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Evans Field Theory of Neutrino Oscillations

Summary. Neutrino oscillations are described with the generally covariant Evans field theory, showing that gravitation is able to influence the transmutation of one type of neutrino into another. The neutrino mass is considered to originate in general relativity as eigenvalues of the Evans Lemma. The wavefunction of the neutrino is considered to be a tetrad made up of a complex sum of two types of neutrino multiplied by the Evans phase $e^{i\theta}$. The latter is also the result of general relativity, so the Evans field theory of neutrino oscillations is causal and generally covariant as required by Einsteinian natural philosophy. Neutrino oscillation is shown to be a confirmation of general relativity and causal quantum mechanics, (concepts that are unified in the Evans field theory). The Heisenberg Bohr quantum mechanics is therefore refuted experimentally by neutrino oscillation, and causal general relativity is preferred over the acausal assertions of the Copenhagen School.

Key words: Evans field theory; neutrino oscillations; Evans phase.

22.1 Introduction

Neutrino oscillation is the term give to the disappearance [1] of atmospheric muon- neutrinos and solar electron-neutrinos. It is thought to be a transmutation of mass/energy, a neutrino of one type changes into a neutrino of another type, with a different mass. This process is thought to be possible only if the neutrino mass is non-zero and only if the masses of the transmuting neutrinos are different [2]. For example, a muon-neutrino from the atmosphere is observed experimentally to disappear, and theoretically it is thought that this is due to the fact that it transmutes into a tau-neutrino with a different mass. The latter is thought to be essentially undetectable, so the overall effect is the apparent disappearance of the muon-neutrino without violation of the Noether Theorem. Similarly an electron-neutrino from the sun changes into a muon-neutrino or tau-neutrino [2], disappears, and leads to the experimentally reproducible and repeatable solar deficit of neutrinos. Given initially an electron-neutrino, oscillation means that it will be a mixture of dif-

ferent types of neutrino after propagating a certain distance as a matter wave. An electron-neutrino is therefore thought to be initially in a quantum state which is a mixture of different mass/energies. In the Evans field theory [3]–[28] this is a tetrad governed by the Evans Lemma, the eigenvalues of which are composite scalar curvatures. The neutrino masses in the Evans field theory are considered to originate in Einsteinian general relativity (causal physics or natural philosophy that is necessarily and always objective to an observer in any frame of reference moving arbitrarily with respect to any other frame of reference).

In the simplest case of oscillation between two neutrinos, Section 2 shows that the wavefunction or tetrad is a complex sum of components multiplied by the Evans phase [3]–[28], which in this paper is denoted $e^{i\theta}$. The Evans phase is the origin in general relativity of the Berry phase and various topological phases, and is considered in Section 2 to be responsible for the reproducible and repeatable phenomenon of neutrino oscillation. The real and imaginary parts of the wavefunction correspond to the two neutrino types, which transmute into each other as the result of the fundamental Evans phase. The propagation of the wavefunction is governed by differential geometry - the tetrad postulate [29] on which the Evans Lemma is based directly [3]–[28].

Section 22.3 is a brief discussion of the origin of the Evans phase that is inter alia responsible for neutrino oscillations and observed experimentally thereby.

22.2 The Mixing of Neutrino Wavefunctions Due to the Evans Phase

The experimental phenomenon of neutrino mass and neutrino oscillation is new to physics [2] and invalidates the standard model, in which the neutrino mass is zero. The available explanations are still essentially empirical. For example [2], it is thought that:

$$\begin{bmatrix} \nu_\mu \\ \nu_\tau \end{bmatrix} = \begin{bmatrix} \cos\theta & -\sin\theta \\ \sin\theta & \cos\theta \end{bmatrix} \begin{bmatrix} \nu_1 \\ \nu_2 \end{bmatrix} \tag{22.1}$$

where v_μ is the muon-neutrino eigenfunction and v_τ that of the tau-neutrino, and where v_1 and v_2 are neutrino flavors. The angle θ is used to mix the neutrino eigenfunctions through the flavors. This is little more than an empirical exercise. In the theory proposed here the physical origin of the angle θ is given through the Evans phase $e^{i\theta}$ of general relativity. The present empirical theory of neutrino oscillations [2] is based on the Schrödinger equation, which is a non-relativistic quantum limit of the Evans wave equation [3]–[28]. The latter is both generally covariant and an equation of causal wave mechanics (deterministic quantum mechanics).

