Prospects for unification under 4-dimensional optics

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Abstract

4-dimensional optics is here introduced axiomatically as the space that supports a Universal wave equation which is applied to the postulated Higgs field. Self-guiding of this field is shown to produce all the modes necessary to provide explanations for the known elementary particles. Forces are shown to appear as evanescent fields due to waveguiding of the Higgs field, which provide coupling between waveguides corresponding to different particles. Carrier particles are also discussed and shown to correspond to waveguided modes existing in 3-dimensional space.

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1 Introduction

Relativity and quantum mechanics seem to be inconsistent theories nonetheless because the geometries used are entirely different. While relativity is set in Riemannian geometry, with signature \((-, +, +, +)\), quantum mechanics employs Euclidean geometry with signature \((+, +, +, +)\). Several approaches have been proposed to circumvent the problem; Kitada [1, 2] proposed an orthogonalized space of dimension 10, obtained by multiplication of the relativistic Riemannian space by the Euclidean phase space of quantum mechanics, complemented with the local time concept. It is well known, though, that superstring theory provides today the most promising prospects for unification, making use of 11-dimension space [3].

The author has shown that relativistic problems can conveniently be expressed in Euclidean space where proper time, rather than time, is used as 0th coordinate [4, 5]. He has also shown that inertial mass can be associated to a guided wave on that space, whereas gravity appears as an evanescent field due to that same guided wave [6]; this theory has been baptized as 4-dimensional optics, henceforth

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designated by 4DO. Thus there is scope for the construction of a unified theory which does not suffer from the inconsistency referred above and 4DO appears as a likely candidate.

The present paper aims to show that not only quantum mechanics and general relativity but also particle physics, as is presently explained by the standard model, have a good prospect of being none but particular aspects of the unified 4DO theory established on very simple principles. Not all the consequences of the theory can be derived in this work nor does the author have the knowledge to draw from the principles he proposes all the implications. Those that he can, though, are important enough to give him the courage to sustain that 4DO holds a great potential for being the next comprehensive theory in physics.

In his previous work the author chose to present 4DO as an alternative to general relativity, which could also accommodate quantization. In this paper the starting point is more fundamental, as the author just assumes that in a given space there is but one harmonic field submitted to a wave equation whose solutions are guided modes corresponding to the elementary particles, these generating evanescent fields which are responsible for particle interactions.

As stated previously, 4DO space is characterized by the 3 physical space coordinates, \( x, y \) and \( z \), complemented by coordinate 0, which is clearly defined in Ref. [5] and is frequently associated with the letter \( \tau \); this coordinate is designated by the name proper time, for reasons that have already been explained [4, 5]. 4DO space characterization is completed by the statement that it is an Euclidean space with signature \((+, +, +, +)\).

This work will make use of three extra dimensions of a localized nature. The local characteristic of these extra dimensions justifies that the theory maintains its initial name of 4-dimensional optics, for most of what is perceived by observers can be set in 4-dimensional space. The new dimensions are sometimes associated with a rigid body’s Euler angles and will be designated by the greek letters \( \iota \), \( \kappa \) and \( \lambda \).

4DO uses non-dimensional units, due to the frequent appearance of coordinates in exponents and the inconvenience of constants being present in most equations. Non-dimensional units are obtained dividing length, time and mass by the normalizing factors \( \sqrt{G\hbar/c^5} \), \( \sqrt{G\hbar/c^3} \) and \( \sqrt{hc/G} \), respectively, while electric charge is normalized by the proton’s charge. The speed of light in vacuum is \( c \), \( G \) is the gravitational constant and \( \hbar \) is Planck’s constant divided by \( 2\pi \). In non-dimensional units all entities are expressed by pure numbers, which in itself raises interesting philosophical questions worthy of discussion in a different sort of paper.
2 Founding principles

The unified 4DO theory is based on the assumption that all elementary particles are manifestations of self-guided modes of a Universal field called the Higgs field with a Universal frequency designated by Higgs frequency. For a stationary particle it is believed that the Higgs field generates a standing wave pattern laid along the \( \tau \) axis and more generally, for non-stationary particles, the standing wave pattern is laid along the particle’s worldline. The basis for the previous assumption was established in Ref. [6] for the derivation of mass and gravity and is here extended to the generation of elementary particles themselves.

