Dynamic Clifford Fiber Transitions and a Spin-2 Signature Order Parameter: A possible Framework for emergent Spacetime Phases

Abstract:

Investigated is a possible model in which spacetime signature is not a fixed background property but emerges from a dynamical Clifford-fiber structure. The fundamental object is assumed to be a local Clifford module with an internal two-state fiber. The two fiber orientations correspond to different realizations of the underlying Clifford structure. A degenerate vacuum state with vanishing signature order parameter undergoes a phase transition into two non-degenerate signature phases, whereby the norm of signature is assumed as a conservation quantity (law) of zero during the splitting in phase transition of different signature states.

Key-words: Spacetime signature; fibre-structure; two system-fibre; spin-2 fibre-spectrum; emergent signature; double vacuum state; Planck border-plane; dynamical Clifford-module; phase-transition; double-universe.

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1. Introduction:

The proposed vacuum sequence is

$$\left[(+1/+1/-1/-1) \rightarrow \{(+1/+1/+1/-1),(-1/-1/-1/+1)\}\right] \tag{1a.}$$

The five admissible signature configurations

$$\left[(+1/+1/+1/+1),(+1/+1/+1/-1),(+1/+1/-1/-1),(-1/-1/-1/+1),(-1/-1/-1/-1)\right] \tag{1b.}$$

form a discrete order-parameter space with eigenvalues of:

$$\left[S=\{-4;-2;0;,+2;+4\}\right] \tag{1c.}$$

After normalization,

$$\left[m=\frac{S}{2},\right] \tag{1d.}$$

the spectrum becomes

$$\left[m=\{-2;-1;0;+1;+2\}\right] \tag{1e.}$$

which corresponds formally to the weight structure of a spin-2 representation of $(SU(2))$ but only formally to have an adequate mathematical description, not in reality. No comparison is meant to gravitons as solutions of linearized GRT field equations. The model combines a dynamical Clifford algebra, a two-dimensional fiber space represented by Pauli matrices, and a spin-2-like order parameter controlling signature phases. Possible implications for chirality transitions, fermionic zero modes, and emergent gravitational degrees of freedom are discussed.

<u>2. Mathematics/Calculation:</u>

<u>2.1. The standard formulation of relativistic physics assumes a fixed metric signature of:</u>

$$\left[g_{\mu\nu}=(-1;+1;+1;+1)\right] \tag{2a.}$$

or an equivalent convention. The Clifford algebra then is defined by [1.]:

$$\left[\{\gamma_{\mu},\gamma_{\nu}\}=2g_{\mu\nu}\right]. \tag{2b.}$$

In the present approach, this relation is reversed conceptually: the Clifford generators themselves are treated as dynamical objects, and the metric signature is an emergent property of their vacuum configuration.

The fundamental hypothesis is:

$$\left[\Gamma_{\mu}=\Gamma_{\mu}(x)\right] \tag{2c.}$$

with

$$\left[\{\Gamma_{\mu}(x),\Gamma_{\nu}(x)\}=2g_{\mu\nu}(x)\right]. \tag{2d.}$$

The metric therefore is derived from the Clifford structure.

<u>2.2. Dynamical Clifford fiber:</u>

Definition 1:

Let the fundamental state space be:

$$[H = S \otimes F] \tag{3a.}$$

where

$$[S] \tag{3b.}$$

is a spacetime spinor module [2.] and there is the condition, where:

$$[F \simeq C^2] \tag{4a.}$$

is an internal fiber [3.].

The fiber basis is:

$$[|+1\rangle ; |-1\rangle] \tag{4b.}$$

The internal algebra is generated by:

$$[\sigma_1 ; \sigma_2 ; \sigma_3]. \tag{4c.}$$

The fiber operator is defined as:

$$[\Sigma = v\sigma_3]. \tag{4d.}$$

Definition 2: Fiber orientations:

The two eigenstates satisfy:

$$[\Sigma|+\rangle = v|+\rangle] \tag{5a.}$$

$$[\Sigma|-\rangle = -v|-\rangle] \tag{5b.}$$

These states represent two possible Clifford orientations.

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3. Signature order parameter:

A signature configuration is represented by:

$$[s_\mu = \pm ; \mu = \{1 ; \ldots ; 4\}] \tag{6a.}$$

The total signature charge is defined by:

$$\left[S = \sum_{\mu=1}^{4} s_\mu\right] \tag{6b.}$$

The allowed values are:

$$[S \in \{-4 ; -2 ; 0 ; +2 ; +4\}] \tag{6c.}$$

The corresponding states then are clearly:

$$S=\begin{Bmatrix} +4 \Leftrightarrow (+1/+1/+1/+1) \\ +2 \Leftrightarrow (+1/+1/+1/-1) \\ 0 \Leftrightarrow (+1/+1/-1/-1) \\ -2 \Leftrightarrow (-1/-1/-1/+1) \\ -4 \Leftrightarrow (-1/-1/-1/-1) \end{Bmatrix} \quad (6d.)$$

Proposition 1:

The discrete signature spectrum is equivalent, after normalization, to the magnetic spectrum of a spin-2 representation.

