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The Inherently Spinning Spacetime in 6D

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Abstract: We present the Inherently Spinning Spacetime (ISST) as proper background for any 6D geometrodynamics based on the three-dimensional time. This is the final step of a thirty-year study on the six-dimensional spacetime with SO(3,3) symmetry. The ISST is a new axiomatization of the General Relativity manifold where each event is characterized by an additional property: its own spin angular velocity. If each point of the continuum is a structureless rotating sphere of null radius, the orientation of its spinning axis is defined by two parameters that we interpret as timelike extra-dimensions. Although merely geometric, our topological analysis affects issues bordering on quantum physics and cognitive science.

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1. Introduction

We conclude a thirty-year-long investigation about a hypothetical 6D geometrodynamics on SO(3,3)-group (Bonacci, 1991–2022) by giving a topological response to two fundamental questions:

1) Why should the spacetime manifold require six dimensions instead of four?

2) Why should the two extra-dimensions be timelike?

The 4D universe is supported by an intuitive logic: to determine an *event*, we need to know *where* and *when* it is occurring, for a total amount of four coordinates (three spatial and one temporal).

Although reasonable, the current representation of the spacetime's intimate structure could be incomplete; we suggest adding the *spin angular velocity* (the Euclidean pseudovector $\vec{\omega}$) among its intrinsic properties.

If we assume that each point of the continuum is a structureless rotating sphere of null radius, we obtain a 6D inherently spinning spacetime (acronym ISST).

In formulating the ISST, we choose to neglect both the spinning magnitude and its direction (up or down), focusing only on the plane of rotation (perpendicular to the spinning axis) as essential information concerning *how* an event happens.

The two parameters defining the orientation of the rotation plane of a spinning point are position-independent surface measures, interpreted as *time* extra-dimensions.

Our geometric revision raises open questions ranging from the observation of a preferential arrow of time (Muchow, 2020) to the role of temporal *local hidden variables* in classic quantum phenomena (Chen, 2005).

2. Construction of the 6D ISST

In the Inherently Spinning Spacetime (ISST) each point has its own spinning axis. The punctual plane of rotation is identified by two *timelike* extra-parameters, involving the group SO(3,3), so that the ISST is six-dimensional.

2.1 Where and when does an event occur?

Einstein Field Equations (EFE for short) are rather difficult even for graduate students, but the logic behind the 4D manifold is trivial; the minimum number of information needed to identify an event is *four*, connected

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to *where* (3 spatial coordinates) and *when* (1 temporal coordinate) it occurs (Fig. 1).

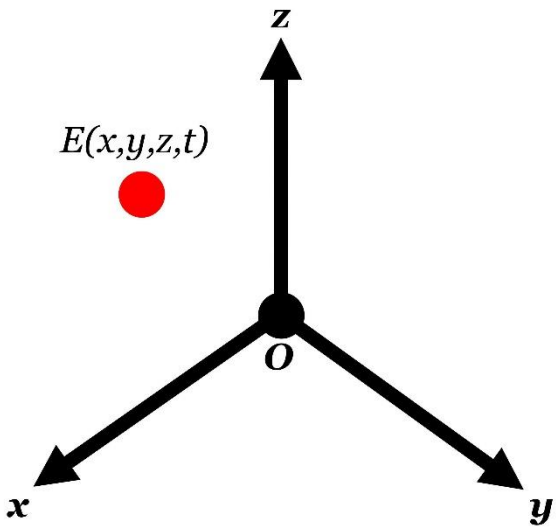

Figure 1. Representation of a 4D event $E(x, y, z, t)$.

This rational construction is yet incomplete; we should respond to a further question: *how* can an event occur?

2.2 How does an event occur?

The answer is an unexplored property of the continuum: each point can *spin* in its own way (Fig. 2).

It means that any point is viewed as a structureless rotating sphere, of null radius, with an intrinsic *spin angular velocity* axial vector $\vec{\omega}$.

