Chapter 13

ECE Theory of gravity induced polarization changes

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Abstract

Gravity induced polarization effects recently observed form a white dwarf are explained straightforwardly in terms of the Einstein Cartan Evans (ECE) unified field theory. The homogeneous current of ECE theory is shown to change circular to elliptical polarization when electromagnetism is affected by gravitation on the classical level. In the Einstein Hilbert (EH) field theory of gravitation, such an effect does not exist. Therefore ECE is preferred to EH using these experimental data, and is preferred to other contemporary theories by Ockham's Razor.

Keywords: Einstein Cartan Evans (ECE) field theory, gravity induced polarization changes in light, interaction of gravitation and electromagnetism.

13.1 Introduction

Einstein Cartan Evans (ECE) field theory is essentially a straightforward extension of Riemann to Cartan geometry [1]– [21] using the well known Cartan torsion. The latter is the electromagnetic field within a scalar factor $A^{(0)}$, where $cA^{(0)}$ has the units of volts and where c is the vacuum speed of light. ECE theory is a standard theory of general relativity and unifies the gravitational and electromagnetic fields using the well known Cartan structure equations and Bianchi

identities. It therefore uses a universally constant speed of light c, and conforms with the Noether Theorem and the Einstein Equivalence Principle.

In order to unify gravitation and electromagnetism on the classical level, there is no need for any fundamental hypothesis of general relativity not already proposed by Einstein. ECE transforms the Cartan torsion directly into the electromagnetic field, resulting in field equations capable of describing both the kinematic and electrodynamic aspects of gravitational lensing. The original Einstein Hilbert (EH) theory of this effect is a semi-classical theory based on the gravitation between a quantized photon and an object such as the sun. As is well known, the EH theory produces a light deflection angle which is twice that given by the Newtonian theory. The photon mass does not enter into the final expression for the light deflection, because it cancels out in the calculation. Therefore the deflection of light by gravitation in the EH theory is independent of frequency and polarization, and does not produce changes in refractive index, and related effects such as reflection, refraction, diffraction and so on.

In ECE theory it is shown in Section 13.2 that the polarization of the deflected light is changed in general from circular to elliptical. This effect is due to the homogeneous current of ECE theory [1]– [20], the current that measures the extent to which gravitation affects electromagnetism on the classical level. The concepts and results of EH theory are obtained in a well defined limit of ECE theory, so the latter describes both the kinematic and electrodynamic aspects of gravitational lensing, on classical, semi-classical and fully quantized levels. The EH theory describes only the semi-classical angle of deflection as already argued. As might be expected by the term "lensing", ECE theory produces polarization, refractive index, reflection, refraction and diffraction effects in general.

In Section 13.2, attention is confined to the change of polarization from circular to elliptical, a change caused by the homogeneous current. In Section 13.3, a discussion is given of a recent paper [22] by Preuss et al. in which gravity induced polarization changes are measured from a white dwarf. A comparison is made of ECE theory with the Poincaré gauge theory used by Preuss et al. [22], showing that ECE is a far simpler description of the data, and is therefore preferred by Ockham's Razor.

13.2 Polarization change due to the homogeneous current

This change originates in the homogeneous ECE field equations [1]– [20]:

$$\boldsymbol{\nabla} \cdot \boldsymbol{B}^a = \mu_0 \widetilde{j}^a \tag{13.1}$$

$$\boldsymbol{\nabla} \cdot \boldsymbol{E}^a + \frac{\partial \boldsymbol{B}^a}{\partial t} = \mu_0 \widetilde{\boldsymbol{j}}^a \tag{13.2}$$

Here $\boldsymbol{B}^a$ is the magnetic flux density in tesla, $\boldsymbol{E}^a$ is the electric field strength in volt m^{-1}, μ_0 is the vacuum permeability in S.I. units, and j is the homogeneous current. The latter is defined in the notation of Cartan geometry [1]– [21] by:

$$j^a = \frac{A^{(0)}}{\mu_0}(R^a{}_b \wedge q^b - \omega^a{}_b \wedge T^b) \tag{13.3}$$

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where $R^a{}_b$ is the Riemann form, q^b is the tetrad form, $\omega^a{}_b$ is the spin connection form, and T^b is the torsion form. Eq. (13.1) is the generally covariant Gauss law of magnetism, and Eq. (13.2) is the generally covariant Faraday law of induction. Interaction of gravitation and electromagnetism occurs when j^a and j^a are non-zero. The interaction is therefore described by the following condition of Cartan geometry:

$$R^a{}_b \wedge q^b \neq \omega^a{}_b \wedge T^b \tag{13.4}$$

This condition has been developed in great detail [1]– [20] elsewhere. For the purposes of this section it is sufficient to note that the current $\widetilde{j}^a$ is non zero when electromagnetism is affected by gravitation on the classical level.

It has been shown [1]– [20] that Eq. (13.2) may be written as:

$$\boldsymbol{\nabla} \times (n\boldsymbol{E}^a) + \frac{\partial}{\partial t}\left(\frac{\boldsymbol{B}^a}{n}\right) = \boldsymbol{0} \tag{13.5}$$

where the refractive index n is defined by:

$$n^2 = \frac{c}{v} \tag{13.6}$$

and where v is the phase velocity. The plane wave solution of Eq. (13.5) is:

$$\boldsymbol{E}_1 = \frac{E^{(0)}}{\sqrt{2}}(\boldsymbol{i} - i\boldsymbol{j})e^{i\phi_1} \tag{13.7}$$

$$\boldsymbol{B}_1 = \frac{B^{(0)}}{\sqrt{2}}(i\boldsymbol{i} + \boldsymbol{j})e^{i\phi_1} \tag{13.8}$$

where:

$$\phi_1 = \frac{\omega}{n}t - n\kappa Z \tag{13.9}$$

The effect of gravity is to change the original $\boldsymbol{E}$ and $\boldsymbol{B}$ of circular polarization as follows:

$$\boldsymbol{E}_1 = n\boldsymbol{E} \tag{13.10}$$

$$\boldsymbol{B}_1 = \frac{1}{n}\boldsymbol{B} \tag{13.11}$$

It has been shown [1]– [20] that this mechanism produces the well known redshift.