In a similar way to which gravity results from the evanescent field of guided waves [6], it is believed that all the fundamental interactions in nature must be the observable effects of evanescent fields. Whether self-guided or guided by external fields, all guided waves generate evanescent fields which are believed to explain all the four fundamental interactions.

In the above cited work the author associated an elementary particle’s field \( \Psi \) to the Lagrangian density

\[
L = \frac{n^{\alpha\beta} \partial_{\alpha} \Psi \partial_{\beta} \Psi}{\Psi \Psi^*} - \Psi^2,
\]

from which one could derive the Euler-Lagrange equation

\[
\partial_{\alpha} \left( \frac{n^{\alpha\beta}}{\Psi \Psi^*} \partial_{\beta} \Psi \right) = \partial_{\alpha} \partial^{\alpha} \Psi = -\Psi.
\]

In Cartesian coordinates \( n^{\alpha\beta} \) is the metric field factor, which is complemented by the inertial factor \( \Psi \Psi^* \). It will be shown that when dealing with gravity the inertial factor becomes the inertial mass, while electric charge is the inertial factor associated with electric field.

The assumption that the elementary particles result from self-guided modes of the Higgs field suggests that one should use an equation based on Eq. (2) without the external field component

\[
\delta^{\alpha\beta} \partial_{\alpha} \left( \frac{\partial_{\beta} \Psi}{\Psi \Psi^*} \right) = -\Psi,
\]

valid in Cartesian coordinates. Nevertheless, the use of Euler angles as coordinates imposes adaptations to the equation above, which will be discussed further along. One important simplification arises from the consideration of stationary particles, for these have a worldline coincident with the \( \tau \) axis. According to the theory developed in Ref. [6], the frequency along the worldline equals the particle’s inertial mass \( m \), whereby it is legitimate to postulate a \( \tau \) dependence of the type \( e^{im\tau} \), with \( j = \sqrt{-1} \).
3 Guided modes and elementary particles

4DO theory is, in many respects, the natural extrapolation of 3-dimensional optical fibers’ waveguide theory into 4-dimensions. Several references will be made to this theory and the reader is referred to textbooks such as Refs. [7, 8] for details. It will also be useful to associate elementary particles to rigid bodies, namely for the understanding of coordinates and degrees of freedom; several textbooks are available for reference but see for instance Ref. [9].

In optical waveguide theory one usually solves the Helmholtz equation which is written in Cartesian coordinates as

$$\delta^{ij}\partial_{ij}\Psi = -k^2n^2\Psi;$$

(4)

here $k$ is the wave number, $n$ is the refractive index and the indices take values between 1 and 3. Waveguiding arises when $n$ is a function of the coordinates with certain characteristics, namely when it is a radially decreasing function of some given axis. Comparing with Eq. (3), it is clear that waveguiding can occur without the intervention of a refractive index because the field amplitude $\Psi\Psi^*$ is inside the first derivative. In other respects, though, self-guiding is not very different from waveguiding by means of a refractive index and is not specific to 4-dimensional space.

