackets can be seen to approach unity at high k, and at low k goes as $1/2a^2$. This betrays a behavior quite distinct from blackbody visible radiation. Look now at the Planck spectrum:

$$d\Psi_p/dk=1/2\pi^{-3}\hbar ck^3[1-e^{-a}]^{-1}e^{-a} \quad .$$

The bracketed quantity here varies from unity (high k) to a^{-1} at low energy. Terms out front are quite different but both forms have the thermodynamic form: $k^3 f(k/T)$, and so are satisfactory on that account. If one integrates for total energy, both go as T^4. The "dark" spectrum has radically different behavior between high and low frequencies, or conversely low and high temperature. The behaviors at both limits are:

	PLANCK	ALBERS
High k (low T):	$1/2\pi^{-3}\hbar c k^3 e^{-a}$	$KT\pi^{-2} k^2 e^{-a}$
Low k (high T) :	$1/2KT\pi^{-3} k^2$	$1/2(\hbar c/\pi^2) k^3$

Curiously the Planck high end agrees closely with the Albers low end, and vice versa. We would expect this energy to expand adiabatically in a way similar to light. Cosmologically it would have had a very different history since it never coupled with particles in the same manner. Thus this energy would have been decoupled long before plasma recombination.