

## Chapter 4

# On The Origin Of Magnetization And Polarization

by

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### Abstract

The origin of magnetization and polarization in the Evans field theory is traced to the spin connection term in the first Maurer Cartan structure equation of differential geometry. The spin connection term originates in the spinning or swirling of spacetime, which sets up a spacetime magnetization around for example a visible laser beam. Spacetime magnetization is not visible but is detectable experimentally in the electromagnetic (and other) Aharonov Bohm effects and in non-local phenomena in general. Magnetization and polarization in material matter is then a change in the spacetime magnetization, i.e a change in the spin connection of the Evans unified field theory.

Key words: Evans unified field theory, magnetization, polarization, spacetime magnetization, spin connection, field matter interaction, magnetization and polarization of matter.

### 4.1 Introduction

Recently the Evans field theory has provided a workable framework upon which to unify the theories of gravitation and electromagnetism [1]– [6]. In this paper

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the theory is used to trace the origin of magnetization and polarization in the spin connection term of the definition of the electromagnetic field tensor. The inference is made of a novel spacetime magnetization  $M^a$ , a magnetization caused by the swirling or spinning of spacetime around a propagating electromagnetic field. If the latter is a visible laser for example,  $M^a$  is an invisible region of magnetization around the visible electromagnetic field, the latter being always defined by the spatial or temporal derivatives of the electromagnetic potential  $A^a$ . In the Evans field theory  $A^a$  is the fundamental tetrad field [7]– [10] within a primordial or universal factor  $A^{(0)} = \phi^{(0)}/c$  where  $\phi^{(0)}$  has the units of volts and where  $c$  is the speed of light. The presence of  $M^a$  is detected experimentally by a novel electromagnetic or second order Aharonov Bohm effect (EAB) [7,8]. If the laser is replaced by a static magnetic field the spacetime magnetization around the magnetic field is detected with the original first order (magnetic) Aharonov Bohm effect first demonstrated by Chambers [9]. Similarly there is a spacetime polarization  $P^a$  around a static electric field (a polarization detectable in the Aharonov Bohm effect due to a static electric field), and a spacetime polarization also accompanies the EAB. Magnetization and polarization in matter is then a change in the spin connection defining the fundamental spacetime magnetization and polarization. This is a correctly objective or generally covariant description as required by the principle of general relativity and as such is a major advance on the standard model. In the latter, electromagnetism is a theory of special relativity and is Lorentz covariant only, and not generally covariant as required of any objective theory of physics. In consequence the effect of gravitation (curved spacetime) on electromagnetism (flat spacetime in the standard model) cannot be analyzed in the standard model, and the concept of spacetime magnetization and polarization is missing. The standard model attempts [10] to explain the class of AB effects with non-simply connected regions of space in special relativity, but it has been shown recently [11] that such an explanation must always violate the fundamental Poincaré Lemma for any type of space.

In Section 4.2 spacetime magnetization and polarization is defined from the first Maurer Cartan structure equation of differential geometry, which in the Evans field theory becomes [1]– [6] the fundamental definition of the anti-symmetric field tensor. In section 4.3 it is argued that spacetime magnetization and polarization becomes the magnetization and polarization of matter through a change in the spin connection of the Evans field theory. This traces the origin of magnetization and polarization to differential geometry and general relativity. Finally in Section 4.4 a discussion is given of the description of magnetization and polarization in the standard model, whereupon it becomes clear that the Evans field theory has several theoretical and experimental advantages over the standard model.