The extra dimension in 4DO introduces waveguiding possibilities that one does not encounter in optical waveguides; the situation is similar to the rotations of a rigid body compared to those of a disc. In the latter case the rotation axis is always normal to the disc and can be made to coincide with the $z$ axis of cylindrical coordinates, while with a rigid body rotation can happen about any of the 3 principal axes and is always orthogonal to the $\tau$ axis of 4-dimensional space for stationary bodies. Transporting the discussion to the waveguide situation, one is allowed to make the axis of a cylindrical optical waveguide coincident with the $z$ axis, so that the angular dependence of the field can be expressed by the azimuth angle of cylindrical coordinates. In a 4-dimensional waveguide one makes the waveguide axis coincide with the $\tau$ axis but needs 3 angles to describe fully the angular dependence of $\Psi$; these are the Euler angles $\iota, \kappa$ and $\lambda$. In order to use Euler angles as coordinates one has to consider a 4-dimensional frame whose 3 spatial axes would coincide with the particle’s principal axes, if the particle were associated to a rigid body.

Not unlike their 3-dimensional counterparts, 4-dimensional waveguides exhibit modes because the waves must interfere constructively after a “full rotation”, although one must be careful about the meaning of this expression in 4-dimensional space. Similar also to optical fibers, 4-dimensional waveguides can loose and gain modes when they are bent. This process has already been shown to explain the
exchange of gravitons between orbiting bodies [6] and it will be shown later to explain decaying of excited atoms through photon emission. In both these cases one is dealing with wave guidance by fields rather than self-guidance but there is no reason for a similar process not to occur with self-guided modes. One has to consider that an elementary particle is associated with a waveguide whose axis lays along its worldline, so that all acceleration suffered by the particle is translated into bending of the associated waveguide and consequent mode loss. This justifies that only first order modes can be considered stable because higher order modes will decay naturally into the lower order ones.

This paragraph looks at the possible first order mode solutions of Eq. (3) in order to show that indeed they match qualitatively all the elementary particles that make the standard model [10, 11].

**Electron, muon and tau:** The electron corresponds to a spherically symmetrical mode obtained by simultaneous rotation about the 3 principal axes. One can consider the variable \( \sigma = 2(\iota + \kappa + \lambda)/3 \) as an independent variable with period \( 2\pi \) and write

\[
\Psi = f(r)e^{i(\pm \sigma + m\tau)}.
\]  

(5)

The equation establishes that the guided mode must have a proper time frequency equal to the electron’s mass, here designated by \( m \). After one full rotation of the angular variable \( \sigma \) the function \( \Psi \) is replicated, ensuring that this is the lowest order mode. The plus and minus signs on the exponent denote rotation in the two possible directions and can be assigned to the electron and positron, respectively. The electric charge is associated with the mode number and thus, if there are higher order modes, even short-lived ones, they must be associated with particles having an electric charge multiple of the electron’s.

The heavier members of the family, the muon and the tau, must be described also as first order modes; it is believed that \( f(r) \) holds the key to understanding the different families of particles. It is likely that there are different solutions corresponding to the same Higgs wave orbiting around a core at different distances from the center, the larger the distance the bigger the particle’s mass.

**The quarks:** In some respects quarks are simpler particles than electron and its family members because they are associated with rotations about one or two axes. Starting with the down quark, it is associated with a rotation about a single axis and is described by the equation

\[
\Psi = f(r)e^{i(\pm \iota + m\tau)},
\]  

(6)
where it has been assumed that rotation was about the axis associated with Euler angle \( \iota \) and \( m \) is the down quark’s mass.

This equation is very similar to the electron’s \((5)\) but hides some important differences. Notice that the total charge of the down quark can be seen as 1/3 the electron’s isotropic charge but with a preferred orientation along one of the principal axes. This preferred orientation is assigned to the quark’s color and the three axes are naturally associated with the three quark colors. As with the electron, one of the rotation directions is related to the quark and the other to the anti-quark.

The up quark is similar to the down quark in every respect, except that simultaneous rotation around two axes must be considered. Naturally the electric charge has now an absolute value of 2/3, with both signs possible. In this case the plus sign is associated with the quark and the minus sign with the anti-quark. Notice that this fact gives color an equivalent interpretation as for the negative charge in the case of rotation around one single axis.