Proof:

Define:

$$\left[m=\frac{S}{2}\right] \quad (7a.)$$

Then:

$$[m \in \{-2;-1;0;+1;+2\}] \quad (7b.)$$

This is exactly the eigenvalue spectrum of:

$$[J_z] \quad (7c.)$$

for:

$$[j=2] \quad (7d.)$$

Therefore:

$$[\{S=2J_z\}] \quad (7e.)$$

up to normalization.

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4. Spin-2 fiber representation:

The generators satisfy:

$$\left[[J_i, J_j] = I\,\epsilon_{ijk} J_k\right] \quad (8a.)$$

The eigenstates satisfy:

$$\left[J_z |m\rangle = m|m\rangle\right]. \quad (8b.)$$

The raising operator obeys:

$$\left[J_+ |m\rangle = \sqrt{(2-m)(3+m)}\,|m+1\rangle\right]. \quad (8c.)$$

Therefore:

$$\left[-2\rangle \rightarrow |-1\rangle\right] \quad (8d.)$$

with amplitude:

$$[2]$$

and

$$\left[-1\rangle \rightarrow |0\rangle\right] \quad (8e.)$$

with amplitude:

$$[\sqrt{6}]$$

The full sequence is:

$$\left[\left((-1/-1/-1/-1) \leftarrow \rightarrow (+1/-1/-1/-1) \leftarrow \rightarrow (+1/+1/-1/-1) \leftarrow \rightarrow (+1/+1/+1/-1) \leftarrow \rightarrow (+1/+1/+1/+1)\right)\right] \quad (8f.)$$

<u>5. Effective vacuum potential:</u>

The order parameter is denoted as:

$$[\Phi] \quad (9a.)$$

A generic symmetric potential is:

$$\left[V(\Phi) = A\,\Phi^2 + b\,\Phi^4 + c\,\Phi^6\right] \quad (9b.)$$

The stationary condition then is:

$$\left[\frac{dV}{d\Phi} = 0\right] \quad (9c.)$$

and gives:

$$\left[2a\,\Phi + 4b\,\Phi^3 + 6c\,\Phi^5 = 0\right]. \quad (9d.)$$

The vacuum solutions then satisfy:

$$\left[\Phi=0\right] \tag{9e.}$$

or:

$$\left[a+2b\Phi^2+3c\Phi^4=0\right]. \tag{9f.}$$

The central vacuum:

$$\left[\Phi=0\right]$$

is identified with:

$$\left[\left(+1/+1/-1/-1\right)\right]. \tag{9g.}$$

A broken phase then produces:

$$\left[\Phi=\pm v\right] \tag{9h.}$$

corresponding to:

$$\left[\left(+1/+1/+1/-1\right)\right] \tag{9i.}$$

and:

$$\left[\left(-1/-1/-1/+1\right)\right]. \tag{9j.}$$

<u>6. Dynamical Clifford-structure:</u>

The key extension compared to a fixed Clifford algebra is, that the Clifford generators themselves represent dynamical fields.

It is therefore written as:

$$C_A:=\left[e_\mu^A(x)\gamma_{A_0}\times F_\mu(x)\right] \tag{10a.}$$

where:

1. $\left(e_\mu^A(x)\right)$ --- is a dynamic polyp,
2. $\left(\gamma_{A_0}\right)$ --- describes a reference-Clifford basis ,
3. $\left(F_\mu(x)\right)$ --- carries the internal fiber structure

The Clifford-condition then is:

$$\left(\gamma_A\right) \tag{10b.}$$

In this way, the metric is not presupposed but emerges from the dynamics of the Clifford fields.

<u>7. Fiberfield and signature-rotation:</u>

The fiberfield is parametrized as

$$[n_\mu^i(x)\sigma_i] \quad . \tag{11a.}$$

The coefficients fulfill:

$$(F_\mu(x)) \tag{11b.}$$

The both stable vacuum-orientations correspond to:

$$[2g_{\mu\nu}(x)] \tag{11c.}$$

and:

$$[n_\mu^i(x)\sigma_i] \tag{11d.}$$

A general configuration is:

$$[n_\mu^i n_\mu^i=1] \tag{11e.}$$

with:

$$[U(x)\in SU(2)] \quad . \tag{11f.}$$

This describes the signature change as a rotation in fiber space.

8. Degenerated transition-states:

A change in signature requires a point at which the Clifford structure loses its rank.
This constraint can be described by:

$$[det(g_{\mu\nu})=0] \tag{12a.}$$

At the transition-point there is:

$$[\Gamma_4\rightarrow 0] \tag{12b.}$$

a reduced Clifford-structure is generated.

$$[Cl(3,1)\rightarrow Cl(2,1)\rightarrow Cl(1,3)] \tag{12c.}$$

The intermediate state is therefore not an ordinary spacetime phase, but a degenerate Clifford phase.

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9. Developed Dirac-equation:

The dynamics of fermions is given by:

$$[(i\Gamma^\mu D_\mu-m)\psi=0] \tag{13a.}$$

The covariant derivation contains a possiple fiber-connection:

$$[\partial_\mu + \Omega_\mu + i A_\mu^i \sigma_i] \tag{13b.}$$

There is:

$$[A_\mu^i \sigma_i] \tag{13c.}$$

a possible intern connection of the two-fibre structure.