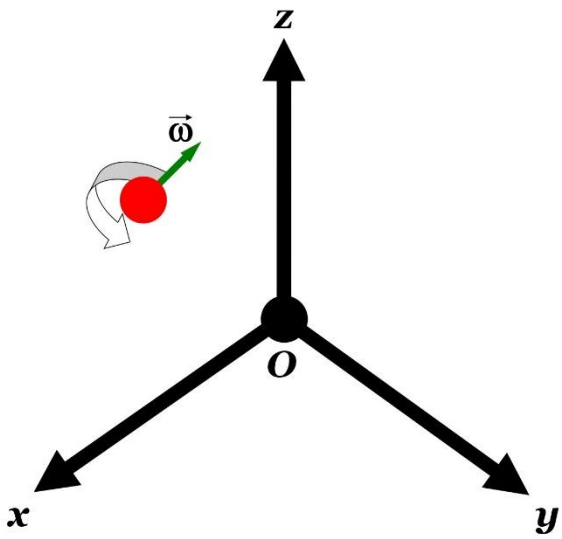

Figure 2. Representation of a spinning point.

2.3 Only the plane of rotation is essential

We rule out both the magnitude and the direction (up or down) of the pseudovector $\vec{\omega}$, assuming only the plane of rotation (perpendicular to the spinning axis) as necessary information about *how* an event happens.

We adopt the Saturn icon to highlight the orientation of each spinning point (Fig. 3).

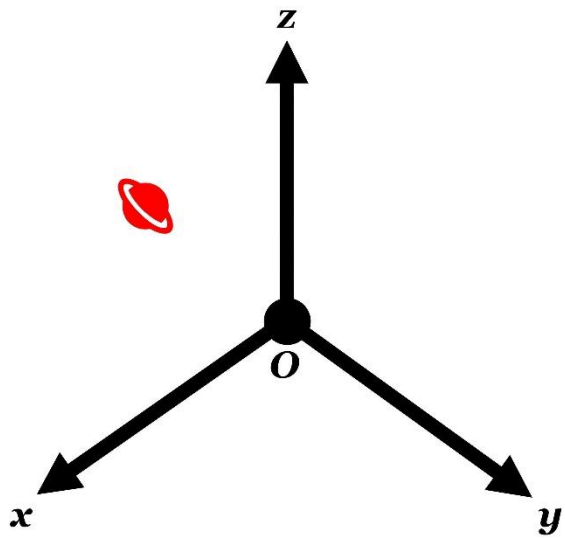

Figure 3. Representation of an oriented point.

2.4 Two timelike extra-dimensions

The plane of rotation of each point has an orientation defined by *two* parameters from vector algebra. They can be, e.g., the first two classic Euler angles α, β (we ignore the third angle γ regarding the line of nodes).

Such parameters become two additional coordinates for an event in the 6D ISST: $E(x, y, z, t, \alpha, \beta)$.

The new coordinates α, β are interpreted as *time* extra-dimensions because:

1) they are surely not spacelike (i.e., not linked to the position in a fixed $Oxyz$ reference frame);

2) as surface measures, they are *timelike* (Bonacci, 1991, 2006, 2009, 2015).

2.5 Where do the temporal extra-dimensions hide?

If the point orientation does not change, time extra-dimensions α, β should not show up (Fig. 4). It means

$\alpha_1 = \alpha_2$ and $\beta_1 = \beta_2$ in the passage between two events $E_1(x_1, y_1, z_1, t_1, \alpha_1, \beta_1)$ and $E_2(x_2, y_2, z_2, t_2, \alpha_2, \beta_2)$.

The coordinate invariance $\Delta\alpha = \Delta\beta = 0$ could be the reason why two temporal dimensions out of three are *hidden*, letting us perceive time passing only as t.

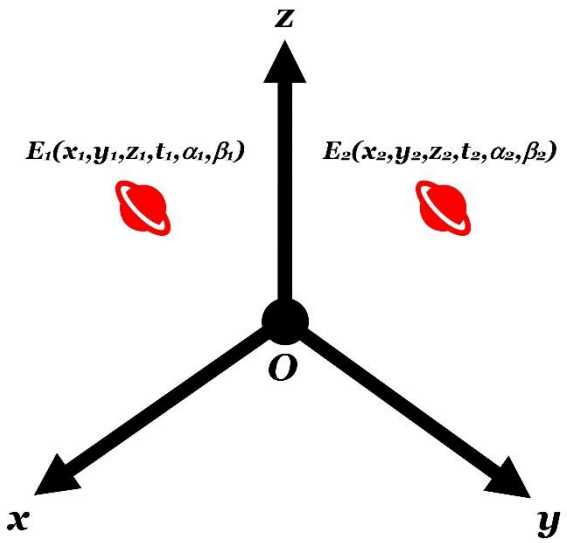

Figure 4. Equally oriented points in the 6D ISST.

