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INVERSE FARADAY EFFECT FROM THE FIRST PRINCIPLES OF GENERAL RELATIVITY.

by

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ABSTRACT

The inverse Faraday effect is described from the first principles of general relativity using the irreducible representations of the Einstein group.

Keywords: Inverse Faraday Effect, $\underline{B}^{(3)}$ field, Einstein group.

The inverse Faraday effect (IFE) is well known to be the magnetization of matter by circularly polarized radiation {1-3}. It is described in the received view using empirical molecular property tensors which are introduced into the Maxwell field equations. Therefore the latter do not describe the IFE from first principles. In this Letter the effect is explained straightforwardly and for the first time from the first principles of general relativity.

Consideration {4} of the irreducible representations of the Einstein group has led to classical, unified field equations of electromagnetism and gravitation, field equations which contain more physical information than both the Maxwell and Einstein field equations. An important result of this theory is that the electromagnetic field tensor contains, under all conditions, a non-Abelian component which is not present in the Maxwell field equations:

$$F^{\mu\nu} = \frac{1}{8} QR \left(q^{\mu} q^{*\nu} - q^{\nu} q^{*\mu} \right). \qquad -(1)$$

Here q^{μ} is a quaternion valued metric {4}, R is a scalar curvature, and Q a universal constant with the units of charge. The asterisk denotes time reversal or quaternion conjugation {4}.

The quaternion valued metric q^{μ} appearing in eqn. (1) is defined as

$$q^{\mu} = \left(q^{\mu 0}, q^{\mu 1}, q^{\mu 2}, q^{\mu 3} \right) \qquad -(2)$$

and the total number of components of q^{μ} is sixteen {4}. The IFE appears from a special case of eqn. (1) through a choice of metric explained as follows. From eqn (1) it is possible to write four-valued, generally covariant cartesian components such as

$$q_x = \left(q_x^0, q_x^1, q_x^2, q_x^3 \right) \qquad -(3)$$

which obey the non-Abelian cyclic relations:

$$q_x^1 q_y^{*2} - q_y^2 q_x^{*1} = 2i\, q_x^3 . \qquad -(4)$$

If the space basis is represented by the complex circular {5} ((1), (2), (3)) then eqn. (4) can be written with superscripts 1, 2, 3 replaced by (1), (2), (3) respectively. This procedure gives the Cartesian vector relation:

$$\underline{q}^{(1)} \times \underline{q}^{(2)} = i\,\underline{q}^{*(3)} \qquad -(5)$$

et cyclicum

where, in the complex circular basis:

$$\underline{q}^{(1)} = \underline{q}^{*(2)} = \frac{1}{\sqrt{2}}\left(i\,\underline{i} + \underline{j}\right) e^{i\phi} \qquad -(6)$$

where the asterisk denotes complex conjugation, where $\underline{i}$ etc. are unit vectors in the Cartesian basis, and where ϕ is a phase factor {6}. This choice of metric gives the magnetic field component:

$$\underline{B}^{(3)} = \frac{1}{8}\,Q R\,\underline{k} \qquad -(7)$$

under all conditions. In particular, $\underline{B}^{(3)}$ exists in the free field {4} as a special case of the field tensor of the unified field theory in general relativity. The $\underline{B}^{(3)}$ field does not exist in the Maxwellian field theory {4}.

The IFE can be explained as the magnetization produced by $\underline{B}^{(3)}$ when the free field encounters an electron, an explanation which reduces to a change of scalar curvature R in unified field theory and is explained in terms of the $\underline{B}^{(3)}$ field. The latter does not exist in the Maxwell field equations so this explanation of the IFE is a method of demonstrating the fact that the unified field theory on which the explanation is based contains more information than the Maxwell field equations. The IFE is characterized in electrons (plasma), atoms and molecules by measuring experimentally the change in scalar curvature R. In other words the magnetization is measured experimentally and expressed in terms of the change in R.

The conventional explanation of the IFE {1-3} is through the use of molecular property tensors and is much more complicated than the explanation offered here. By Okham's Razor the new explanation is preferred. The complexity of the conventional explanation is due to the fact that Maxwell's field equations are incomplete, they cannot produce the $\underline{B}^{(3)}$ field which is responsible for the IFE.

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