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Free Disturbance Propagation and the Primitive Analog of c in the Scalar Relational UEF Model

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Abstract

This paper examines free disturbance propagation in the scalar relational model of the Universal Energy Field (UEF), proposed within an energistic ontology. The UEF is treated as a pre-spatiotemporal substratum whose stable localized formations may later be described as condensates. The present study focuses on the undisturbed background sector and asks whether small perturbations of the UEF can obey a well-defined propagation law. Starting from the primitive dynamical equation, the analysis fixes the regime parameter, selects a stationary background, linearizes around that background, and uses spectral decomposition of the relational coupling matrix. It is shown that a spectrum alone is not sufficient to define propagation: a regular large-scale relational sector is also required, allowing normal modes to be labelled by an emergent wave number. Under a normalized positive Laplacian-type coupling, the long-wavelength limit yields a relativistic-type dispersion relation. In the gapless sector, the group velocity becomes constant. This constant is interpreted not as the speed of light in pre-given spacetime, but as a primitive precursor of c.

Keywords: Universal Energy Field; free disturbance propagation; constant propagation speed; primitive c analog

Introduction

The previous work [8] proposed an energistic ontology together with a Universal Energy Field (UEF), understood as a pre-spatiotemporal energistic substratum from which physical entities and spacetime-like structures may eventually emerge. In order to move beyond a purely conceptual formulation, that work also introduced an initial scalar relational model of UEF dynamics. The present paper develops one specific consequence of that model: the propagation of small free disturbances around the undisturbed UEF background.

This problem is important for two reasons. First, any physical ontology that treats a substratum as fundamental must explain not only how localized entities may arise, but also how disturbances of the substratum can propagate. Second, if spacetime and causal structure are not assumed at the primitive level, then a propagation speed cannot simply be imported from ordinary spacetime physics. It must be derived, at least conditionally, from the structure of the underlying model.

The central question of this paper is therefore the following: under what assumptions does the scalar relational UEF model yield a constant propagation speed for small free disturbances? If such a speed exists, it cannot yet be identified directly with the speed of light in an already given spacetime. Rather, it should be understood as a primitive propagation constant defined relative to primitive succession and emergent relational extension. Only at a later stage, if a relativistic spacetime description emerges from the UEF framework, could this constant become the precursor of the physical constant c.

This paper should therefore be read as a first focused test of the scalar relational UEF model. It does not yet derive spacetime, light, or relativistic physics in full. It establishes a more modest but necessary result: the model contains, under identifiable assumptions, a free-propagation sector capable of supporting a primitive analog of c.

1. Aim of the paper

The aim of this paper is to derive, within the scalar relational UEF model, the law governing small free disturbances of the energistic substratum, and then to determine under what conditions this law yields a constant propagation speed. If it does, that speed may be interpreted as a primitive analog of c, and may later become relevant for emergent causal and metric structure.

The analysis will proceed in several steps. First, the primitive dynamical law of the scalar relational model is fixed in the undisturbed background regime. Second, small perturbations are introduced and the equation is linearized. Third, the relational coupling matrix is treated spectrally, yielding normal modes and a dispersion relation. Fourth, an additional assumption is introduced: the undisturbed UEF must contain a sufficiently regular large-scale relational sector, so that modes can be labelled by an emergent wave number. Finally, for a normalized positive Laplacian-type coupling, the long-wavelength limit is examined.

In accordance with the above, we begin from the primitive dynamical law of the UEF, then choose a stationary background state, linearize around that background, derive the normal-mode equation, obtain the dispersion relation, and finally pass to a regular large-scale limit in which an effective propagation law can be written in continuum form.

2. Primitive dynamical law

The scalar relational UEF dynamics is governed by [8]

$$\frac{d^2\Psi_i}{d\lambda^2} + \sum_j K_{ij}(\chi)\,\Psi_j + V'(|\Psi_i|^2;\chi)\,\Psi_i = 0. \tag{1}$$

Here, i labels primitive differentiations of the UEF, λ is the primitive ordering parameter, $\Psi_i(\lambda)$ is the primitive state variable, $K_{ij}(\chi)$ is the relational coupling matrix, V is the site-local nonlinear potential, and χ is the regime parameter.