In order to derive a physically more incisive explanation of neutrino oscillations we re-express Eq. (22.1) in this Section as a complex valued tetrad multiplied by the Evans phase $e^{i\theta}$. The latter is therefore part of the wavefunction of the Evans Lemma, the subsidiary geometrical proposition (lemma) leading to the Evans wave equation [3]–[28]. From Eq. (22.1):

$$\nu_\mu = \nu_1 \cos\theta - \nu_2 \sin\theta \tag{22.2}$$

$$\nu_\tau = \nu_1 \sin\theta + \nu_2 \cos\theta. \tag{22.3}$$

When $\theta = 0$:

$$\nu_\mu = \nu_1 \tag{22.4}$$

$$\nu_\tau = \nu_2 \tag{22.5}$$

and when $\theta = \frac{\pi}{2}$:

$$\nu_\mu = -\nu_2 \tag{22.6}$$

$$\nu_\tau = \nu_1. \tag{22.7}$$

It can be seen from Eqs. (22.4) and (22.7) that the muon-neutrino has become the tau-neutrino. The origin of this transmutation is the fundamental Evans phase $e^{i\theta}$ of general relativity. Therefore the empirical angle θ of the available theory [2] is identified as the Evans phase angle, θ, a fundamental spin invariant of non-Minkowski spacetime [3]–[28]. If this is accepted then neutrino oscillation becomes experimental confirmation of causal general relativity and thus of causal quantum mechanics. There is no explanation for the Evans phase in acausal Heisenberg Bohr quantum mechanics. This is because $e^{i\theta}$ (being part of the neutrino wavefunction) would be "unknowable" in the Heisenberg Bohr theory and therefore neutrinos would appear and disappear, without cause and at random. Such is not observed experimentally [2] and in the Copenhagen interpretation of wave mechanics neutrino oscillations would not be repeatable and reproducible as observed experimentally. They would be events that appeared without any cause, and so would appear in an "unknowable" way. This subjective assertion means that the oscillations would be caused by nothing knowable. Evidently this is not objective natural philosophy. Statistical averaging of wavefunctions occurs in the Evans field theory, and thus in general relativity, but this is entirely different from what is meant by the wavefunction of the Copenhagen School.

Using the well known formulae:

$$\cos\theta = \frac{1}{2}\left(e^{i\theta} + e^{-i\theta}\right) \tag{22.8}$$

$$\sin\theta = \frac{1}{2i}\left(e^{i\theta} - e^{-i\theta}\right) \tag{22.9}$$

it is seen that Eq. (22.1) is equivalent to:

$$\nu = \nu_\mu + i\nu_\tau = (\nu_1 + i\nu_2)\, e^{i\theta} \tag{22.10}$$

The origin of neutrino flavors in general relativity is given by Eq (22.10) - the neutrino flavors v_1 and v_2 are the pre-multipliers of the Evans phase of the complete neutrino wavefunction. Other types of elementary particle transmutation (for example that observed in the kaon [2]) can be explained similarly.

The Evans phase is a fundamental property in physics and has been used recently [3]–[28] to explain various electromagnetic effects such as the Aharonov Bohm and Sagnac effects, and also used to explain the origin in general relativity and unified field theory of everyday optical phenomena such reflection and interferometry. The Evans phase and Evans spin field $\boldsymbol{B}^{(3)}$ are spin invariants of the non-Minkowski spacetime of Evans field theory, a generally covariant unified field theory based directly on differential geometry. The theory is essentially the geometrization of all natural philosophy [3]–[28], and not just gravitation.

The eigenfunction (22.10) is governed by the Evans Lemma [3]–[28] and so must be possessed of a tangent bundle index a for all base manifolds. The complete description of the neutrino eigenfunction v in general relativity is therefore in terms of a tetrad $\nu^a{}_\nu$.