## 4.2 Definition of Spacetime Magnetization and Polarization

In the correctly objective (i.e. generally covariant) unified field theory of Evans [1]– [6] the anti-symmetric electromagnetic field tensor is defined by the following vector valued two-form:

$$F^a = D \wedge A^a = d \wedge A^a + \omega^a_b \wedge A^b. \quad (4.1)$$

Here  $D \wedge$  denotes the covariant exterior derivative,  $d \wedge$  the exterior derivative,  $A^a$  the vector valued potential one-form and  $\omega^a_b$  is the spin connection of the Palatini variation of general relativity [12]– [14]. The homogeneous Evans field equation (HE) is the correctly objective form [1]– [6] of the standard model's [10] homogeneous Maxwell-Heaviside field equation (HME). The HE is:

$$d \wedge F^a = -A^{(0)} (q^b \wedge R^a_b + \omega^a_b \wedge T^b). \quad (4.2)$$

Here  $R^a_b$  is the tensor valued Riemann or curvature two-form [14],  $T^a$  is the vector valued torsion two-form, and  $q^a$  is the vector valued tetrad one-form. In the Palatini variation the tetrad is the fundamental field of general relativity [12]– [14]. In the original Einstein - Hilbert variation [14] the symmetric metric  $g_{\mu\nu}$  is the fundamental field. The symmetric metric is factorized [14] into the dot product of two tetrads as follows:

$$g_{\mu\nu} = q^a_\mu q^b_\nu \eta_{ab} \quad (4.3)$$

where  $\eta_{ab}$  is the Minkowski metric of the tangent bundle spacetime at any point  $P$  in the base manifold (Evans spacetime).

The Evans Ansatz [1]– [6] is as follows:

$$A^a = A^{(0)} q^a. \quad (4.4)$$

From Eq.(4.4):

$$F^a = A^{(0)} T^a \quad (4.5)$$

Eqs. (4.4) and (4.5) show that electromagnetism in the Evans unified field theory is differential geometry within a factor  $A^{(0)}$ , a fundamental,  $C$  negative, universal and primordial influence, the vector potential magnitude. Within this factor  $A^{(0)}$  the field tensor (4.5) is the first Maurer Cartan structure equation [14] of standard differential geometry:

$$T^a = D \wedge q^a = d \wedge q^a + \omega^a_b \wedge q^b \quad (4.6)$$

and within the factor  $A^{(0)}$ , the HE is the first Bianchi identity of standard differential geometry:

$$D \wedge T^a = R^a_b \wedge q^b. \quad (4.7)$$

Eq.(4.7) can be rewritten as:

$$d \wedge T^a = - (q^b \wedge R^a_b + \omega^a_b \wedge T^b) \quad (4.8)$$

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The homogeneous electromagnetic current of the unified field theory is defined as:

$$j^a = -\frac{A^{(0)}}{\mu_0} (q^b \wedge R^a{}_b + \omega^a{}_b \wedge T^b) \quad (4.9)$$

where  $\mu_0$  is the vacuum permeability in S.I. units. Under laboratory conditions:

$$j^a \sim 0 \quad (4.10)$$

because Eq.(4.2) is the correctly objective combined expression of the Faraday Law of induction and the Gauss Law of magnetism [1]– [6]. Both these laws appear to hold within contemporary experimental precision under laboratory conditions. In a cosmological context however, for example the deflection of light grazing an intensely gravitating object in an Eddington experiment,  $j^a$  is already known to be observable, because it is the electromagnetic current responsible for this deflection of light. In other words  $j^a$  is a measurable influence of intense gravitation on electromagnetism propagating in free space. It is well known that Einstein predicted the deflection of light by intense gravitation using a purely gravitational theory, the photon being assumed implicitly to be a mass that is attracted gravitationally by the mass of the sun. In the Evans unified field theory this SAME influence or mutual interaction appears classically through  $j^a$ . Therefore the Evans field theory correctly predicts the results of the Eddington experiment, (deflection of light by the sun), and in addition, the Evans theory shows that the Faraday Law of induction and Gauss Law of magnetism no longer hold in the presence of intense gravitation. In order to realize this a UNIFIED field theory is evidently needed, a purely gravitational theory such as that used originally by Einstein, is not enough to give us the homogeneous current  $j^a$ . The fact that the well known Gauss and Faraday laws appear always to hold in the laboratory is due to the fact that the gravitation of the Earth is too small to detect  $j^a$ . Therefore in the unified field theory there are experimentally verifiable effects such as the Eddington experiment which do not exist in the standard model. Another example is the well known relativistic pulsar radiation [15], and this will be the subject of future work to analyze the effect of intense gravitation on synchrotron radiation. A pulsar is essentially a synchrotron located on a rotating and very intensely gravitating neutron star.

