Electron nature: light, vacuum or something else?

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1. POSITION

Firstly: nature (as measured in experiment) is primary. Theories are merely speculations one makes up to try to describe her underlying processes. Mathematics is a powerful, but formal and strictly limited, language which may be used to try to describe certain aspects of whatever nature does in reality. Mere mathematics, however, must not be allowed to cloud any of the fundamental features of nature observed in experiment. Any (practically useful) mathematics should follow nature, not the other way round. If one cannot measure it, it is, (for all practical purposes) not there. Any theories predicting things which are (observed to be) just not there should be modified or discarded. This is the proper process of the scientific method. The logical conclusion of this process, the solution of Hilbert's sixth problem such that a complete mathematical system describing all of nature just and no more, may not be possible at all. Though that remains to be seen, it is worth striving for.

Having said this, the body of theory as it stands in the early twenty-first century, is a marvellous intellectual achievement garnered through generations of the thinking of many excellent folk. Human theory encapsulates a great deal of truth about the nature of reality. Any new theories should either encompass, improve on, or underpin that thinking - or they are likely to fail. The creation of new theories may be a deeply creative process - but it is also strongly constrained.

My current favoured position is that there are only the three dimensions of space, time and a square-root-energy density. These five degrees of freedom, for me, are sufficient to encompass most, if not all, of that which has been so far observed in human experiment. In particular they are sufficient to derive models of the photon, electron and other particles. It proves possible to derive why, how and to what extent light is quantised, what the underlying nature of the elementary charge and the quantum spin is and what the underlying nature of some of the fundamental forces of nature are. They are also, in my view, sufficient to either encompass, underpin or improve the existing practical theories of current physics. The development of a new, continuous linear theory to describe this has been the subject of the papers presented last year at FFP14 and submitted this year to this conference. If this approach should prove of any merit, it will remain the work of many man-years to develop the solutions to the level of those of Maxwell, Dirac or Schroedinger theories. Even if the new theory is worth anything, there remains much work to be done.

The new theoretical view holds that space and time are primary. They exist everywhere (and for all time!), whether or not any energy is present within them or not. The root four dimensions of space and time may also manifest in products and quotients of the base four "directions". This allows root-energy to manifest not only in vectors, but also such things as physical areas - as the product of space with perpendicular space. Multiplying any space (or time) with a parallel space gives a conceptually different kind of object to an area. The sequence area-line-point would identify this with a "point". This object, however, is not a point in the way the word is usually understood. Just as a line may be extended to one of any length (magnitude), this kind of point may also have any magnitude. If one attributes the experimentally measured (relativistic) properties of space and time to lines in space and time, then the lines must vary as a four-vector, the plane product as a field, and the point product as a Lorentz invariant. Introducing root-energy into these forms then gives stuff with the physical properties of a root 4-current density, an electromagnetic field and a rest-mass, respectively. Further, the volume forms act as a root angular momentum - a spin. It is simple to show that the equations describing this for the field are identical to the four, coupled differential equations known as the Maxwell equations. A new, general, equation over the sixteen terms (1 scalar, 4-vector, 6-field, 4-spin, 1 pseudo-scalar) encompassing the free-space Maxwell equations is then:

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$$\mathcal{D}_4 G_{16} = \alpha_0(\vec{\nabla} \cdot \vec{E} + \partial_0 P) + \alpha_{123}(\vec{\nabla} \cdot \vec{B} + \partial_0 Q) + \alpha_i \left(\vec{\nabla} \times \vec{B} - \partial_0 \vec{E} - \vec{\nabla}P \right) + \alpha_{0ij}(\vec{\nabla} \times \vec{E} + \partial_0 \vec{B} + \vec{\nabla}Q) +$$

$$\alpha_P(\vec{\nabla} \cdot \vec{A} + \partial_0 A_0) + \alpha_{0123}(\vec{\nabla} \cdot \vec{T} + \partial_0 T_0) + \alpha_{i0} \left(\partial_0 \vec{A} + \vec{\nabla}A_0 + \vec{\nabla} \times \vec{T} \right) + \alpha_{jk} \left(\partial_0 \vec{T} + \vec{\nabla}T_0 - \vec{\nabla} \times \vec{A} \right) = 0 \quad (1)$$

Here the basis vectors, denoted by the α's have one numerical index for the vectors, two for the planes, three for the volumes and four for the 4-volume. $\mathcal{D}_4$ is a 4-vector differential. E and B denote the electric and magnetic fields, and A and T the vector and tri-vector potential respectively. P and Q are rest-mass like components invariant under a Lorentz transformation. The special root-energy density scalar is denoted α_P. For the field only part, the first four equations without the P and Q terms, this reduces to Maxwell's equations. The new approach, however, allows new kinds of holomorphic, covariant solutions to the pure field (light-speed) Maxwell equations describing a covariant wave. Viz, for a single photon travelling in the "z" direction:

$$F_L = H_0 U_F R \mathcal{E}(\alpha_{10} + \alpha_{31}) e^{\frac{\mathcal{E}}{\hbar} R(\alpha_3 \frac{z}{c} - \alpha_0 t)\alpha_{012}} = F_0 R(\alpha_{10} + \alpha_{31}) e^{R(k\alpha_3 z - \omega\alpha_0 t)\alpha_{012}} = \mathcal{FW} \qquad (2)$$

Except for U_F, which is a new universal constant converting to field units and related to $\hbar$, the pre-factor terms are normalisation terms in phase (H_0) and energy (R and $\mathcal{E}$). The crucial features of this new wave function are that the photon energy ($\mathcal{E}$), appears in both pre-factor and exponent, that the argument of the exponential is not a simple number but contains explicitly the proper nature of space and time in the form of α_3 a proper unit vector in the direction of z and α_0, a proper unit vector in the direction of time and that a proper unit angular momentum (α_{012}) is required for this to be a travelling wave solution. Lorentz transformations are described in the wave-function by the single parameter R - scaling both field and frequency (and hence integral energy) linearly. This allows the same photon to be described in different frames - particularly those of the emitter and absorber. The function describes photons of any energy from gamma to radio and beyond - right to the limit of as close as you like to zero energy.

Extending the theory to include some of the new terms, especially the root invariant rest-mass term P, allows qualitatively new kinds of solutions. These contain, as well as the rest-mass component, re-circulating field components. Such solutions are necessarily charged, have half-integral spin and have the proper 720 degree symmetry of fermions. These solutions are identified with the electron and positron. The new theory then describes both light-speed field only solutions corresponding to the photon and re-circulating solutions corresponding to the electron within the same framework. It allows, for the first time, the description of the process of particle-antiparticle pair creation within a single linear theory.

Within the theory, the elementary charge q may be estimated in terms of the elementary spin $\hbar$ (or vice-versa) and is found to be close to the value observed in experiment. The new solutions describe both both light and material particles and arise from the constraints imposed by the deeper principles of the nature of space and time and the linearity of field and energy. Quantisation arises from the rigorous development of relativity.

In the new theory space and time - the defining components of the physical vacuum, are primary and are always present. Space and time condition any root-energy into different forms, manifesting as mass (scalar), charge and current (vector), fields (areas), spin (volumes) and a spin root (a 4-dimensional volume).The theory allows, however, for the possibility that the root-energy at certain places may go to zero - an empty vacuum. For all practical purposes, of course, "free" space is always full of the photons that paint our world - even if they are only those of the 3K background radiation. The answer then, for me, to the question posed in the title is "all three". With "something else", here being the proper nature of space, time and energy - the underlying form of the "vacuum" present at all localities.