# Mass Particles as Bosons in Five Dimensional Euclidean Gravity

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**Abstract**

Velocities in both space and time are formalized and generalized for $n$-dimensional Euclidean spaces. Applied to photons and mass particles, this implies a dimensional hierarchy between their velocities. It is suggested that mass particles, that are fermions in 4D, behave like bosons in 5D gravity where they follow null geodesics.

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# 1 Introduction

In previous work [1] the author has given an Euclidean interpretation of special relativity as an alternative to the Minkowski framework. It introduces the notion of velocity in the (proper) time dimension. Other key elements are the role of proper time $\tau$, acting as the fourth Euclidean dimension, and the promotion of time $t$ to a fifth Euclidean dimension. It appears that in this context all objects have constant speed $c$ in 4D Euclidean space-time. In the traditional Minkowski framework the 4-velocity vector cannot actually be treated as an extrapolation of 3D spatial velocity vectors. Its components do not behave like in ordinary velocities as has been worked out by the author in [2].

In this paper, the interpretation of time $t$ as a fifth Euclidean dimension, instead of merely a parameter for tracking the objects position on its world-line in 4D Euclidean space-time, will be further justified. Ultimately it will be used to give arguments why mass particles, instead of gravitons, should be seen as the bosons for 5D gravity, in addition to their role as fermions in 4D.

# 2 Velocities in $n$ Dimensions

In [1], velocities in 4D Euclidean space-time have been defined from the invariant 4D velocity of magnitude $c$ according to:

$$c^2 = (cd\tau/dt)^2 + (dx/dt)^2 + (dy/dt)^2 + (dz/dt)^2 \quad (1)$$

Indexing $x_{1..3}$ for the spatial dimensions, $x_4$ for proper time $\tau$, and $x_5$ for time $t$, this leads to definitions for the velocity component in the proper time dimension (time-speed)

$$\chi = cdx_4/dx_5 = \sqrt{c^2 - v^2} \quad (2)$$

and for spatial velocity components

$$v_i = dx_i/dx_5 \;\; (i = 1, 2, 3) \quad (3)$$

These definitions for velocity components in 4D Euclidean space-time can be generalized to $n$-dimensional Euclidean spaces, defined as:

$$X_n = (x_1, x_2, x_3, x_4......x_n) \quad (4)$$

The generalized time-speed in $n$-dimensional space $X_n$ becomes

$$\chi_n = dx_n/dx_{n+1} \quad (5)$$

whereas the generalized spatial velocity components become

$$v_a = dx_a/dx_{n+1} \;\; (a = 1, 2, ...n - 1) \quad (6)$$

[depending on the choice of units in $x_a$ or $x_n$ a factor may have to be added to Eqs. (5) and (6).] Together with these expressions the following conditions define the dimensional *viewpoint* in $X_n$:

- Observers in $X_n$ have the skill to observe dimensions 1 to $n - 1$ as spatial dimensions.
- The dimension $n$ is the equivalent for 'proper time' for observers in $X_n$.

This definition means that we are observers in $X_4$ where $x_4$ is our proper time dimension but that for instance in 3D Euclidean space $X_3$, observers are 'Flatlanders', *i.e.,* they live in a 2D space. See also [3]. They experience the third dimension $x_3$ as their equivalence of proper time, while their basis for speed measurements is $x_4$.

A conclusion from this section is that time-speed in $X_n$ is to be regarded a spatial speed in $X_{n+1}$. From the dimensional viewpoint of $X_{n+1}$, no distinction can be made between spatial and time speed in $X_n$.

# 3 Null Geodesic Motion in $n$ Dimensions

Photons propagate at a spatial speed $c$ in every frame of reference which means that their time-speed $\chi$ is always zero. This effectively eliminates one dimension from the geometric environment of the photon.

From our dimensional viewpoint in $X_4$ we thus may consider the photon to have its properties position and speed defined in a 3D subspace $X_3$ (note that the photon is treated here as a particle and not as a (4D) electromagnetic wave). The photon follows null geodesics in $X_4$ that are equivalent to timelike geodesics from the dimensional viewpoint of $X_3$ (the viewpoint of the photon itself). The time-speed of the photon may therefore be expressed in $X_3$ as

$$\chi_3 = dx_3/dx_4 \quad (7)$$

conform the generalized definition given in Eq. (5).

The view from the rest frame of the photon in $X_3$ (which is impossible in $X_4$ but possible in $X_3$) closely resembles the view that we have of $X_4$. The photon's own spatial speed $c$, as measured in $X_4$, is seen as the flow of time in $X_3$. In $X_3$ photons can have spatial speeds relative to each other ranging from zero to $c$. The main difference is that in $X_3$ relative spatial motion between photons is only measurable in two dimensions, $x_1$ and $x_2$. This conforms to the generalized definition for spatial speeds in $X_3$ according to Eq. (6):

$$v_a = dx_a/dx_4 \quad (a = 1, 2) \tag{8}$$

Similarly, the timelike geodesics for mass particles in $X_4$ can be regarded null geodesics from the perspective of $X_5$ (see also [4] for a similar treatment of geodesics in Kaluza-Klein like theories). This apparent hierarchy between geodesic motion for mass particles and photons (an observation that is also made in [5]) suggests a similar hierarchy between the fields for electromagnetism and gravity. The electromagnetic field should then be describable in terms of a curved Riemannian manifold with one less dimension as gravity.