The neutrinos: The modes associated with the neutrinos don’t have correspondents in optical fibers. They are purely transverse modes which can only exist in waveguides of infinite longitudinal length or waveguides that are closed on themselves. The waveguides associated with elementary particles are either infinite in length or closed, depending on the Universe being open or closed, and allow the establishment of these modes. Neutrinos can not be associated with a worldline in the same sense as massive particles because for the latter the worldline coincides with the wavefront normal in the center of the waveguide. As a consequence neutrinos fail the basic equation of 4DO \((\frac{dt}{c})^2 = n_{\alpha\beta}dx^\alpha dx^\beta \[4\]). The equation defining the neutrino is quite simply

\[
\Psi = f(r). \tag{7}
\]

Just as with electrons, for quarks and neutrinos the different solutions for \( f(r) \) should explain at least three families of particles.

Solving the differential equations is a very difficult task and the author does not have, for the moment, any solutions to propose for any of the fundamental particles. The neutrino equation is probably the easiest one to write due to the fact that the field depends only on \( r \). Start by noting that Eq. \((5)\) can be simplified whenever \( \Psi \) is real

\[
\delta^\alpha_\beta \partial_\alpha \left( \frac{1}{\Psi} \right) = -\Psi. \tag{8}
\]

The first member of the equation is a 4-dimensional Laplacian of the inverse of \( \Psi \). Replacing \( \Psi \) by Eq. \((4)\) and evaluating the Laplacian in spherical coordinates one
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gets the neutrino differential equation

\[ \partial_{rr} f + \frac{2 \partial_r f}{r} - \frac{2 (\partial_r f)^2}{f} = -f^3, \]  

(9)

which is a non-linear equation unknown to the author.

The electron and quark equations are separable and will eventually fall into the same radial equation, which will explain why all the particle families have the same 3 or more levels, corresponding to different solutions of this equation.

Carrier particles (bosons) are generated in a totally different manner and their discussion must be postponed until later in this work.

4 Evanescent fields and particle interaction

All guided waves generate evanescent fields outside the waveguide. This is known for optical waveguides and must also be true in 4 dimensions, be it for potential generated waveguides or for self-guided waves. This argument was used in Ref. [6] to derive the gravitational field as the evanescent field associated with the \( \tau \) component of the wave vector. Apart from neutrinos, which don’t generate an associated evanescent field, all particles must generate a gravitational field, which must be complemented by an evanescent field associated with isotropic rotation. Quarks will also generate a field associated with non-isotropic rotation.

The argument for gravitational field derivation is reproduced here. In Ref. [6] it was argued that the radially symmetric component of the evanescent field \( \psi \) due to a stationary particle of mass \( m \) must exhibit a frequency \( m \) along the \( \tau \) direction so that \( \partial_\tau \psi = j m \psi \). The field must verify the equation

\[ v^2 \delta^{ij} \partial_{ij} \psi = \partial_{\tau \tau} \psi, \]  

(10)

where the indices take values between 1 and 3 and the letter \( v \) designates a generalized propagation speed of wavefronts defined generally as the derivative \( ds/d\tau \), with \( ds \) the arc length of the wavefront normal in flat Euclidean space.

Naturally the resulting field must have spherical symmetry, which implies that the wave equation will have a more manageable form in spherical coordinates. Furthermore, because \( \psi \) is a function of \( r \) and \( \tau \) alone, it is possible to express \( v \) as

\[ v = \frac{\partial_r \psi}{\partial_\tau \psi}. \]  

(11)

The operator \( \delta^{ij} \partial_{ij} \) is a Laplacian; considering spherical symmetry one can make the replacement \( \delta^{ij} \partial_{ij} = \partial_{rr} + 2 \partial_r / r \). Re-writing Eq. (10) in spherical
coordinates and inserting Eq. (11) one gets upon simplification
\[
\psi \left( \partial_{rr} \psi + 2 \frac{\partial_r \psi}{r} \right) = (\partial_r \psi)^2,
\]
which has the general solution
\[
\psi = C_1 e^{(C_2/r \pm j m \tau)}.
\]

