Chapter 14

On The Origin Of Dark Matter As Spacetime Torsion

by
Myron W. Evans,
Alpha Foundation's Institutute for Advance Study (AIAS).
(emyrone@oal.com, www.aias.us, www.atomicprecision.com)

Abstract

It is suggested qualitatively that the origin of dark matter in the universe is spacetime torsion in the gravitational sector of the Evans unified field theory. In the general spacetime manifold containing both curvature and torsion, the Newton inverse square law is affected by the fact that the first Bianchi identity used in the 1915 Einstein/Hilbert field theory is no longer obeyed geometrically. Consequent departures from the inverse square law can be interpreted as due to the effective and unseen mass of dark matter in a cosmological context. Torsion introduces mass - dark matter. Since dark matter does not radiate electromagnetically, its presence can be detected only indirectly. The torsion tensor in the Evans unified field theory obeys the same laws as electromagnetism within a C negative factor. Therefore the characteristics of dark matter may be similar to those of electromagnetism.

Key words: Evans field theory, torsion tensor, dark matter.

14.1 Introduction

A substantial fraction of the mass of the universe is thought to be made up of dark matter, which does not radiate and can therefore be detected only indirectly. It is suggested qualitatively in this paper that dark matter may be due to departures from the 1915 Einstein / Hilbert field theory due to the presence of spacetime torsion and the interaction of torsion with curvature. Gravitational general relativity [1,2] is almost always developed without torsion, in a spacetime containing curvature only. In Wald [1] for example there is only a brief mention of torsional theories of gravitation, and no development thereof. Similarly for Carroll [2]. The 1915 theory of Einstein and Hilbert is accurate to one part in about one hundred thousand for the sun [3] but in other cosmological contexts appears to be qualitatively unable to account for reproducible and repeatable observation [4], in particular, dark matter. In order to construct a generally covariant unified field theory [4]– [22] the torsion tensor becomes fundamentally important because it is the electromagnetic field within a fundamental vector potential magnitude $A^{(0)}$. The Palatini variation of general relativity [1, 2] is also required for a unified field theory, because in this variation the fundamental field is the tetrad [1,2] and not the symmetric metric of the Einstein Hilbert variation of general relativity (the original 1915 theory). The interaction of various types of radiated and matter fields is described [4]– [22] by Cartanś differential geometry, in which the torsion and curvature are related by the two Cartan structure equations [2] and the two Bianchi identities of differential geometry. The latter are more general than the two Bianchi identities of Riemann geometry used in the 1915 Einstein Hilbert field theory of pure gravitation. Therefore in a spacetime or base manifold where there is both torsion and curvature present simultaneously, departures from the 1915 theory are expected in general. It is well known [23] that Einstein himself thought of the 1915 theory as a beginning only, and from about 1925 to 1955 sought a unified field theory that is both objective (generally covariant) and causal. It is generally agreed [24] that the Evans unified field theory achieves this aim in one relatively straightforward way [4]– [22].

In Section 14.2 the fundamental differential geometry is defined of a field theory of gravitation in which torsion and curvature are both present in general and interact in general. This field theory is the gravitational sector of the Evans unified field theory [4]– [22]. In Section 14.3 the approximations are defined which are needed to reduce the general field theory (gravitational sector of the Evans unified field theory) to the Einstein Hilbert field theory of 1915. The major approximation is that the torsion tensor is assumed to vanish. This is not true in general of differential geometry, and in Riemann geometry the torsion tensor vanishes if and only if the Christoffel connection is assumed [2]. In general therefore the Newton inverse square law is obtained in the weak field limit if and only if the torsion vanishes. Reinstate the torsion and new physics is expected. A part of this new physics may be dark matter physics. It is already known [4]– [22] that the torsion tensor multiplied by $A^{(0)}$ is the field tensor of electromagnetism in the Evans unified field theory.