3. Plausible features of the 6D ISST

The six-dimensional Inherently Spinning Spacetime (ISST) is an ultrahyperbolic picture of the inner structure of our universe's manifold, where the events $E(x, y, z, t, \alpha, \beta)$ are characterized by three spacelike $S(x, y, z)$ and three timelike $T(t, \alpha, \beta)$ dimensions.

The ISST seems an appropriate background for any 6D geometrodynamics via three-dimensional time, included the hexadimensional extension of Einstein's General Relativity we proposed in the 93rd (Bonacci, 2007a, 2007b) and 95th (Bonacci, 2009) national congresses of the Italian Physical Society, and in the 18th conference of the Italian Society of General Relativity and Gravitational Physics (Bonacci, 2008a, 2008b); we recall it as follows.

3.1 The algebra of our six-dimensional spacetime

The ISST extends in 6D: the Lorentz transformations, the squared invariant interval, the metric tensor, the quadratic form, the Ricci curvature tensor, the scalar curvature, the contracted Bianchi identities, the conservation equations, the Lagrangian of matter, the scalar function, the variation principle, and the Einstein field equations $G_{\mu\nu} = kT_{\mu\nu}$ $(\mu, \nu = 1,2,3,4,5,6)$.

The thirty-six EFE(6D), reducible to twenty-one by symmetry, are good candidates to fulfil the dream of unified forces. The 6D ISST enhances also the recent efforts to bridge the chasm between Relativity and Quantum Physics centred on GraviGUT models (Chester et al., 2020) or on energy vectors (Rakotonirina, 2021).

3.2 The geometry of our six-dimensional spacetime

Each six-dimensional event $E(X_1, X_2, X_3, X_4, X_5, X_6)$ is unique, i.e., represented without ambiguity in reference frames consisting of the three spatial *lines* and three temporal *surfaces*.

For a flat spacetime, the three-dimensional time is measured on mutually orthogonal surfaces (Fig. 5).

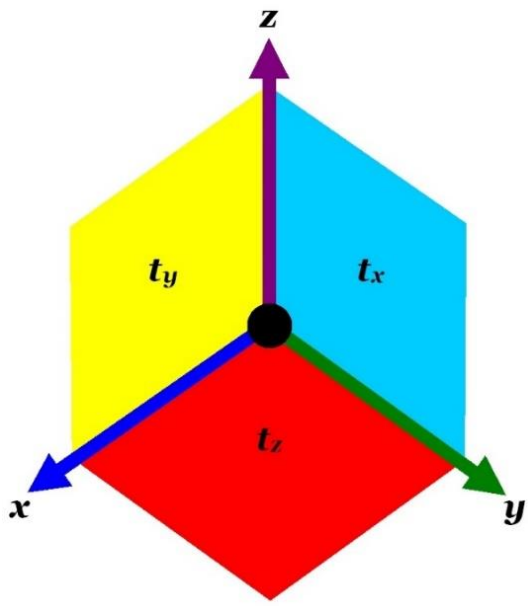

Figure 5. Cartesian-like reference frame in 6D.

For a curved spacetime, locally almost flat, the three spatial lines X_1, X_2, X_3 are not necessarily neither rectilinear nor mutually perpendicular and the three temporal surfaces X_4, X_5, X_6 are not necessarily neither plane nor pairwise orthogonal (Fig. 6).