So far no comments were made about the nature of the field $\psi$ but this question must be addressed in order to understand its relation to gravity. It is postulated that $\psi$ is the local coordinate scale factor, by which it is meant that space is corrugated with the Compton frequency on the particle’s worldline and that this corrugation is extended to infinity on the form of an evanescent field. There must be a transition from the field on the worldline to the evanescent field but so far there are no means to choose among the many possibilities. In any case a particle will always act as a 4-dimensional waveguide for the field $\psi$, which will allow the extrapolation of many effects known in their 3-dimensional counterparts.

The field $\psi$ defines the local scale factor or alternatively it defines how the geodesic arc length should be measured; accordingly one makes the assignment $g_{\alpha\beta} = \psi \psi^* \delta_{\alpha\beta}$ for the metric around the particle. In the absence of mass it is expected that the scale factor will be unity and so constant $C_1$ in the equation above can be made unity; constant $C_2$ must become zero for zero mass. The actual value for constant $C_2$ is easy to establish resorting to compatibility with Newton mechanics; if this path is taken constant $C_2$ can be made equal to the mass, in a similar way to what was used in Refs. [6, 12]. This argument will be used in the present work and an independent derivation of this constant’s value will be deferred until there is better understanding of the waveguiding process. Consequently the gravitational field due to a stationary elementary particle will be written as
\[
\psi = e^{(m/r \pm j m \tau)}.
\]

A similar argument holds for the field associated with isotropic charge, except that the field is now a function of $r$ and $\sigma$. One has to replace $\partial_r \psi$ by $\partial_\sigma \psi$ and assume a $\sigma$ dependence such that $\partial_\sigma \psi = jq \psi$, where $q$ represents the particle’s electric charge. The end result is obviously an evanescent field given by
\[
\psi = e^{(q/r \pm j q \sigma)}.
\]

Although the fields resulting from Eqs. (14) and (15) have similar expressions, they have quite different effects on the space around the particle, due to the fact that gravity depends on $\tau$ and the electric field depends on $\sigma$. This aspect will be discussed further along.
One has to consider finally the evanescent field originated by non-isotropic rotation, for instance that associated to a down quark. The rotation takes place around an axis which one can consider aligned with the $x$ axis for the sake of the argument. Under these circumstances the $x$ axis becomes an axis of symmetry and on this axis the field must depend only on one of the Euler angles, $\iota$ for instance, and the value of the $x$ coordinate. Re-writing Eq. (10) with the appropriate modifications

$$v^2 \delta^{ij} \partial_{ij} \psi = \partial_\iota \psi,$$

(16)

with $\partial_\iota \psi = j \psi$.

On the $x$ axis, for the reasons stated above, $v$ can be replaced by

$$v = \frac{\partial_\iota \psi}{\partial_x \psi},$$

(17)

which can be introduced in Eq. (16). In Cartesian coordinates it is

$$\psi \partial_{xx} \psi = (\partial_x \psi)^2.$$

(18)

Solving the equation one gets the particular solution

$$\psi = e^{j(x \pm \iota)}.$$

(19)

The field associated with Eq. (19) is not truly evanescent because it increases with distance and an evanescent field should tend to zero. This fact explains the non-existence of isolated quarks [11]. In reality even the gravitational and electric fields are not truly evanescent, as they tend asymptotically to oscillatory fields of unit amplitude. This is seen as a feature that ensures compatibility with the uncertainty principle and fills vacuum with the extreme richness of the gravitational and electric field remnants from all the particles in the Universe. It is also a reversal of the zero point field argument [13, 14] because mass and electric charge are the sources of the vacuum field and not the reverse.