Since the present goal is to study free disturbances of the undisturbed substratum, we place the UEF in its stationary background regime by setting

$$\chi = \chi_0, \tag{2}$$

where χ_0 is the characteristic value of the undisturbed UEF. It is convenient to abbreviate

$$K^0_{ij} := K_{ij}(\chi_0). \tag{3}$$

Equation (1) then becomes

$$\frac{d^2\Psi_i}{d\lambda^2} + K^0_{ij}\Psi_j + V'(|\Psi_i|^2;\chi_0)\,\Psi_i = 0. \tag{4}$$

3. Choice of background state

The simplest stationary background is the trivial undisturbed state

$$\Psi_i^{(0)} = 0 \; for \; all \; i. \tag{5}$$

We then write

$$\Psi_i(\lambda) = \eta_i(\lambda), \tag{6}$$

where η_i is a small disturbance.

Substituting (6) into (4) gives

$$\frac{d^2\eta_i}{d\lambda^2} + \sum_j K^0_{ij}\eta_j + V'(|\eta_i|^2;\chi_0)\,\eta_i = 0. \tag{7}$$

A specific form of the V potential, referred to as a "quartic-sextic potential", is adopted in the scalar relational model. It has been widely used in various fields of physics, e.g. [1] [12].

Here, accordingly, to first order in η_i, the nonlinear term disappears for the quartic-sextic potential. Indeed, if

$$V(|\Psi_i|^2;\chi) = \frac{a(\chi)}{2}|\Psi_i|^4 + \frac{b(\chi)}{3}|\Psi_i|^6, \tag{8}$$

then

$$V'(|\Psi_i|^2;\chi) = a(\chi)|\Psi_i|^2 + b(\chi)|\Psi_i|^4, \tag{9}$$

so that

$$V'(0;\chi_0) = 0. \tag{10}$$

Hence the free-disturbance equation becomes

$$\frac{d^2\eta_i}{d\lambda^2} + \sum_j K^0_{ij}\eta_j = 0. \tag{11}$$

This is the primitive linear propagation law for small disturbances of the UEF around the undisturbed background.

4. Linearization around a nonzero stationary background

Although the zero background is the cleanest choice for the free-propagation problem, it is useful to record the more general structure. Suppose the background is a stationary configuration $\Psi_i^{(0)} \neq 0$, and write

$$\Psi_i = \Psi_i^{(0)} + \eta_i, \; |\eta_i| \ll 1. \tag{12}$$

Linearization then yields a Bogoliubov-type system [2] [4] of the form

$$\frac{d^2\eta_i}{d\lambda^2} + \sum_j L_{ij}\eta_j + \sum_j M_{ij}\eta_j^* = 0, \tag{13}$$

where, for a site-local potential $V(|\Psi|^2; \chi_0)$,

$$L_{ij} = K_{ij}^0 + (V'(|\Psi_i^{(0)}|^2; \chi_0) + |\Psi_i^{(0)}|^2 V''(|\Psi_i^{(0)}|^2; \chi_0))\delta_{ij}, \tag{14}$$

And

$$M_{ij} = (\Psi_i^{(0)})^2 V''(|\Psi_i^{(0)}|^2; \chi_0)\,\delta_{ij}. \tag{15}$$

Thus both η_i and η_i^* appear whenever the background is nonzero. For the present paper, however, we remain with the zero background, where the free law is simply Eq. (11).

5. Spectral decomposition

To simplify the analysis of the Universal Energy Field dynamics, and specifically the relational coupling matrix, K_{ij}^0, which is a key component the UEF primitive dynamical law, we use the spectral decomposition method [6] [13]. For this purpose, let us assume that K_{ij}^0 is symmetric, or in the complex case, Hermitian:

$$K_{ij}^0 = K_{ji}^0. \tag{16}$$

Then K^0 admits an orthonormal eigenbasis $u_i^{(\alpha)}$ with eigenvalues κ_α:

$$\sum_j K_{ij}^0 u_j^{(\alpha)} = \kappa_\alpha u_i^{(\alpha)}. \tag{17}$$

Expand the disturbance as

$$\eta_i(\lambda) = \sum_\alpha q_\alpha(\lambda)\, u_i^{(\alpha)}. \tag{18}$$

Substituting into Eq. (11) and using orthonormality gives, mode by mode,

$$\frac{d^2 q_\alpha}{d\lambda^2} + \kappa_\alpha q_\alpha = 0. \tag{19}$$

Thus each normal mode has the solution

$$q_\alpha(\lambda) = A_\alpha e^{-i\Omega_\alpha \lambda} + B_\alpha e^{i\Omega_\alpha \lambda}, \tag{20}$$

with dispersion relation

$$\Omega_\alpha^2 = \kappa_\alpha. \tag{21}$$

The background is stable in the physically relevant sector provided

$$\kappa_\alpha \geq 0. \tag{22}$$

If some $\kappa_\alpha < 0$, the corresponding modes grow exponentially and signal instability of the background.