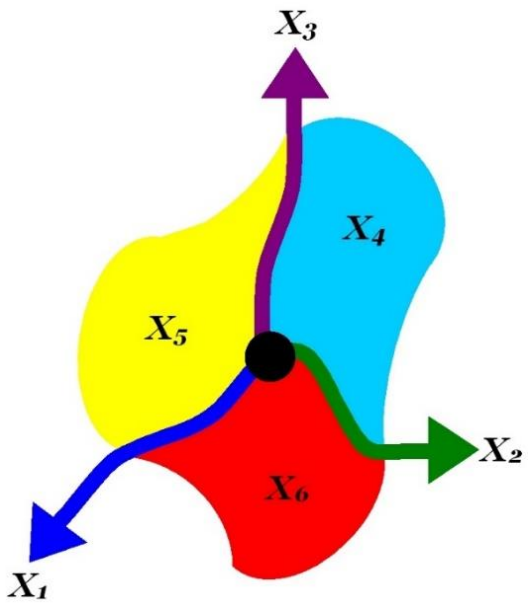

Figure 6. Gaussian-like reference frame in 6D.

3.3 The cosmology of our six-dimensional spacetime

The *dark* entities postulated in the Λ-CDM model could just be artificial tools (Bonacci, 2018) balancing the lack of dimensions in EFE(4D)-based cosmology with respect to EFE(6D).

In fact, the EFE(6D) $G_{\mu\nu} = kT_{\mu\nu}$ would not need any cosmological constant (Λ) and related *dark energy*.

Furthermore, the time distortions around a 6D structureless spinning sphere would explain the gravitational anomalies without *dark matter*.

4. Open questions from the 6D topology

4.1 The double-slit experiment in 6D?

The interference pattern obtained as if the particle passed through both the slits *at once* is justified in quantum mechanics by replacing the concept of trajectory with a probability wave or a Feynman path-integral.

What would happen if the simultaneous double-slit traversing was *illusive*?

If the particle passed the slits at a different timing $T_1(t, \alpha_1, \beta_1)$ and $T_2(t, \alpha_2, \beta_2)$, with only one temporal coordinate t in common, the presence of two undetected time dimensions would avert the trajectory from splitting and would save the General Relativity setting (albeit in six dimensions). The trajectory points in the ISST should be oriented differently beyond the slits (Fig. 7).

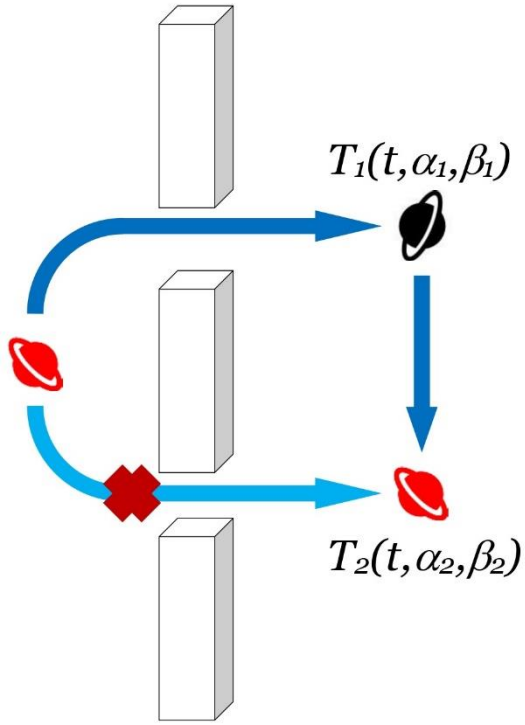

Figure 7. A unique trajectory in the 6D ISST.

4.2 The quantum tunnelling in 6D?

A particle overcoming a potential barrier without enough energy is illustrated by quantum mechanics as a wavefunction propagation or via Heisenberg uncertainty principle.

What would happen if the tunnelling was caused by the *absence* of the barrier at the particle passage?

If the particle did not find any barrier along its way, because located in another temporal triple $T(t, \alpha, \beta)$, classical mechanics could explain the phenomenon through two *hidden* timelike dimensions.

The barrier would not be *there* at the traversing time, like if we crossed a valley before a wall was erected or after its fall. The trajectory points in the 6D ISST should be oriented differently from the barrier's pseudovectors to avoid the interaction (Fig. 8).