5 Evanescent fields and worldlines

The way in which exponential gravitational fields are actually compatible with Newtonian mechanics has already been explained [6], as was the duality between wave description of movement under gravity and geodesics in 4DO. The approach used in that paper was less general than is used here because geodesics were the point of departure and waves were inferred. In Ref. [4] the author introduced electromagnetism in the movement metric of 4DO without resorting to the Euler angles and this is now seen to be an improper way of facing the problem. In this paragraph
it will be shown that movement under gravitational or electric fields can easily be derived from the evanescent fields described above. Magnetic fields will not be treated here as they have already been shown to result naturally from electric fields when the source charges are moving [4]. Movement under color charge fields will only be discussed in general terms.

When dealing with particles’ worldlines it is considered that the metric is affected by the amplitude of the local field. So, if a stationary particle with mass \( M \) is the field source, using Eq. (14), one sets

\[
    n_{\alpha\beta} = e^{2M/r}\delta_{\alpha\beta}. \tag{20}
\]

For the moment consider a general gravitational field given by \( n_{\alpha\beta} = n^2\delta_{\alpha\beta} \). Suppose the particle under the gravitational field’s influence is an electron; the argument is easier to establish for an elementary particle but can be extended to massive bodies as has been discussed [5]. Until the field equations have been solved there is no way of knowing what \( f(r) \) in Eq. (3) looks like but assume that \( \Psi \) can be replaced by a plane wave of amplitude \( m \), the electron’s mass. Eq. (2) becomes

\[
    \delta_{\alpha\beta} \partial_\alpha \left( \frac{\partial_\beta \Psi}{n^2} \right) = -m^2 \Psi. \tag{21}
\]

From this equation one derives first of all

\[
    \delta_{\alpha\beta} \partial_\alpha \left( \frac{1}{n^2} \right) \partial_\beta \Psi + \frac{\delta_{\alpha\beta} \partial_\alpha \partial_\beta \Psi}{n^2} = -m^2 \Psi. \tag{22}
\]

The first term of the equation is orthogonal to \( \Psi \), in the sense that \( \partial_\beta \Psi \) is something multiplied by \( j\Psi \). This term precludes the use of a plane wave as solution to the equation unless, as a limiting case, \( n \) is constant. If \( n \) is a slowly varying function, though, one can neglect the first term and try a solution described by the function \( \Psi = m \exp(jp_\alpha x^\alpha) \), where \( p_\alpha \) is the wave vector. Eq. (22) becomes

\[
    \frac{1}{m^2n^2} \delta_{\alpha\beta} p_\alpha p_\beta = 1. \tag{23}
\]

The equation above is the geodesic equation of the space whose metric is \( g_{\alpha\beta} = m^2n^2\delta_{\alpha\beta} \) and can also be written [5]

\[
    m^2n^2\delta_{\alpha\beta} \dot{x}^\alpha \dot{x}^\beta = 1, \tag{24}
\]

where the ”dot” is used to represent derivatives with respect to arc length, this being the same as time length in 4DO. The geodesic and movement Lagrangian is made equal to \( 1/2 \) and \( p_\alpha = m^2n^2\delta_{\alpha\beta} \dot{x}^\beta \) is the conjugate momentum.
From the Lagrangian it is easy to derive the Euler-Lagrange movement equations:

\[ \dot{p}_\alpha = m^2 n \partial_\alpha n \delta_{\mu\nu} \dot{x}^\mu \dot{x}^\nu. \]  

(25)

Considering (24), \( m^2 n \delta_{\mu\nu} \dot{x}^\mu \dot{x}^\nu \) can be replaced by \( \frac{1}{n} \); making the replacement

\[ \dot{p}_\alpha = \partial_\alpha (\log n). \]  

(26)

Usually \( n \) will not depend on \( \tau \), with the consequence that \( p_0 = m^2 n^2 \dot{x}^0 \) is a constant of the movement.