6. Emergent wave-number sector

Equation 21 gives a spectrum, but not yet a propagation speed. To obtain a propagating-mode interpretation, an additional assumption is needed.

Assumption: The undisturbed UEF contains a sufficiently regular large-scale relational sector such that the primitive index structure, together with the support of K_{ij}^0, approximates a translationally regular graph or lattice. In that sector, the normal modes may be labeled by an emergent wave number k.

This is a substantial assumption, but it is the minimal one needed if one wants to speak of propagation, wavelength, or dispersion in the familiar sense. It is also important to note that the effective spatial dimension d that will appear below is, at this stage, a free parameter of that regular sector. It is not yet derived from the primitive UEF dynamics.

7. Canonical Laplacian-type coupling

For simplifying the study of how small disturbances propagate in the UEF, we introduce Laplacian-type coupling that is common in physics models [9]. To make the propagation problem concrete, we choose the *minimally structured canonical form* [10]:

$$K_{ij}^{0} = \mu_{*}^{2}\delta_{ij} + C_{lat}^{2} L_{ij}, \tag{23}$$

The above equation defines the canonical form of the relational coupling matrix, K_{ij}^{0}, for the undisturbed Universal Energy Field, where:

where:

$\mu_{*}^{2} \geq 0$ is an effective gap or background stiffness term,

$C_{lat}^{2} > 0$ is the lattice-scale coupling constant,

L_{ij} is the normalized positive graph Laplacian [5].

We define L_{ij} so that its action on a disturbance is

$$(L\eta)_{i} = \frac{1}{a_{*}^{2}} \sum_{j} A_{ij} (\eta_{i} - \eta_{j}), \tag{24}$$

where A_{ij} is the adjacency matrix and a_{*} is the effective lattice spacing of the regular relational sector. With this convention, L is positive semidefinite [11].

The free-disturbance equation now reads

$$\frac{d^{2}\eta_{i}}{d\lambda^{2}} + \mu_{*}^{2}\eta_{i} + C_{lat}^{2}(L\eta)_{i} = 0. \tag{25}$$

This form removes the sign and normalization ambiguity that would arise if one worked instead with an unnormalized Laplacian of indefinite sign.

8. Lattice dispersion relation

On a *regular hypercubic relational lattice* [7], we seek modes of the form

$$\eta_{i}(\lambda) = A\, e^{i(k\cdot x_{i} - \Omega\lambda)}. \tag{26}$$

Then the normalized positive Laplacian has eigenvalue

$$_{L}(k) = \frac{2}{a_{*}^{2}} \sum_{m=1}^{d} (1 - cos(k_{m} a_{*})), \tag{27}$$

and the dispersion relation becomes

$$\Omega^{2}(k) = \mu_{*}^{2} + C_{lat}^{2}\ {}_{L}(k), \tag{28}$$

that is,

$$\Omega^{2}(k) = \mu_{*}^{2} + \frac{2C_{lat}^{2}}{a_{*}^{2}} \sum_{m=1}^{d} (1 - cos(k_{m} a_{*})). \tag{29}$$

This is the exact lattice dispersion law for free UEF disturbances in the regular sector.

9. Long-wavelength limit

Now consider the large-scale regime

$$|k_m a_*| \ll 1. \tag{30}$$

Using $$1 - cos(k_m a_*) \approx \frac{(k_m a_*)^2}{2}, \tag{31}$$

Eq. (29) reduces to

$$\Omega^2(k) \approx \mu_*^2 + C_{lat}^2 |k|^2. \tag{32}$$

This is the familiar relativistic-type dispersion relation in the long-wavelength limit.