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10. Changing of chirality:

The Clifford-Volume element is:

$$[i\Gamma_0 \Gamma_1 \Gamma_2 \Gamma_3] \quad . \tag{14a.}$$

The chiral projectors are:

$$P_{L,R} = \left[\frac{1 \pm \Gamma_5}{2}\right] \tag{14b.}$$

A reversal of the Clifford orientation can result in:

$$[\Gamma_5 \rightarrow -\Gamma_5] \tag{14c.}$$

Therefore follows

$$[P_L \leftarrow \rightarrow P_R] \tag{14d.}$$

The signature phase could thus possess a chiral orientation:

$$[\psi_L \leftarrow \rightarrow \psi_R] \quad . \tag{14e.}$$

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11. Fermionic zeromodes at the area of transition:

Supposed is a spatial variable ordering parameter:

$$[v \cdot \tanh(kz)] \tag{15a.}$$

The Dirac-equation reduces itself for the transversal direction to:

$$[(\gamma^5 \delta_z + g \Sigma(z)) X(z) = 0] \tag{15b.}$$

For a component of chirality there is:

$$[\gamma^5 \chi_L = -\chi_L] \quad . \tag{15c.}$$

Therefore follows as a partial term:

$$[-g\,\Sigma(z)\,\chi\,L] \tag{15d.}$$

The solution of the differential equation then is:

$$[X_L(z) = C\cosh(kz)^{gv/k}] \tag{15e.}$$

or

$$[X_R(z) = C\cosh(kz)^{-gv/k}] \tag{15f.}$$

and is located for suitable parameters. Therefore the transition can generate fermion modes on a signature domain.

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12. Relationship to the spin-2 sector:

The five signature-states have the structure of:

$$[m = (-2; -1; 0; +1; +2)] \tag{16a.}$$

A spin-2-field classical is described by a symmetrical tensor of:

$$[h_{\mu\nu} = h_{\nu\mu}] \quad . \tag{16b.}$$

Hypothetically the relation can be written as:

$$[\Phi_m \to h_{\mu\nu}] \quad , \tag{16c.}$$

whereby the five states could represent the irreducible degrees of freedom of a spin-2 order parameter. A possible projection then could be:

$$\left[\varepsilon_{\mu\nu}^{(m)} = h^{\mu\nu}\right] \quad . \tag{17a.}$$

The Tensorpolarisations:

$$[\varepsilon_{\mu\nu}^{(m)}] \tag{17b.}$$

then carry the spin-2 informations.

<u>**13. Charge symmetry and intern symmetries:**</u>
A possible inner generator is:

$$[a\sigma_3 + b\Gamma_5 + c\,\sigma_3\Gamma_5] \tag{18a.}$$

At a changing of the fibre:

$$[\sigma_3 \rightarrow -\sigma_3] \tag{18b.}$$

also is changing:

$$[Q_F \rightarrow -Q_F] \tag{18c.}$$

only then, iff the charge-part completely is coupled to the fibre. Therefore a charge-conjugation situation structure or something similiar is possibly possible but not given determined automatically as a fact.

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14. Discussion:

The model contains several interconnected structures:

$$c = (Two-Fibre-Structure) \rightarrow (SU(2)-like\ Algebra) \rightarrow (dynamical\ Clifford-Structure) \rightarrow (Signature-phases) \rightarrow (Spin-2\,Order-\ parameter).$$

The most important open questions are:

1. Can the effective potential be derived from a fundamental action?
2. Does the fiber connection actually generates a gauge field?
3. Can the spin-2 order parameter cause a transition into the Einstein-Hilbert term?
4. Does the structure exactly reproduces the known fermion and charge spectra?

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15. Conclusion:

The presented model of spacetime doesn‘t interprete the universe as a static manifold with given determined fix signature but as a phase of a dynamical Clifford structure of fibres. The central hypothesis is:

Geometry generates by the dynamics of a Clifford-fibre.

The five signature states formally constitute a spin-2 structure, while the two-fiber sector represents a potential source of internal degrees of freedom. The theory provides a mathematical framework for investigating:
1. Signature phases,
2. Dynamic Clifford geometry,
3. Chiral transitions,
4. Possible emergent gravitational degrees of freedom.

Problems and challenges: However, a complete physical theory requires derivation from a fundamental principle of action and verification against known observations. For instance, this model here predicts a dynamical 2-dimensional domain-wall of $(1;2)$ with minimal depth of $d=L_{PL}$ between two existing phase states $(3;1)$ or $(1;3)$ in the 3^{rd} spacelike dimension.

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16. References:

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17. Non-scientific comment:

--- Battering one's head against the domain- wall. I want to get through here! ---

--- Always hugging the domain-wall, along the wall, along the wall … searching for the passage. Where is the gate with $[det(g_{\mu\nu})=0]$? ---

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18. Verification:

This paper definitely is written without support from an AI, LLM or chatbot like Grok or Chat GPT 4 or other artificial tools. It is fully, purely human work in every universe.
