Chapter 5

Explanation Of The Eddington Experiment In The Evans Unified Field Theory

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Abstract

The Evans unified field theory offers a classical explanation of the refraction of electromagnetic radiation by gravitation (the Eddington effect or gravitational lensing). In so doing a number of other electromagnetic effects of gravitation are predicted by the theory.

Key words: Evans unified field theory, Eddington experiment, gravitational lensing, electromagnetic effects of gravitation.

5.1 Introduction

The Eddington experiment (1919 - 1922) [1] observed refraction of light by starlight in regions near the sun during an eclipse. The effect was a confirmation of the Einstein/Hilbert theory of general relativity [2] because the orbit of a photon around the sun is Einsteinian rather than Newtonian. Although based on the classical field theory of generally covariant gravitation, the Einstein/Hilbert explanation of the Eddington effect does not involve classical electrodynamics. In this paper a straightforward classical explanation of the Eddington effect (gravitational lensing) is offered using the Evans unified field theory [3]– [10]. In Section 5.2 the equations needed to explain the Eddington effect are written out in terms of standard differential geometry. These are the homogeneous Evans field equation (HE) and the inhomogeneous Evans field equation (IE). In general the electromagnetic effects of gravitation are found by solving these two equations simultaneously with initial and boundary conditions. The equations show that in general, gravitation will cause all the kinematic and electrodynamic effects familiar from the phenomena observed in the interaction of electromagnetic radiation with a dielectric [11]. These include refraction, the deflection of light (visible frequency electromagnetic radiation) by gravitation, the Eddington effect.

In Section 5.3 a short discussion is given of the origin of the fundamental vector potential magnitude $A^{(0)}$ of the Evans field theory.

5.2 Classical Field Theory on the Eddington Effect

The classical explanation of the Evans unified field theory is based in general on the solution of the HE and IE simultaneously, given initial and boundary conditions. The explanation is summarized as follows:

$$d \wedge F^a = 0 \qquad \longrightarrow \qquad d \wedge F^a = \mu_0 j^a \tag{5.1}$$

$$d \wedge \widetilde{F}^a = 0 \qquad \longrightarrow \qquad d \wedge \widetilde{F}^a = \mu_0 J^a. \tag{5.2}$$

Here F^a is the differential two-form [12] representing the electromagnetic field tensor and $\widetilde{F}^a$ is its Hodge dual. The symbol $d\wedge$ denotes the exterior derivative of differential geometry. The effect of gravitation on light grazing the sun is analyzed by the homogeneous current:

$$j^a = -A^{(0)} \left(q^b \wedge R^a{}_b + \omega^a{}_b \wedge T^b \right) \tag{5.3}$$

and the inhomogeneous current:

$$J^a = -A^{(0)} \left(q^b \wedge \widetilde{R}^a{}_b + \omega^a{}_b \wedge \widetilde{T}^b \right) \tag{5.4}$$

of the Evans field theory [3]– [10]. Here μ_0 is the S.I. permeability in vacuo, T^a is the torsion form of differential geometry [12], $R^a{}_b$ is the Riemann form of differential geometry, $\omega^a{}_b$ is the spin connection of differential geometry and q^a is the tetrad form of differential geometry. The scalar valued $A^{(0)}$ is a primordial vector potential magnitude with the units of volt s/m. Its origin and meaning is discussed further in Section 5.3.

In the absence of gravitation (in regions far from the sun) the currents j^a and J^a are vanishingly small, but for light grazing the sun the currents become finite and cause the Eddington effect. The origin of the currents is spacetime itself and this inference means that spacetime itself can act as a source for an electromagnetic field given the primordial vector potential magnitude $A^{(0)}$. The existence of the latter is also indicated by the Eddington effect on the classical level. The very fact that a light beam is refracted (i.e. deflected) by mass (the sun) proves the Evans unified field theory qualitatively on the classical level. Einsteins famous explanation of the Eddington effect is implicitly quantum in nature because the explanation is based on the gravitational attraction of the particulate photon by the sun. The light beam is made up of an ensemble of photons. This explanation does not use classical electrodynamics and kinematics because the explanation is based on a theory of gravitation only, and not on a unified field theory as required for a fuller understanding of the phenomenon. In the Maxwell-Heaviside (MH) theory of the contemporary standard model refraction by mass does not occur at all, because mass and gravitation do not occur in classical MH electrodynamics, in which the source of electromagnetism is accelerated charge. The charge is considered in MH theory as a point charge without mass and without volume. The latter is introduced only through the charge density. Similarly the current in MH theory is the motion of point charges, and volume is introduced only through current density. These nineteenth century concepts predate general relativity and are not compatible with general covariance or objectivity in physics. In consequence the MH equations are Lorentz covariant equations of special relativity but not generally covariant as required by general relativity. The standard model is therefor flawed fundamentally in several ways [3]– [10]. The inability of classical electrodynamics to explain the Eddington effect is a clear indication of these flaws.