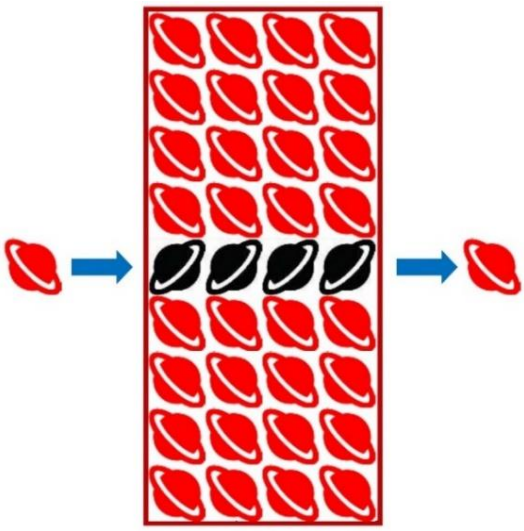

Figure 8. A time tunnel in the 6D ISST.

4.3 A four-dimensional mindset?

We clarified that a possibility for being tuned on a certain 4D sheet of a 6D universe is keeping invariant the punctual orientation of the continuum and the relative temporal dimensions ($\Delta\alpha = \Delta\beta = 0$).

What would happen if the origin of the hidden time variables was, instead, our *mindset*?

If our minds were *set* on a particular pair α_0, β_0 we could recognize only events with a specific orientation. All the other events (with $\alpha \neq \alpha_0$ or $\beta \neq \beta_0$) would be *invisible* for us (Fig. 9).

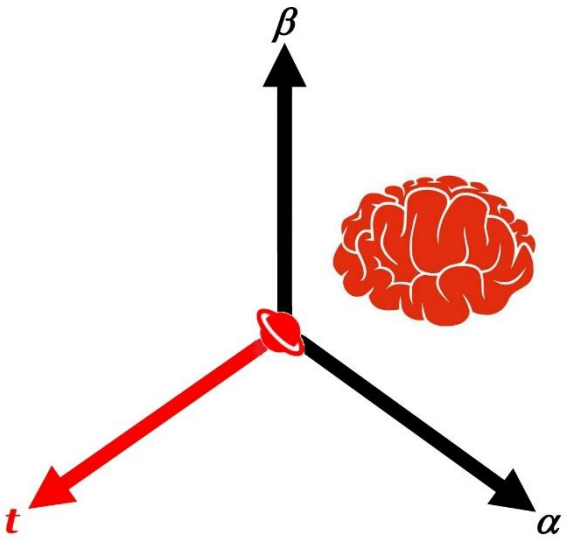

Figure 9. A t-oriented mind within $T(t, \alpha, \beta)$.

5. Conclusions

We usually want to know *where* and *when* to find a point in the spacetime continuum, but we never ask *how* (i.e., in which condition) considering such question irrelevant for a dimensionless entity.

It is however legitimate to think about any point as a structureless sphere of null radius and, as such, it could be characterized by a spinning axis.

A simple additional property like the punctual *spin angular velocity* $\vec{\omega}$ would mean two extra-parameters defining the *orientation* of each point. In fact, the space of rotation axes S^2 is parametrized by the angles α, β corresponding to two (not spacelike) extra-dimensions.

We would be in an ultrahyperbolic manifold where the events $E(x, y, z, t, \alpha, \beta)$ are described by three spacelike $S(x, y, z)$ and three timelike $T(t, \alpha, \beta)$ dimensions.

If the point orientation in the continuum does not change, two time dimensions out of three are *hidden*.

Since its continuum is axiomatized on *spinning points*, we call it Inherently Spinning Spacetime (ISST).

The ISST is consistent with the 6D spacetime on SO(3,3)-group proposed two decades ago in three major Italian conferences on physics (SIF 2007 in Pisa, SIGRAV 2008 in Cosenza, SIF 2009 in Bari) and here quickly summarized.

The possible existence of two temporal extra-dimensions revives the debate about local hidden-variable interpretations of quantum mechanics.

Namely, the 6D ISST supplies an alternative realistic scenario to depict:

1) the double-slit experiment;
2) the quantum tunnelling;
3) our mindset in time perception.

Remarks

The spin angular velocity $\vec{\omega}$ is a Euclidean axial vector not associated to quantum numbers.

The ISST should not be confused with the 6D phase space built on the punctual pseudovector $\vec{\omega}$, whose position-spin elements would be $E(x, y, z, \omega_x, \omega_y, \omega_z)$.

Acknowledgments

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