is conserved, because $\theta_{\rho\sigma}$ is symmetrical and divergence free. In the usual classical formulation of the Maxwell field, the angular momentum is automatically resolved into orbital and spin components[4]. This decomposition is not justifiable on physical grounds, and, in addition, it is not gauge-invariant. If one associates a spin density with $G_{omn} - G_{onm}$, customary Maxwell theory yields the non-gauge invariant $E_m A_n - E_n A_m$, whereas Dirac's theory yields $E_m kv_n - E_n kv_m$. In space-time regions where there is electric charge, the latter expression seems to be unique. For space-time regions where there is no charge, the Dirac spin density, in the Lagrangian formulation of his theory, seems to be indeterminate, because v_μ is indeterminate[2].

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The Energy Momentum Tensor in Dirac's New Electromagnetic Theory

TYABJI[1] has shown that the energy momentum tensor in the vortical form of Dirac's new electromagnetic theory[2] has the same form as that belonging to the non-vortical theory. The method he uses of first obtaining a non-symmetrical form and then adding a suitable symmetrizing term depends on the particular definition of the electromagnetic potential A_μ and thus does not show why the two energy momentum tensors should have the same form.

The energy momentum tensor can be obtained by a different method, namely, by writing the metrical tensor $g_{\mu\nu}$ explicitly in the Lagrangian function L and then considering the variation of the integral $\int L \sqrt{-g}\, dx^1 dx^2 dx^3 dx^4$ with respect to $g_{\mu\nu}$.

In the non-vortical form of Dirac's theory, one has :

$$L = -\tfrac{1}{4} g^{\mu\sigma} g^{\nu\tau} F_{\sigma\tau} F_{\mu\nu} + \tfrac{1}{2}\lambda (g^{\mu\nu} A_\mu A_\nu - k^2), \quad (1)$$

and in the vortical form :

$$L = -\tfrac{1}{4} g^{\mu\sigma} g^{\nu\tau} F_{\sigma\tau} F_{\mu\nu} + \tfrac{1}{2}\lambda' (g^{\mu\nu} v_\mu v_\nu - 1), \quad (2)$$

where

$$v_\mu = k^{-1}\left(A_\mu - \xi \frac{\partial\eta}{\partial x^\mu}\right) \quad (3)$$

and

$$\lambda' = k^2 \lambda. \quad (4)$$

While a velocity vector is usually regarded as contravariant, the v_μ defined in Dirac's vortical theory is initially covariant, so that v_μ is independent of $g_{\mu\nu}$ and $v^\mu = g^{\mu\nu} v_\nu$. For this reason the covariant v_μ is used in (2). Variation with respect to $g_{\mu\nu}$ gives directly the symmetrical form of the energy momentum tensor obtained by Tyabji. Since the velocity vector in the non-vortical theory is defined by $v_\mu = k^{-1} A_\mu$, and since (1) and (2) contain $g_{\mu\nu}$ in the same way, it is clear that the resulting energy momentum tensors will have the same form, despite the different definitions of the electromagnetic potentials in the non-vortical and the vortical theories. Since the variables ξ, η do not enter (2) explicitly, they do not appear explicitly in the energy momentum tensor.

I take this opportunity to mention that the Schrödinger form of the non-vortical theory[3] is contained in the similarity theory of relativity, the variational principle being constructed in terms of the curvature scalar of a general symmetrical similarity tensor $S_{\sigma\tau}$. The details will shortly appear in *Physical Review*.

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Colour in Electron Microscopy

THE wave-length of the beam of an electron microscope, compared with visible light, is the property akin to colour. The beam is 'monochromatic' and it is standard practice to maintain it so within very narrow limits. The wave-length for electrons, in terms of their velocity expressed in electron volts, is given by the equation $\lambda = \sqrt{(150/V)}$ Angstrom units, where λ is the wave-length and V is the voltage accelerating the electrons. The 'colour' (wave-length) of the electron beam is varied by varying the voltage accelerating the electrons.

The image produced by the electron microscope is somewhat similar to a radiograph. The light and shade depend on the difference in the scattering and absorption of the beam by different parts of the specimen, which in turn depend on the wave-length. This is a function of the accelerating voltage, the thickness of the specimen, and the atomic numbers of the atoms composing the specimen.

The electron micrographs of the same specimen taken with electron beams of 25 kV. and 75 kV., respectively, show different detail and a certain amount of overlap. The internal detail in the higher-voltage picture shows up very well; but very little is seen in the lower-voltage picture (see Figs. 1 and 2). The contrast of some low-density detail outside the bacteria which can be distinguished in the lower-voltage micrograph is reduced to such an extent as to render it nearly invisible in the higher-voltage picture. The similarity between micrographs taken at various voltages and X-ray pictures taken at various voltages, which is the basis of colour radiography introduced by Donovan[1,2], is obvious.

Colour electron microscopy involves the use of electron beams of two or more different voltages, and produces images in which colour is used to differentiate structure. Electron micrographs of the specimen are taken at two or more voltages (wave-lengths) selected to give the desired contrast. The images thus produced are each tagged in a visible colour such as red, green and blue, for a set of three electron micrographs, and are combined by optical superimposition or other means to form a colour electron micrograph. Such a composite colour picture shows not only variations in density but also variations in colour. Different colours in the final micrograph represent varying distribution of materials in the specimen absorbing or scattering at one or another of the wave-lengths (voltages) selected. In