A third example (out of many) is the subject of this paper and is defined in this section - spacetime magnetization and polarization.

In the unified field theory a visible frequency laser beam, for example, is defined on the classical level by:

$$F^a = d \wedge A^a + \omega^a{}_b \wedge A^b \quad (4.11)$$

$$d \wedge F^a = \mu_0 j^a \sim 0. \quad (4.12)$$

The first term in Eq.(4.11) describes the visible part of the beam, and the invisible second term in Eq.(4.11) describes spacetime swirling around the beam in analogy to a whirlpool set up by a stirring rod. The latter is the analogy for

the beam, and the water of the whirlpool is the analogy for swirling or spinning spacetime ITSELF. This produces SPACETIME MAGNETIZATION:

$$M^a = \frac{1}{\mu_0} \omega^a_b \wedge A^b. \quad (4.13)$$

It is concluded that: 1) The visible light of a laser is defined by  $d \wedge A^a$ , i.e. by the spatial and temporal DERIVATIVES of the potential or tetrad field  $A^a$ . These derivatives define the electric and magnetic fields of the laser beam. 2) The spacetime magnetization  $M^a$  surrounding the laser beam is invisible but gives rise to an Aharonov Bohm effect at second order - the electromagnetic Aharonov Bohm effect (EAB) [7, 8].

The EAB occurs in regions where:

$$d \wedge A^a = 0 \quad (4.14)$$

but where:

$$M^a \neq 0. \quad (4.15)$$

Similarly in the well known Chambers experiment [9] the magnetic field inside the iron whisker is defined by Eq.(4.11) and the well known Chambers effect or magnetic Aharonov Bohm effect is due to the spacetime magnetization set up by the static magnetic field rather than by the laser (electromagnetic field). 3) It is seen that the origin of magnetization (and also polarization) is differential geometry, the existence of spinning or swirling spacetime.

Spacetime magnetization is defined by the Evans spin field [1]- [6]:

$$M^a = \frac{1}{\mu_0} B^a \quad (4.16)$$

and the  $B^a$  Field is observed directly in the inverse Faraday effect [16]. Both  $M^a$  and  $B^a$  are due to the spinning of spacetime in general relativity. In the standard model both  $M^a$  and  $B^a$  are undefined from first principles because electromagnetism in the standard model is a theory of special relativity in which the Minkowski spacetime is flat and static. Since  $M^a$  and  $B^a$  are both experimental observables, the Evans theory is preferred experimentally to the standard model. The Evans theory is also preferred philosophically and theoretically because it is correctly objective and generally covariant and because it is a unified field theory of all radiated and matter fields.

### 4.3 Magnetization and Polarization in Field Matter Interaction

When there is field matter interaction, magnetization and polarization are defined by the following changes in the spin connection and field tensor:

$$\omega^a_b \longrightarrow \Omega^a_b \quad (4.17)$$

$$F^a \longrightarrow G^a, \quad (4.18)$$

so Eq.(4.1) becomes:

$$G^a = d \wedge A^a + \Omega^a_b \wedge A^b \quad (4.19)$$

and  $\Omega^a_b$  is seen to be the origin of magnetization and polarization of matter by an electromagnetic field. The interaction process is described by the inhomogeneous Evans field equation (IE) [1]- [6]:

$$d \wedge \tilde{G}^a = \mu_0 J^a \quad (4.20)$$

in which the inhomogeneous current is defined by:

$$J^a = -\frac{A^{(0)}}{\mu_0} \left( q^b \wedge \tilde{R}^a_b + \Omega^a_b \wedge \tilde{T}^b \right). \quad (4.21)$$