Consider now the field due to a particle of mass \( M \), given by Eq. (20), insert into Eq. (26) and re-write in spherical coordinates to get the 4 differential equations of orbital motion. Making \( \theta = \pi/2 \) it is:

\( \bullet \) \( e^{2M/r} \dot{r} = \gamma \), constant, \( \rightarrow \) speed limited by the speed of light;

\( \bullet \) \( e^{2M/r^2} \dot{\phi} = J \), constant, \( \rightarrow \) perihelium advance in closed orbits;

\( \bullet \) \( \dot{p}_r = -\frac{M}{r^2} + \frac{m^2 e^{-2M/r} J^2}{r^3} \), \( \rightarrow \) compatibility with Newton mechanics.

The situation is not very different in the case of an electric field, where one has to consider a field metric of the type \( n_{\alpha\beta} = \delta_{\alpha\beta} \) when the two indices are not simultaneously zero and \( n_{00} = n^2 \). In particular, the field originated by a point charge \( Q \) results in \( n = \exp(Q/r) \); inserting into Eq. (2) one gets

\[ \frac{\partial_{00} \Psi}{n^2} + \delta^{ij} \partial_{ij} \Psi = -m^2 \Psi, \]  

(27)

with \( i, j = 1 \) to 3.

Inserting \( \partial_\alpha \Psi = j p_\alpha \Psi \)

\[ \frac{(p_0)^2}{m^2 n^2} + \frac{\delta_{ij} p_i p_j}{m^2} = 1, \]  

(28)

which is a geodesic equation of the space and can equivalently be written

\[ m^2 n^2 \left( \dot{x}^0 \right)^2 + \delta_{ij} \dot{x}^i \dot{x}^j = 1. \]  

(29)

Proceeding as above one can set the Lagrangian equal to 1/2.

If \( n \) is a function of the spatial coordinates only, \( p_0 = m^2 n^2 \dot{x}^0 \) is constant; for the other components one gets

\[ \dot{p}_i = m^2 n \partial_i n \left( \dot{x}^0 \right)^2 = p_0 \partial_i (\log n). \]  

(30)
This equation represents movement under an electric field if \( p_0 \) equals the electric charge of the moving particle. Notice that the equation above is not entirely coincident with the equation used in Ref. [4] for a similar situation, where the approach was different and now considered incorrect.

When gravitational and electric fields are considered simultaneously one has to associate to the moving particle a field with two components: gravitational and electric. Each of two components verifies Eqs. (21) and (27) respectively. The field to be considered is then a two-component vector field and the appropriate wave equation is a vector wave equation. The two component vector field is an artifact to represent the "real" twisted field through the decomposition into "longitudinal" and "torsional" components.

Quark interaction needs special attention and will not be discussed here. Suffice it to say that either a quark and an anti-quark or three quarks of different color must be associated in order to cancel most or all the color filed and create a "stable" particle. The association does not imply annihilation, on the contrary, the associated quarks orbit around each other greatly contributing with this orbital motion to the total mass. Consideration of color charge implies that the total number of vector field components is increased from two to four, because isotropic rotation can be associated with simultaneous influence on the three charge field components.

6 Interactions and carrier particles

The interaction between two particles can be understood as coupling between the fields in two waveguides through their respective evanescent fields. This process generates the force of gravity, electric force and also color force without the need to appeal to force carriers. One can postulate virtual carriers such as gravitons, photons and gluons, respectively, but this is a wave process that does not require such mechanism. For massive bodies with a large number of internal modes that are allowed to move in response to mutual interactions the worldlines of their centers of mass become bent and so do their respective waveguides, allowing effective mode exchange between them. This phenomenon happens very dramatically in atom excitation and decay but it happens also, in a less dramatic form, with the very closely spaced modes of planet orbits [6].