In the Evans field theory j^a and J^a are properties of spacetime with both curvature and torsion, so gravitation can cause the refraction of light. There are also other effects predicted by the Evans unified field theory, effects such as absorption and dispersion due to gravitation, and in general any classical electrodynamical effect of a "dielectric". The "dielectric" in this case is spacetime ITSELF, specifically the Evans spacetime [3]– [10] defined by the presence of both curvature and torsion.

The simplest approximation to Eqs.(5.2) and (5.2) is:

$$j^a = 0 \tag{5.5}$$

$$J^a = -A^{(0)} q^b \wedge \widetilde{R}^a{}_b \tag{5.6}$$

i.e.:

$$d \wedge F^a = 0 \tag{5.7}$$

$$d \wedge \widetilde{F}^a = \mu_0 J^a = -A^{(0)} q^b \wedge \widetilde{R}^a{}_b \tag{5.8}$$

In this approximation

$$q^b \wedge R^a{}_b = 0 \tag{5.9}$$

$$\omega^a{}_b \wedge T^a = 0 \tag{5.10}$$

for gravitation and

$$q^b \wedge R^a{}_b + \omega^a{}_b \wedge T^a = 0 \tag{5.11}$$

for electromagnetism. Eqs.(5.9) and (5.10) define the differential geometry appropriate to the Einstein field theory of gravitation [3]– [10], and Eq.(5.11) defines the differential geometry of electromagnetism in free space [3]– [10].

In this simplest approximation the Eddington effect is caused by Eqs.(5.7) and (5.8), which must be solved simultaneously with given initial and boundary conditions. Written out in vector notation [13] these equations are as follows:

$$\nabla \cdot \mathbf{B}^a = \mathbf{0} \tag{5.12}$$

$$\nabla \times \mathbf{E}^a + \frac{\partial \mathbf{B}^a}{\partial t} = \mathbf{0} \tag{5.13}$$

$$\nabla \cdot \mathbf{E}^a = -cA^{(0)} \left(R^a{}_1{}^{10} + R^a{}_2{}^{20} + R^a{}_3{}^{30} \right) \tag{5.14}$$

$$\begin{aligned} \nabla \times \mathbf{B}^a = \frac{1}{c^2}\frac{\partial \mathbf{E}^a}{\partial t} - \frac{A^{(0)}}{\mu_0} \left(\left(R^a{}_0{}^{10} + R^a{}_2{}^{12} + R^a{}_3{}^{13} \right) \mathbf{i} \right. \\ \left. + \left(R^a{}_0{}^{20} + R^a{}_1{}^{21} + R^a{}_3{}^{23} \right) \mathbf{j} + \left(R^a{}_0{}^{30} + R^a{}_1{}^{31} + R^a{}_2{}^{32} \right) \mathbf{k} \right) \end{aligned} \tag{5.15}$$

A quantitative explanation of the Eddington effect in the Evans field theory therefore requires a knowledge of the scalar-valued Riemann components in Eqs.(5.14) to (5.15), and a knowledge of $A^{(0)}$. The Riemann scalar elements can be calculated from the Einstein field theory for a given metric, notably the Schwarzschild metric [12] for the sun. All the kinematic and electrodynamic effects normally associated with a dielectric are also expected from Eqs.(5.12) to (5.15) and this inference illustrates the predictive power of the Evans field theory. The standard model is unable to make these predictions.

It is helpful to summarize the above explanation in a barebones notation which suppresses all indices to leave the basic structure of the equations.