14.2 The Gravitational Sector Of The Evans Unified Field Theory

In the manifold with torsion and curvature both present, the Evans field theory is described by standard Cartan geometry [2,4]– [22] in terms of the two Cartan structure equations of differential geometry:

$$T^a = D \wedge q^a = d \wedge q^a + \omega^a{}_b \wedge q^b \tag{14.1}$$

$$R^a{}_b = D \wedge \omega^a{}_b = d \wedge \omega^a{}_b + \omega^a{}_c \wedge \omega^c{}_b \tag{14.2}$$

and the two Bianchi identities of differential geometry:

$$D \wedge T^a := R^a{}_b \wedge q^b \tag{14.3}$$

$$D \wedge R^a{}_b := 0. \tag{14.4}$$

In Eq.(14.1) T^a is the torsion form, q^a is the tetrad form, $\omega^a{}_b$ is the spin connection, $\omega^a{}_b$ is the Riemann form, $d\wedge$ denotes exterior derivative and $D\wedge$ denotes covariant exterior derivative. Cartan geometry is always defined by the Evans Lemma [4]– [22]:

$$\Box q^a{}_\mu := R q^a{}_\mu \tag{14.5}$$

where R is a well defined scalar curvature. Using the fundamental equation of general relativity:

$$R = -kT \tag{14.6}$$

in Eq.(14.5) produces the Evans wave equation:

$$(\Box + kT)\, q^a{}_\mu = 0 \tag{14.7}$$

which is the fundamental wave equation of all radiated and matter fields. Here k is Einsteins constant and T is the canonical energy momentum density. The wave equation (14.7) straightforwardly quantizes the gravitational field, which is the tetrad field.

14.3 Approximations To The General Theory

The original theory of general relativity, developed independently by Einstein and Hilbert in 1915, assumes that:

$$T^a = 0. \tag{14.8}$$

Therefore the Cartan structure equation (14.1) in this limit reduces to:

$$d \wedge q^a + \omega^a{}_b \wedge q^b = 0 \tag{14.9}$$

and the Bianchi identity (14.3) reduces to:

$$R^a{}_b \wedge q^b = 0. \tag{14.10}$$

The Newton inverse square law is obtained in the weak field limit of the geometry defined by Eqs.(14.8), (14.9) and (14.10). The presence of even an infinitesimal amount of spacetime torsion will produce a perturbation in the Bianchi identity (14.10) such that:

$$R^a{}_b \wedge q^b \neq 0 \tag{14.11}$$

implying that the connection is no longer a Christoffel connection. The perturbation will therefore lead to departures from the Newton inverse square law in the weak field limit and to departures from the Einstein Hilbert field theory in cosmological contexts. Evidently [3] such departures are too small to be observed in an earthbound laboratory because the Newton inverse square law is valid to within contemporary instrumental precision. They are also too small to be measured in the solar system, because the 1915 law is valid for the sun to within contemporary instrumental precision (NASA Cassini experiments [3]).

Dark matter is well known to exist in the universe, however, and it is suggested qualitatively that dark matter is due to the interaction of torsion with curvature in the more general theory of Section 14.2. There are numerous other cosmological anomalies [25] which are reproducible and repeatable. They are anomalies because they cannot be described by the 1915 theory, and so become candidates for investigation with the gravitational sector of the Evans unified field theory (Section 14.2) rather than by the 1915 field theory of Einstein and Hilbert (Section 14.3).

The Newtonian limit of the Evans field theory is a very special approximation of the general wave equation (14.7). Newton's theory happens to work well because of the instrumental limits of contemporary physics. With sufficiently sensitive instruments departures from the Newtonian laws would be observable in the laboratory and departures form the 1915 theory would be observable in the solar system. The well known force law of Newton:

$$\mathbf{F} = m\mathbf{g} \tag{14.12}$$

where $\mathbf{F}$ is the force on a particle of mass m and $\mathbf{g}$ is the acceleration due to gravity, is the non-relativistic, classical, limit of the Dirac equation. The latter is now known [4]– [22] to be the limit of Eq.(14.7) when:

$$kT \longrightarrow \frac{km}{V_0} = \frac{m^2c^2}{\hbar^2}. \tag{14.13}$$

Here m is the mass of a particle, $\hbar$ is the reduced Planck constant and c the speed of light. The Evans rest volume V_0 [4]– [22] is defined for all elementary particles (i.e. all radiated and matter fields now known) by:

$$V_0 = \frac{\hbar^2 k}{mc^2}. \tag{14.14}$$

The tetrad of the Dirac equation is [4]– [22]:

$$q^a{}_\mu = \begin{bmatrix} q^R{}_1 & q^R{}_2 \\ q^L{}_1 & q^L{}_2 \end{bmatrix} \tag{14.15}$$

from which we obtain the Dirac spinor:

$$\psi = \begin{bmatrix} q^R{}_1 \\ q^R{}_2 \\ q^L{}_1 \\ q^L{}_2 \end{bmatrix} = \begin{bmatrix} \phi^R \\ \phi^L \end{bmatrix} \tag{14.16}$$

where ϕ^R and ϕ^L are the right and left Pauli spinors.