A different situation happens with carrier particles that exist on their own, of which one knows for sure there are photons and assumes there can also be gluons and gravitons. One must start by defining carrier particles in some way that is consistent with observations and with the theory developed above. Carrier particles are not expected to result from guided modes of the Higgs field and are expected to have zero momentum along the \( \tau \) direction. Using photons as the only available
example to test with observations, it is clear that their worldlines must exist in 3-dimensional space [4, 5] and so their momentum is characterized by $p_0 = 0$. If this condition is inserted in Eq. (2) one gets exactly the same equation, with indices varying between 1 and 3.

Just as in the 4-dimensional case, the equation will generate self-guided modes which will exist completely in 3-dimensional space. These modes don’t have the richness of their 4-dimensional counterparts and are very similar to ordinary optical fibers. The field that undergoes self-guidance is the electric field in the case of photons and the gravitational field in the case of gravitons. Presumably gluons can be explained similarly if the analysis is extended to the color field. Without the constraint of a Universal field, carrier particles can be generated with any longitudinal frequency, unlike massive particles which are restricted to the modes supported by the Higgs field.

7 Conclusions

A Universal wave equation is shown to provide self-guidance to the postulated Higgs field in 4DO. 4-dimensional waveguides result with modes that can explain all the elementary particles such as are understood today. Although solutions to the differential equations that result could not be found, the rationale that is presented supports the argument towards this being a plausible model.

Waveguiding originates evanescent fields in 4-dimensions such as they do in 3-dimensional optical fibers; these are shown to be responsible for gravitational and electric fields and it is argued that a similar effect can explain color fields. Forces result from coupling between waveguides of different particles by intermediate evanescent fields. The equivalence between wave description and worldlines is explored for the cases of gravity and electric field, justifying the introduction of a vector field concept to describe elementary particles.

Carrier particles are then dealt with by setting the $\tau$ component of moment equal to zero. The wave equation becomes 3-dimensional and self-guidance then explains the appearance of photons and gravitons. Gluons are not discussed, although it is expected that they can be explained similarly.

References

[1] H. Kitada, “Theory of local times,” *Il Nuovo Cimento* **109** B(3), pp. 281–302, 1994. astro-ph/9309051.
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[2] H. Kitada and L. Fletcher, “Local time and the unification of physics, Part I: Local time,” Apeiron 3, pp. 38–45, 1996. gr-qc/0110065.

[3] B. Greene, The Elegant Universe: Superstrings, Hidden Dimensions, and the Quest for the Ultimate Theory, W. W. Norton & Company Inc., N. York, 1999.

[4] J. B. Almeida, “4-dimensional optics, an alternative to relativity,” gr-qc/0107083, 2001.

[5] J. B. Almeida, “K-calculus in 4-dimensional optics.” Submitted to Int. J. of Theoret. Phys., physics/0201002, 2002.

[6] J. B. Almeida, “A theory of mass and gravity in 4-dimensional optics.” physics/0109027, 2001.

[7] K. Okamoto, Fundamentals of Optical Waveguides, Optics and Photonics Series, Academic Press, San Diego, USA, 2000.

[8] H. G. Unger, Planar Optical Waveguides and Fibres, Clarendon Press, Oxford, U.K., 1977.

[9] V. J. José and E. J. Saletan, Classical Mechanics – A Contemporary Approach, Cambridge University Press, Cambridge, U.K., 1st. ed., 1998.

[10] R. M. Barnett, H. Muhry, and H. R. Quinn, The Charm of Strange Quarks: Mysteries and Revolutions of Particle Physics, Springer-Verlag, N. York, USA, 2000.

[11] F. Halzen and A. D. Martin, Quarks and Leptons: An Introductory Course in Modern Particle Physics, J. Wiley and Sons, New York, 1984.

[12] J. B. Almeida, “On the anomalies of gravity.” gr-qc/0105036, 2001.

[13] B. Haisch, A. Rueda, and Y. Dobyns, “Inertial mass and the quantum vacuum fields,” Ann. d. Phys. 10, pp. 393–414, 2001.

[14] W. Nernst Verhandlungen der Deutschen Physikalischen Gesellschaft 4, p. 83, 1916.