The Eddington effect therefore is the refraction of light by Evans spacetime near the sun. The spacetime is considered to be a dielectric defined by two differential equations:

$$d \wedge F = \mu_0 j \tag{5.16}$$

$$d \wedge \widetilde{F} = \mu_0 J. \tag{5.17}$$

In the simplest approximation we assume that the interaction of electromagnetism with gravitation does not change the free space fields **E** and **B**, respectively the electric field strength and the magnetic flux density of the electromagnetic field. This is a standard approximation used also in MH theory, in which the homogeneous equations are written in terms of **E** and **B** and the inhomogeneous equations in terms of **D** and **H**, respectively electric displacement and magnetic field strength. This approximation, when used in the Evans field theory, means that we assume:

$$q \wedge R + \omega \wedge T = 0 \tag{5.18}$$

in the HE and we assume:

$$q \wedge \widetilde{R} + \omega \wedge \widetilde{T} = 0 \tag{5.19}$$

in the IE. This approximation is equivalent to a standard minimal prescription [13] and simplifies Eq.(5.17) to:

$$d \wedge \widetilde{F} = \mu_0 J = -A^{(0)} q \wedge \widetilde{R} \tag{5.20}$$

where $q \wedge \widetilde{R}$ in Eq.(5.20) indicates the gravitational geometry of the Einstein field theory. The latter is defined geometrically [2]– [10] by:

$$q \wedge R = 0 \tag{5.21}$$

$$\omega \wedge T = 0 \tag{5.22}$$

but:

$$q \wedge \widetilde{R} \neq 0. \tag{5.23}$$

In general J of Eq.(5.20) is the sum of two terms:

$$J = J_c + J_p \tag{5.24}$$

where J_c is due to free charges and J_p is due to polarization and magnetization in the dielectric (i.e. Evans spacetime). This deduction can be seen from the structure of the MH inhomogeneous equations [14]:

$$\nabla \cdot \mathbf{D} = \rho \tag{5.25}$$

$$\nabla \times \mathbf{H} = \frac{\partial \mathbf{D}}{\partial t} + \mathbf{J} \tag{5.26}$$

where

$$\mathbf{D} = \epsilon_0 \mathbf{E} + \mathbf{P} \tag{5.27}$$

$$\mathbf{H} = \frac{1}{\mu_0} \mathbf{B} - \mathbf{M}. \tag{5.28}$$

Here ϵ_0 is the S.I. vacuum permittivity, μ_0 is the S.I. vacuum permeability, ρ is charge density, $\mathbf{J}$ is current density, $\mathbf{P}$ is polarization and $\mathbf{M}$ is magnetization.

Eq.(5.26) can be rewritten in terms of the free fields $\mathbf{E}$ and $\mathbf{B}$ as:

$$\nabla \times \mathbf{B} = \frac{1}{c^2} \frac{\partial \mathbf{E}}{\partial t} + \mu_0 \left(\mathbf{J} + \mathbf{J}_p \right) \tag{5.29}$$

where:

$$\mathbf{J}_p = \frac{\partial \mathbf{P}}{\partial t} + \nabla \times \mathbf{M}. \tag{5.30}$$

In the absence of free charges (i.e. in a dielectric such as glass):

$$\mathbf{J} = \mathbf{0} \tag{5.31}$$

and

$$\nabla \times \mathbf{B} = \frac{1}{c^2}\frac{\partial \mathbf{E}}{\partial t} + \mu_0 \mathbf{J}_p. \tag{5.32}$$

This equation may be generalized to:

$$d \wedge \widetilde{F} = \mu_0 J_p \tag{5.33}$$

Finally we assume that:

$$J_p = -\frac{A_p^{(0)}}{\mu_0} q \wedge \widetilde{R} \tag{5.34}$$

where $A_p^{(0)}$ is the equivalent of $A^{(0)}$ for an uncharged dielectric.

The Eddington effect is described by Eqs. (5.33) and (5.34) as the refraction of light in a dielectric, a well known problem solved in many standard texts [15].

The mass of the sun creates $q \wedge \widetilde{R}$ in the regions of Evans spacetime where starlight grazes the sun in an eclipse. Conceptually the Eddington effect becomes the familiar refraction seen for example in a prism or lens. As for any dielectric such as glass or water the refraction is accompanied by reflection, dispersion, and frequency shifts of the radiation. The frequency shifts in the Evans field theory are frequency shifts of light caused by gravitation. There are also polarization changes of electromagnetic radiation due to gravitation expected in general. The Evans spacetime is characterized by a refractive index, as for any dielectric such as glass or water. The permittivity ϵ and permeability μ of the dielectric (i.e. the Evans spacetime with curvature and torsion) are different from ϵ_0 and μ_0 defined in S.I. units by:

$$\epsilon_0 \mu_0 = \frac{1}{c^2}. \tag{5.35}$$

These differences are again due to gravitation. None of these effects occur in the MH theory, and none occur in the Einstein field theory of gravitation. They occur only in a unified field theory, and clearly illustrate the predictive power of the Evans field theory. The Eddington effect then follows from the standard textbook theory of refraction, i.e. from the fact that ϵ and μ are different from ϵ_0 and μ_0 in regions close to the sun in a solar eclipse. Thus the terminology gravitational lensing - the Evans spacetime around the sun is a giant lens through which starlight passes before reaching the observer.

