"ESSAYS ON GRAVITATION"

THE UNIFIED FIELD.

The unification of the electromagnetic and gravitational fields can be achieved within Riemann's ~~theory of curvilinear~~ geometry using the newly discovered longitudinal components of the electromagnetic field in the vacuum {1-10}. The ~~flatlander's~~ conventional, theory of electromagnetism is a two dimensional world which works within the familiar U(1) group {11}, the group of rotations in a plane, with nothing defined perpendicular to that plane. The discovery of the $\underline{B}^{(3)}$ field of Evans and Vigier {1-10} leads to U(1) being replaced by the group of rotations in the ordinary three dimensional world, the ~~group~~ space symmetry group O(3). In spacetime, this is enlarged to the local Poincaré group, which becomes the ~~description~~ of electromagnetism. It follows that the electromagnetic field is a particular contraction of the Riemann tensor in which the affine connections are antisymmetric {8-10}. This contraction gives an antisymmetric Ricci tensor, which is proportional to an electromagnetic field strength tensor $G_{\mu\nu}$. The latter contains within it a longitudinal component in the vacuum, the $\underline{B}^{(3)}$ field. It is now understood that $\underline{B}^{(3)}$ is one of a set of longitudinal solutions of the propagating electromagnetic field. Chubykalo and Smirnov-Rueda {12} have proven that it is the longitudinal component responsible for instantaneous action at a distance. The magnetic components of the electromagnetic field are inter-related in the vacuum through an O(3) cyclical symmetry governed in structure by the commutators of angular momentum, or equivalently, by the relation between infinitesimal rotation generators of O(3). This structure remains the same in the Poincaré group of spacetime provided that 3 x 3 matrices are replaced by 4 x 4 equivalents. Therefore the electromagnetic field becomes spacetime curved according to O(3) within the Poincaré group. The Ricci tensor that governs this type of

spacetime curvature is the antisymmetric component of the overall rank two tensor whose symmetric part appears in the Einstein equations for the gravitational field in the general theory of relativity. Since any rank two tensor is the sum of its symmetric and antisymmetric parts, we arrive at a simple, Riemannian, method of treating electromagnetism and gravitation as a unified field.

In the conventional point of view, the electromagnetic field is not curved spacetime, it is a physical entity which is philosophically distinct from the frame of reference, as in physics prior to the equivalence principle. The difficulties of unifying the electromagnetic and gravitational fields in the conventional ("pre $B^{(3)}$") point of view spring largely from the fundamental philosophical difference between the concept of field as given by Faraday, Maxwell, and contemporaries and the concept of field / frame equivalence as given by Einstein. The local group of gravitation in general relativity is the Poincaré group; that of electromagnetism, until recently, was thought to be U(1). These groups are mutually incompatible because they are dimensionally incompatible. The myth of transversality was founded in turn on the belief that in the vacuum, only transverse components existed in the electromagnetic field, whose particulate embodiment, the photon, was thought to be a particle, but one without mass; and one which could not be localised. The transverse components were thought to propagate in the vacuum at the speed of light, the signal velocity known empirically with great precision. These transverse components were related within the linear field equations of Maxwell, ~~originally written in the 1860's in terms of quaternions, equations which introduced the displacement current responsible for electromagnetic waves.~~ The equations of gravitation in general relativity can be reduced to the special relativistic form of Maxwell's equations, but only in the linear, weak field approximation. Gravitation

otherwise carries its own source in a non-linear mathematical structure. Electromagnetism in the vacuum was written within a linear field calculus and was considered to be source free. Above all there loomed the philosophical barrier between the idea of a field as spacetime curvature (gravitational theory) and that of the field as a separate physical entity (electromagnetic theory).

A look at the Riemann or Ricci tensors in gravitation, and at gauge theory in electromagnetism written for the field strength tensor in a group symmetry other than the flatlander's U(1), reveals a close similarity of structure. In U(1) the structural similarity disappears with that part of the Riemann or field strength tensor quadratic in the affine connection. However, the Riemann tensor is written with covariant derivatives; the electromagnetic field strength tensor with ordinary ones in U(1) theory. There is an analogous and related similarity of structure between the Jacobi / Bianchi identity in gravitation and the homogeneous Maxwell equation in electromagnetism; but again, covariant is replaced by ordinary derivative. These seemingly fundamental dissimilarities in derivative operators disappear however if we accept longitudinal components for the vacuum electromagnetic field. If so, the latter's field strength tensor becomes an antisymmetric Ricci tensor, defined with covariant derivatives in which appear antisymmetric affine connections {8-10}. Similarly, the homogeneous Maxwell equations become a Jacobi / Bianchi identity within O(3), or more rigorously, within the Poincaré group. The metric coefficient for the electromagnetic field becomes totally antisymmetric (off diagonal); and the longitudinal component of the electromagnetic field is incorporated self-consistently in a non-linear, non-Abelian structure. The philosophy of the electromagnetic field becomes compatible with that of the gravitational field, because the electromagnetic field strength tensor becomes proportional to the