The real and physical part of Eq. (13.7) is:

$$\boldsymbol{E}_1 = \frac{E^{(0)}}{\sqrt{2}}(\boldsymbol{i}\cos\phi_1 + \boldsymbol{j}\sin\phi_1) \tag{13.12}$$

and the real and physical part of the circularly polarized $\boldsymbol{E}$ is:

$$\boldsymbol{E} = \frac{E^{(0)}}{\sqrt{2}}(\boldsymbol{i}\cos\phi + \boldsymbol{j}\sin\phi) \tag{13.13}$$

It is seen that if:

$$\cos\phi_1 = a\cos\phi \tag{13.14}$$

$$\sin\phi_1 = b\sin\phi \tag{13.15}$$

then:

$$\boldsymbol{E}_1 = \frac{E^{(0)}}{\sqrt{2}}(a\boldsymbol{i}\cos\phi + b\boldsymbol{j}\sin\phi) \qquad (13.16)$$

for example, if $\phi = 45°$,and $\phi_1 = 60°$, then $a = 1.414$, $b = 0.816$. This means that gravity changes the original circular polarization of $\boldsymbol{E}$ to elliptical polarization, in which a is not the same as b. This effect is not present in EH theory, but has been observed by Preuss et al. [22], whose work is discussed in the next section and compared with ECE theory.

13.3 Gravity induced birefringence from a white dwarf

Polarization changes from a white dwarf have been reported recently by Preuss et al. [22]. The experimental data consist of flux of net circular polarization at a given wavelength divided by the total emitted stellar flux. This is denoted [22] V / I. A gravity induced depolarization is observed experimentally, and measured by a fall in V / I from 26.5% to 20.0%. There is a difference between the linear polarization perpendicular and parallel to the local stellar limb. The theory of Section 13.2 describes the change of polarization qualitatively and straightforwardly and a quantitative description from Section 13.2 could be developed for given $R^a{}_b$, q^b, $\omega^a{}_b$ and T^b.

The theory used by Preuss et al. [22] is far more abstract and convoluted than ECE theory and is called [22] Poincaré gauge theory (PGT). Being a gauge theory, it is at a disadvantage to ECE from the outset because gauge theory introduces concepts such as gauge invariance and an abstract internal gauge space. These concepts are not needed in ECE theory, which relies on general covariance and geometry as in the original theory of general relativity by Einstein. This level of abstraction in PGT is compounded by the use of string theory. The latter has been heavily criticized, as is well known, and can be applied only to cosmology and particle physics. Even in those areas it is rarely predictive, and even when something new is predicted by string theory, many adjustable parameters must be used, rendering the prediction essentially meaningless.

ECE is a foundational theory of general relativity which can be applied more straightforwardly and far more simply [1]– [20] to all areas of physics and chemistry; and ECE theory uses only the four physical dimensions of relativity. The theory used by Preuss et al. [22] is typical of the hugely abstracted levels of string theory and gauge theory in contemporary physics. However PGT and ECE have one thing in common, they use both the Cartan curvature and torsion, but the latter is in PGT a massless, anti-symmetric, Kalb Rammond field of super-gravity and superstring theory.

The torsion in PGT is thus a gravitational torsion and is introduced as a second order Lagrangian term in Eq. (1) of [22]. This results in the authors [22] Lorentz field (their Eq. (11)) and translation field (their Eq. (12)). These are both electromagnetic fields. Their Lorentz field is a Riemann tensor which contains terms to second order in the electromagnetic potential. These terms may be used to define the ECE spin field, $\boldsymbol{B}^{(3)}$ [1]– [20], but are derived in a much more complicated manner. Nevertheless, the spin field does emerge form

PGT [22]. This gets us away from the Maxwell Heaviside field of the standard model. Their translation field [22] is a torsion tensor of Riemann geometry, equivalent to a torsion form of Cartan geometry [1]– [21].

In ECE theory the electromagnetic field is the Cartan torsion itself within the factor $A^{(0)}$, as suggested independently in 2003 by Evans [1]– [20] and Cartan himself in well known correspondence with Einstein. In PGT the torsion is a gravitational torsion which is introduced through gauge invariance. PGT does not recognise that the Cartan torsion is itself the electromagnetic field. Therefore PGT cannot produce the ECE spin field observed in non-linear optics in the inverse Faraday effect [1]– [20].

String theory cannot be applied to non-linear optics, but ECE theory has been extensively applied to non-linear optics [1]– [20]. There is another conceptual difference between PGT and ECE. The former assumes a violation of the Einstein Equivalence Principle in gravity induced polarization changes, but as seen in Section 13.2, ECE produces the phenomenon without violation of this fundamental principle. Finally, PGT also assumes a non-constant c, while ECE uses the constant c advocated originally by Einstein in 1905.

It is concluded that ECE is preferred to EH on the grounds of experimental data, and is preferred to PGT and all string theories by Ockham's Razor.

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