5.3 The Fundamental Vector Potential Magnitude $A^{(0)}$

A classical expression can be derived for $A^{(0)}$ starting from the standard definition [15] of total electromagnetic field energy En within the volume of radiation V:

$$En = \frac{1}{\mu_0} \int B^2 dV \tag{5.36}$$

a definition which can be found in the standard texts [15] of classical electrodynamics. Now use dimensionality to find that:

$$B = \kappa A = \frac{\omega}{c} A \tag{5.37}$$

where κ has the dimensions of wavenumber (inverse meters). From Eqs.(5.36) and (5.37)

$$A^2 = \frac{\mu_0}{\kappa^2} \frac{\partial En}{\partial V} \tag{5.38}$$

and it is possible to define the root mean square:

$$A^{(0)} = \frac{c}{\omega} \mu_0^{1/2} \left\langle \left(\frac{\partial En}{\partial V} \right)^{1/2} \right\rangle . \tag{5.39}$$

Therefore $A^{(0)}$ is seen to originate in the root mean square of the derivative of En with respect to V, a pure classical definition.

The quantity En is defined in terms of the electromagnetic energy density U:

$$En = \int U dV \tag{5.40}$$

where

$$U = \frac{\kappa^2}{\mu_0} A^2 . \tag{5.41}$$

Therefore

$$A^{(0)} = \left\langle A^2 \right\rangle^{1/2} = \mu_0^{1/2} \frac{c}{\omega} U^{1/2} \tag{5.42}$$

and it is seen that $A^{(0)}$ can be defined as being proportional to the square root of the electromagnetic energy density U. The latter can be related to the power density I of the electromagnetic field:

$$I = cU \tag{5.43}$$

so:

$$A^{(0)} = \mu_0^{1/2} c^{1/2} \left(\frac{I^{1/2}}{\omega} \right) \tag{5.44}$$

where I is measured in watts per square meter. Therefore $A^{(0)}$ is proportional in free space to the square root of I and inversely proportional to the angular frequency ω of the beam in radians per second.

A quantum classical equivalence can be forged for an electromagnetic beam consisting of one photon occupying a volume V. In this case the total electromagnetic field energy is that of the photon, i.e. $\hbar\omega$, and so:

$$\hbar\omega = \frac{1}{c} \int I dV \tag{5.45}$$

and $A^{(0)}$ can be expressed in terms of the energy of one photon in a volume of radiation V. In classical electrodynamics **A** and **B** are entities superimposed on a Minkowski spacetime, but in the Evans field theory **A** and **B** are properties of spinning spacetime [3]– [10]. The electromagnetic field in the Evans theory is generally covariant and the electromagnetic field is spinning spacetime itself. An index contracted canonical energy - momentum density T can be defined for the Evans unified field, and is proportional to scalar curvature:

$$R = -kT. \tag{5.46}$$

Here k is the Einstein constant. It is deduced that $A^{(0)}$ originates classically in R [3]– [10]. It is seen from Eq.(5.42) that electromagnetic energy density U is proportional to $A^{(0)2}$. This equation indicates that there are two signs of $A^{(0)}$ for one sign of energy density. $A^{(0)}$ may be positive (positive charge) or negative (negative charge), and this is the origin of the fact that there are two signs of charge in nature. The fundamental reason is that energy density U is quadratic in $A^{(0)}$, and therefore R is also quadratic in $A^{(0)}$ in the Evans unified field theory.

The Eddington effect shows that gravitation can deflect light on the classical level. This phenomenon can be understood in terms of J^a, a charge current density three-form, so the phenomenon is clear and important proof that electric power can be generated by Evans spacetime acting as J^a, the source of the power. This has very important technological consequences which must be worked out by computer simulation, i.e. by solving the HE and IE simultaneously in a circuit designed to amplify the available power to practical levels.

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