antisymmetric Ricci tensor through the elementary fluxon (quantum of magnetic flux $\hbar$ / e, where $\hbar$ is Dirac's quantum; and e the quantum of charge). In order therefore to describe the electromagnetic field we require a spacetime that is curved antisymmetrically, and we require the elementary fluxon. Similarly, in order to describe gravitation we need a scaling constant proportional to the gravitational constant. The electromagnetic and gravitational fields, within given factors of proportionality, become respectively the antisymmetric and symmetric parts of the same Ricci tensor. These parts are obtained from the same Riemann tensor by different types of index contraction {8-10} and the beauty of this is that both fields are Riemannian in nature.

This type of field unification rests on the empirical evidence for the existence of longitudinal components of the electromagnetic field in the vacuum; ~~and by tautology, such evidence becomes available in field / matter interaction and equilibrium~~; for example magneto-optic phenomena {13} in which electromagnetic radiation magnetizes matter. Transverse mythology requires a phenomenon of inverse induction, for example phase free magnetization by a ruby laser {14} (the inverse Faraday effect), to be described through non-linear, quadratic, products of transverse field components. One of these, the conjugate product {1-10}, is the vector product of the vector potential with its own complex conjugate. ~~This vector product in O(3) symmetry produces another axial vector in the axis of propagation, i.e. a~~ longitudinal axial ~~vector; and this is~~ the result of ordinary vector algebra in three dimensions. There is an immediate and irreconcilable conflict with the flatlander's U(1) group, which allows nothing to be defined outside the U(1) plane. ~~The latter is transverse to the propagation direction.~~ This is the point at which the older philosophy of the

electromagnetic field can be transmuted logically into a proportionality between field and frame, i.e. into a general theory of relativity within Riemannian curvilinear geometry.

~~The magnetization vector produced empirically by circularly polarized electromagnetic radiation in the inverse Faraday effect is parallel to the direction of propagation of the beam~~, i.e. is a longitudinal, phase free, magnetization. ~~The latter is now known to be~~ produced by one of a family of new and extraordinary longitudinal solutions in the vacuum of the electromagnetic field {15-20}. This is the phase free component, the fundamental spin, $\underline{B}^{(3)}$. It becomes rational to look at vacuum electromagnetism from the longitudinal perspective; and to construct, or infer the existence of, transverse components by an expansion of the fundamental spin. In this way, it is possible to introduce the electromagnetic phase, containing the frequency and wavenumber; and to deduce that the electromagnetic field is defined completely in terms of {1, 6} the Pauli Lyubansky axial 4-vector $B^{\mu} = (B^{(0)}, \underline{B}^{(3)})$, where B is the magnitude of $\underline{B}^{(3)}$; and the energy momentum ~~four~~ polar 4-vector p^{μ}.

~~A very new but important parallel development in electromagnetism is that~~ the old coulombic problem of action at a distance can be explained in terms of $\underline{F} = \underline{B}(3)$, where $\underline{F}$ is ~~the~~ a field introduced by Chubykalo and Smirnov-Rueda {12}, and now identified {21} with $\underline{B}^{(3)}$. Significantly, experimentally observable superluminal phenomena {22-26} cannot be explained from Maxwell's equations without longitudinal wave components being present in the vacuum. Instantaneous action at a distance surely means that there is some influence present that is transmitted through the intervening vacuum at speeds much greater than c: logically, infinitely greater than c. ~~The beginnings of an understanding are being reached now among several leading researchers {15-26}~~ and [15-26] ~~that~~ action at a distance means a physical longitudinal transmission [27] - ~~as advocated by Pope and others {27} for many years~~ (a violation). Such a

theory also allows simple, Riemannian, unification of the electromagnetic and gravitational fields as components of the same Ricci tensor; and if this is accepted, action at a distance also becomes logically possible in gravitation. ~~Wheeler {28} has turned the argument on its head and has already suggested that~~ general relativity ~~may~~ be a logical outcome of action at a distance. Superluminal phenomena in the electromagnetic field have recently appeared in the popular literature {26} following the transmission of Mozart at greater than c: the music of the spheres.

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References.

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