The expressions for speeds of mass particles in $X_4$, $\chi_4 = cdx_4/dx_5$ and $v_i = dx_i/dx_5$, show that $x_5$ must be an essential part of the field that *propagates* mass particles, *i.e.*, gravity must be 5D. This is consistent with the expression $\chi_3 = dx_3/dx_4$ where $x_4$ is part of the electromagnetic field that propagates photons. Gravity being 5D thus allows the logic association of electromagnetism with four dimensions, which shows from the four-vector for potential $A^\mu = (\phi, c\mathbf{A})$ (see [2] that shows the Euclidean nature of this 4-vector, as opposed to the Minkowski nature of other 4-vectors) and the 4D tensor notation for $\mathbf{E}$ and $\mathbf{B}$.

Extending general relativity to five dimensions is not uncommon in Kaluza-Klein like theories (using the Minkowski metric). The universal speed $c$ for objects in 4D, as found in the Euclidean treatment of special relativity in [1], also holds in general relativity based on five Euclidean dimensions if it is assumed that, due to the curved space-time near a massive object, an additional rotation of the universal speed $c$ towards the axis of the fifth dimension takes place from the perspective of an observer at infinity who uses a flat 5D coordinate system. Individual velocity components for a particle falling radially towards a massive object would then be the coordinate speed in 3-dimensional space,

$$v(r) = \{1 - 2MG/(rc^2)\}\sqrt{2MG/r} \tag{9}$$

the speed in the proper time dimension $x_4$,

$$\chi(r) = c\sqrt{1 - 2GM/(rc^2)} \tag{10}$$

and the speed in $x_5$,

$$v_5(r) = \sqrt{c^2 - \chi(r)^2 - v(r)^2} \tag{11}$$

Figures 1 and 2 illustrate the developments of these velocity components for a radially falling object. The dotted vertical line intersecting the graphs in Fig. 1 corresponds to the position of the velocity vector of magnitude $c$ in Fig. 2. At the Schwarzschild radius the rotation will have completed, resulting in the predicted zero speed in both space and time, while in all geodesics the 5D velocity vector maintains magnitude $c$. This process may be identical (translated to 4D) to the way photons approach electrical charges. In that case the photon's velocity vector rotates towards the fourth dimension when nearing an electrical charge. Its spatial speed reduces to zero at the moment that it is absorbed by the charge and the velocity vector is fully rotated into the fourth dimension. Mass particles falling into black holes is then equivalent to photons being absorbed by electrical charges.

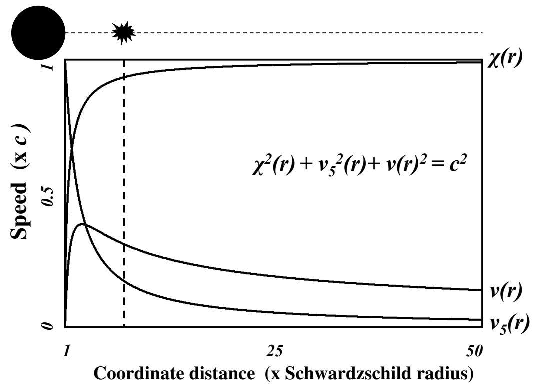


Figure 1: Graph of velocity components in space: $v(r)$, proper time: $\chi(r)$, and $x_5$: $v_5(r)$ for an object falling radially towards a black hole.

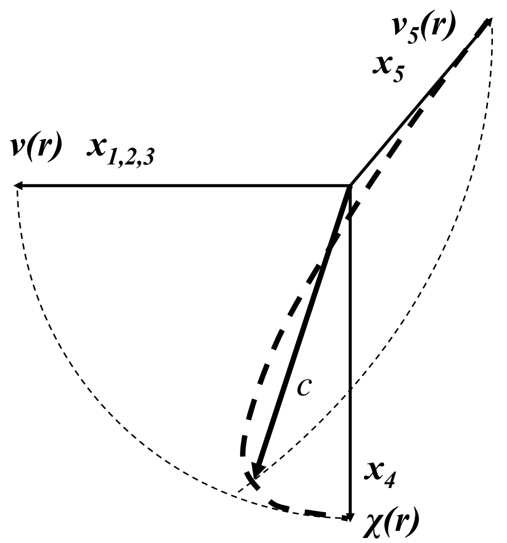


Figure 2: Velocity of magnitude $c$ in 5 dimensions for an object falling radially towards a black hole.

## 4 Dualities Between Bosons and Fermions

It has been shown in [1] that energy of mass particles is constant from the dimensional viewpoint of $X_5$ while it is measured proportional to $\gamma$ from $X_4$. Similarly, the energy of a photon is independent of its direction in 3D space from the dimensional viewpoint of $X_4$ but will be measured as variable from $X_3$. Other parallels between mass particles and photons are found in their universal speed $c$ in null geodesics in, respectively, $X_5$ and $X_4$, and potentially in the absorption process by, respectively, black holes and electrical charges. Yet, in view of these many parallels between mass particles and photons, one of the conclusions may now be that mass particles *themselves* are to be regarded the bosons for 5D gravity in $X_5$, in addition to their role as fermions in $X_4$ (which is related to their electrical charge). Their invariant 4D momentum in $X_5$, $m_0c$ or $E/c$ should be ranked hierarchically in line with the expression $p = E/c$ for the photon in $X_4$. An inevitable conclusion from the previous Section must than be that black holes form the corresponding fermions in $X_5$.

It is very tempting to think of the geometrical hierarchy and dualities between gravity and electromagnetism as a general principle, covering also the nuclear forces in the lower-dimensional spaces $X_3$ and $X_2$. The author has the intention to elaborate this in future work at www.euclideanrelativity.com.

## References

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