The latter is defined [29] in differential geometry as the invertible matrix linking vectors or basis elements in the tangent bundle (indexed a) and base manifold (indexed μ). The Evans Lemma then states that:

$$\Box\nu^a{}_\mu = R\nu^a{}_\mu \tag{22.11}$$

and can be written for all μ of the base manifold as

$$\Box\nu^a = R\nu^a. \tag{22.12}$$

Eq. (22.12) is then an equation, for all μ, in the flat or Minkowski spacetime of the tangent bundle. The effect of gravitation on this equation (and indeed on all equations of physics) is measured through elements of the tetrad [3]–[28]. Therefore one way of distinguishing between the Evans field theory of neutrino oscillations and the empirical theory [2] would be to look for the effect of gravitation on neutrino oscillations. In the available empirical theory of the type summarized in ref. [2], there is no effect of gravitation. Similarly, in the Evans field theory, gravitation affects the electro-weak field and therefore affects radio-activity [30], and gravitation evidently affects the electromagnetic field, weak field and strong field. These powerful results apply to all the physical and life sciences [30] and are expressions of general relativity itself, expressions of the objective nature of physics. The objective nature of physics invalidates the subjective assertions of the Copenhagen School. Therefore to invalidate Heisenberg Bohr quantum mechanics, effects of gravitation should be looked for experimentally as described in this paper.

The physical part of the tetrad is the real part of the mathematical expression:

$$\begin{aligned}\nu^a &= \left(\nu^a{}_1 + i\nu^a{}_2\right) e^{i\theta} \\ &= \left(\nu_\mu + i\nu_\tau\right).\end{aligned} \tag{22.13}$$

Initially, $\theta = 0$, and so:

$$\nu^a = \left(\nu^a{}_\mu + i\nu^a{}_\tau\right), \tag{22.14}$$

which means that the real part of the neutrino wavefunction is initially that of a pure muon-neutrino $\nu^a{}_\nu$ with mass m_μ. The tau-neutrino is described initially (zero Evans angle θ and unit Evans phase $e^{i\theta}$) by the pure imaginary and therefore initially unphysical component of the complete neutrino wave function. If the masses of the muon-neutrino and the tau-neutrino were the same, the two neutrinos would be the same elementary particle, and their wave-functions would be the same. This means that mixing according to Eq. (22.13) could never occur and the Evans phase angle would always be zero. In this case the relevant equation in the Evans field theory would be:

$$\Box\nu^a{}_\mu = R\nu^a{}_\mu, \tag{22.15}$$

and would be a wave equation for a muon-neutrino which could never change into a tau-neutrino.. The observation of neutrino oscillations experimentally means however that the needed Evans equation must be Eq. (22.13). If the various neutrino masses were each zero there would be no Evans phase of the right type present to explain the observed neutrino oscillations. Zero mass is evidently a special case of neutrinos with the same mass.

22.3 Origin of the Evans Phase in General Relativity

The Evans angle is a spin invariant of general relativity defined [3]–[28] by the generally covariant Stokes Theorem:

$$\theta = \kappa \oint_{DS} q^a = \kappa \int_S D \wedge q^a = \kappa \int_S T^a \tag{22.16}$$

where q^a is the tetrad one-form and T^a is the torsion two-form. The Evans phase factor is then the complex exponential:

$$\Phi = \exp(i\theta) \tag{22.17}$$

and has been shown to be the origin of the Berry phase and the various topological phases, and to be the generally covariant electromagnetic phase needed for the correct description of optics and interferometry and so forth. Therefore the fundamental geometrical origin of the Evans angle is the definition of the torsion form, one of the two fundamental forms of differential geometry, the other [29] being the curvature or Riemann form. The torsion form is defined by the second Maurer-Cartan structure relation, and the curvature form by

the first Maurer-Cartan structure relation. The Evans phase law is therefore the generally covariant form of all phase laws in physics, for example the Dirac and Berry phase laws.

In order to describe neutrino oscillations the Evans phase law has been used to mix the original wavefunctions. In the Evans field theory this means that there is a mixing of spacetime properties, easily understood geometrically through the fact that one type of geometry may be deformed into another in a causal manner.

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