Here  $\tilde{R}^a_b$  is the Hodge dual of  $R^a_b$  and  $\tilde{T}^b$  is the Hodge dual of  $T^b$ . In the absence of magnetization and polarization of matter, the spin connection  $\Omega^a_b$  reverts to  $\omega^a_b$  and eqn.(4.20) becomes:

$$d \wedge \tilde{F}^a = \mu_0 J_0^a \quad (4.22)$$

where the inhomogeneous current is now defined by:

$$J_0^a = -\frac{A^{(0)}}{\mu_0} \left( q^b \wedge \tilde{R}^a_b + \omega^a_b \wedge \tilde{T}^b \right). \quad (4.23)$$

Eqn.(4.21) therefore describes an idealized or mathematical type of field matter interaction which does not produce magnetization or polarization. In situations of interest to physics however, magnetization and polarization are always produced in matter by an electromagnetic field, even on the one electron level [17]. The HE (Eq.(4.2)) describes the propagation of electromagnetic radiation in free space.

It is seen that a concise and rigorously objective description of magnetization and polarization is given by differential geometry in the Evans field theory.

## 4.4 Magnetization and Polarization in the Standard Model

In the standard model classical electromagnetism is a theory of special relativity and the electromagnetic field is a mathematical or abstract entity superimposed on a flat and static Minkowski spacetime. Magnetization ( $\mathbf{M}$  in  $Am^{-1}$ ) and polarization ( $\mathbf{P}$  in  $Cm^{-2}$ ) are introduced phenomenologically (i.e. from the existence of the phenomenon and not by reasoning or deduction from a first principle) in the constitutive equations that define the magnetic field strength  $\mathbf{H}$  (in  $Am^{-1}$ ) and the electric displacement  $\mathbf{D}$  (in  $Cm^{-2}$ ):

$$\mathbf{H} = \frac{1}{\mu_0} \mathbf{B} - \mathbf{M} \quad (4.24)$$

$$\mathbf{D} = \epsilon_0 \mathbf{E} + \mathbf{P}. \quad (4.25)$$

Here  $\mathbf{E}$  is the free space electric field strength (in volt  $m^{-1}$ ) and  $\mathbf{B}$  is the free space magnetic flux density (in tesla). In Eqs.(4.24) and (4.25) the permittivity in vacuo ( $\epsilon_0$ ) and permeability in vacuo ( $\mu_0$ ) have the S.I. values:

$$\epsilon_0 = 8.854188 \times 10^{-12} J^{-1} C^{-2} m^{-1} \quad (4.26)$$

$$\mu_0 = 4\pi \times 10^{-7} J s^2 C^{-2} m^{-1}. \quad (4.27)$$

The equivalents of Eq.(4.2) in the standard model are:

$$\nabla \cdot \mathbf{B} = 0 \quad (4.28)$$

$$\nabla \times \mathbf{E} + \frac{\partial \mathbf{B}}{\partial t} = \mathbf{0}, \quad (4.29)$$

and the equivalents of Eq.(4.20) in the standard model are:

$$\nabla \cdot \mathbf{D} = \rho \quad (4.30)$$

$$\nabla \times \mathbf{H} = \frac{\partial \mathbf{D}}{\partial t} + \mathbf{J}. \quad (4.31)$$

Here  $\rho$  is charge density (in  $Cm^{-3}$ ) and  $J$  is current density (in  $Am^{-2}$ ). Eq(4.28) is the Gauss law applied to magnetism; Eq.(4.29) is the Faraday law of induction; Eq.(4.29) is the Coulomb law and Eq. (4.31) is the Ampère Maxwell law.