Thus:

$$\left(\Box + \frac{m^2c^2}{\hbar^2}\right)\psi = 0 \tag{14.17}$$

is the well known Dirac wave equation for a free particle. The free particle Schrödinger equation is the non-relativistic quantum limit of the Dirac equation:

$$\frac{\hbar^2}{2m}\nabla^2\psi = -i\hbar\frac{\partial\psi}{\partial t}. \tag{14.18}$$

Using the operator equivalence:

$$En = i\hbar\frac{\partial}{\partial t}, \quad \mathbf{p} = -i\hbar\nabla \tag{14.19}$$

the Newtonian limit of the Schrödinger equation is obtained:

$$En = \frac{p^2}{2m} \tag{14.20}$$

where En is Newtonian kinetic energy and p is Newtonian momentum. Eq.(14.20) may also be expressed as:

$$En = \frac{1}{2}mv^2 \tag{14.21}$$

and may be found from Eq.(14.12).

A series of approximations is therefore needed to reduce the Evans wave equation to the Dirac equation, and thence to the Schrödinger and Newton equations. One of these approximations is that the torsion tensor has to vanish in order to recover Newtonian dynamics. Reinstate the torsion tensor as in Section 14.2 and all of these well known equations of dynamics are affected, leading to a considerable amount of new physics given the instrumental precision required.

Similarly the Poisson equation of Newtonian dynamics is found from the Evans wave equation in the limit:

$$V^a \to V^\mu, \quad V^a = q^a{}_\mu V^\mu \tag{14.22}$$

and

$$q^a{}_\mu \longrightarrow 1 \tag{14.23}$$

where 1 in Eq(14.23) is the unit diagonal matrix. The limit (14.22) means that the base manifold approaches a Minkowski spacetime. The latter is the spacetime in differential geometry of the tangent spacetime to the base manifold at a point P [2]. If it is assumed that $q^a{}_\mu$ is essentially time independent, and when:

$$T \rightarrow \frac{m}{V} = \rho \tag{14.24}$$

the Evans wave equation (14.7) becomes the Poisson equation:

$$\nabla^2 q = k\rho \tag{14.25}$$

where we have written:

$$q = q^1{}_1 = q^2{}_2 = q^3{}_3 \sim 1. \tag{14.26}$$

Using:

$$k = \frac{8\pi G}{c^2} \tag{14.27}$$

and

$$\Phi = \frac{1}{2}c^2 q \tag{14.28}$$

we recover the standard Poisson equation used in Newtonian dynamics [2]:

$$\nabla^2 \Phi = 4\pi G\rho \tag{14.29}$$

from which the Newton inverse square law follows directly.

Therefore we have recovered the force law (14.12) and the inverse square law from the same equation, the Evans wave equation. This shows why gravitational and inertial mass is the same, they are both approximations to the same differential geometry. In the presence of torsion all of these well known laws of physics are affected, and so dark matter enters into consideration through the interaction of torsion with curvature. In order to describe dark matter physics, the Evans wave equation must be solved with given initial and boundary conditions for spin and gamma connections which are in general asymmetric in their lower two indices. This is a problem for the computer in general, although analytical solutions may be found to the Evans wave equation analogous to the Schwarzschild solution of the 1915 field equation of Einstein and Hilbert.

The Dirac, Schrödinger, Newton and Poisson equations of dynamics are all limits of the Evans wave equation when torsion is zero.

The torsion is described within a factor $A^{(0)}$ by the same equations as those of electromagnetism in the Evans unified field theory [4]– [22], i.e. by:

$$d \wedge T^a = -\left(q^b \wedge R^a{}_b + \omega^a{}_b \wedge T^b\right) \tag{14.30}$$

$$d \wedge \widetilde{T}^a = -\left(q^b \wedge \widetilde{R}^a{}_b + \omega^a{}_b \wedge \widetilde{T}^b\right). \tag{14.31}$$

Therefore if dark matter is described by torsion, the former behaves like electromagnetism without the presence of electric charge. Dark matter cannot be detected by electromagnetic radiation, and does not obey the 1915 theory in general. If there is a large amount of torsion present in a given region of the universe, then the 1915 theory will appear to be highly anomalous. Such anomalies are well known experimentally [25] and are reproducible and repeatable. There is no reason to expect the 1915 theory to be valid in regions of intense spacetime torsion, such as near a pulsar or example.

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