The standard model's description of electromagnetism is not generally covariant and in consequence cannot analyze the effect of gravitation on electromagnetism or vice versa. Evidently the notion of spacetime curvature and torsion is absent from the standard model entirely, whereas they are present in the Evans theory through  $R^a_b$  and  $T^a$ . The spin connection  $\omega^a_b$  is missing from the standard model because the latter describes electromagnetism with a static Minkowski spacetime. In consequence the Evans spin field  $B^a$  and the spacetime magnetization  $M^a$  are missing from the standard model. This means in turn that the standard model is not able to describe the inverse Faraday effect or the Aharonov Bohm effects from the first principle of objective physics, the principle of general relativity. The standard model's description of electromagnetism is not able, again, to describe the Eddington experiment and gravitational lensing: the deflection of light by gravitation. In the standard model a beam of light in vacuo (the "source free" region of the standard model) is described by Eqs.(4.28) and (4.29), the Gauss and Faraday laws, and if this beam of light grazes an intensely gravitating object such as the sun no effect is expected in the standard models Eqs.(4.28) and (4.29). Yet it is observed that the light is deflected by the mass of the sun during an eclipse (the original Eddington experiment). Einstein's well known explanation of this phenomenon uses or implies the concept of particulate photon mass but the very concept of the photon as quantum of electromagnetic energy is missing entirely from Eqs.(4.28) to (4.31).

In the Evans field theory the Eddington experiment can be described on a classical level from Eq.(4.2), the HE. This result can be seen qualitatively as follows. Einstein's essentially quantum and particulate explanation of the Eddington experiment is based on Riemann geometry with a symmetric or Christoffel or Levi-Civita connection. This geometry is summarized succinctly by:

$$q^b \wedge R^a_b = 0. \quad (4.32)$$

$$\omega^a_b \wedge T^b = 0. \quad (4.33)$$

Eq.(4.32) is the Bianchi identity used by Einstein [14], and Eq.(4.33) follows from the fact that in Einsteins 1916 theory of general relativity the torsion form is zero:

$$T^b = 0. \quad (4.34)$$

It follows from Eqs.(4.32) and (4.33) that:

$$d \wedge F^a = \mu_0 j^a = 0. \quad (4.35)$$

This result is due to the fact that in the Einstein theory gravitation is not unified with electromagnetism on the classical level and there can never be any mutual influence of one field on another if we use the geometry defined by Eqs. (4.32) to (4.34). Eq.(4.35) means that the beam of light is not deflected. Electromagnetism uninfluenced by gravitation is defined [1]– [6] in the Evans field theory by the free space condition:

$$q^b \wedge R^a_b + \omega^a_b \wedge T^b = 0 \quad (4.36)$$

and Eq.(4.36) again leads to Eq. (4.35). Again there is no deflection of the beam of light by the sun. This result is again due to the fact that gravitation and electromagnetism are not mutually influential.

In order for the beam of light to be deflected by the sun in an Eddington experiment, the homogeneous current  $j^a$  must be non-zero. Conversely the experimental observation of deflection of light by the sun means that the Evans field theory is verified on a classical level, and the standard model is invalidated on a classical level. The geometry needed for this deflection is, from Eq.(4.2), defined by:

$$j^a = -\frac{A^{(0)}}{\mu_0} (q^b \wedge R^a_b + \omega^a_b \wedge T^b) \neq 0. \quad (4.37)$$

The presence of the sun therefore has the effect of changing:

$$d \wedge F^a = 0 \quad (4.38)$$

to

$$d \wedge F^a = \mu_0 j^a \neq 0. \quad (4.39)$$

This means that the beam is refracted by mass, i.e. its path is deflected. Similarly a beam of light is refracted when it interacts with matter (e.g. water).



The refraction by mass is described by the homogeneous current  $j^a$ , the refraction by water is described by the inhomogeneous current  $J^a$ . The refraction is accompanied in general by a change in polarization from the circular polarization of Eq.(4.38) to a modified polarization in Eq.(4.39). To calculate these changes quantitatively needs a computer in general, but the results can be seen qualitatively as described without any further calculation.

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