10. Group and phase velocities

The group velocity is

$$v_g(k) = \frac{d\Omega}{d|k|}. \tag{33}$$

From Eq. (32),

$$\Omega(k) = \sqrt{\mu_*^2 + C_{lat}^2 |k|^2}, \tag{34}$$

Hence

$$v_g(k) = \frac{C_{lat}^2 |k|}{\sqrt{\mu_*^2 + C_{lat}^2 |k|^2}}. \tag{35}$$

There are two cases.

Case 1: Gapped sector (0)

Then

$$v_g(k) < C_{lat} \, for \, all \, finite |k|, \tag{36}$$

and the propagation is dispersive.

The corresponding phase velocity is

$$v_{ph}(k) = \frac{\Omega}{|k|} = \sqrt{\frac{\mu_*^2}{|k|^2} + C_{lat}^2} \geq C_{lat}. \tag{37}$$

This superluminal phase velocity is, however, physically "harmless", since phase velocity does not by itself transmit energy or information.

Case 2: Gapless sector (0)

Then

$$\Omega(k) = C_{lat} |k|, \tag{38}$$

and therefore

$$v_g(k) = C_{lat} \tag{39}$$

for all long-wavelength modes.

This is the precise condition under which the model yields a constant propagation speed.

11. Continuum limit

In the continuum approximation, the normalized graph Laplacian tends to the positive operator $-\nabla^2$ [3]. More precisely,

$$(L\eta)_i \longrightarrow -\nabla^2 u, \tag{40}$$

where $u(x, \lambda)$ is the continuum field corresponding to the large-scale disturbance.

Equation (25) then becomes

$$\frac{\partial^2 u}{\partial \lambda^2} - C^2 \nabla^2 u + \mu_*^2 u = 0, \tag{41}$$

where, in order to keep the notation clean, the continuum propagation constant C is identified with the large-scale counterpart of the lattice coupling C_{lat}. With the normalized Laplacian convention adopted in Eq. (24), no hidden extra factor of a_*^2 remains in Eq. (41).

If the free sector is gapless, $\mu_* = 0$, then Eq. (41) reduces to

$$\frac{\partial^2 u}{\partial \lambda^2} - C^2 \nabla^2 u = 0. \tag{42}$$

This is the standard wave equation [14], now emerging from the scalar relational UEF model.

12. Primitive analog of c

The gapless dispersion relation

$$\Omega = C|k| \tag{43}$$

shows that all long-wavelength free disturbances propagate with the same constant speed

$$v_g = C. \tag{44}$$

This C may therefore be interpreted as a primitive analog of c.

At this stage, one must state the claim carefully. C is not yet the speed of light in a pre-given spacetime. Rather, it is the invariant propagation rate of free UEF disturbances relative to primitive succession and emergent relational extension. If a relativistic spacetime description later emerges from the free-propagation sector, then C becomes the natural precursor of the constant c.

13. Assumptions and scope

The derivation above is conclusive within the following assumptions:

– the UEF is in the stationary undisturbed regime $\chi = \chi_0$;

– the disturbance amplitude is small, so linearization is justified;

– K_{ij}^0 is symmetric or Hermitian;

– the undisturbed UEF contains a sufficiently regular large-scale relational sector;

– the effective coupling in that sector is of normalized positive Laplacian type;

– the free-disturbance sector is gapless if one wants a universal constant propagation speed.

The result is therefore conditional, but nontrivial: within this scalar relational framework, the UEF admits a linear free-disturbance sector, and in the gapless case that sector carries a universal propagation speed.

14. Summary

The paper has examined the propagation of small free disturbances around the undisturbed background of the scalar relational UEF model. Starting from the primitive dynamical law, the analysis fixed the regime parameter in the stationary background regime, introduced a small perturbation, and linearized the equation of motion. For the zero background and the quartic-sextic potential used in the model, the nonlinear term does not contribute at first order, and the disturbance obeys a primitive linear propagation law.

The next step was spectral. Assuming that the relational coupling matrix Kij is symmetric, or Hermitian in the complex case, the disturbance can be expanded in normal modes. This yields a dispersion relation. However, a spectrum by itself does not yet provide a propagation speed. To speak meaningfully of wavelength, wave number, and propagation, an additional large-scale assumption is required: the primitive relational structure must contain a sufficiently regular sector that can be approximated by a translationally regular graph or lattice.

With this assumption in place, a canonical normalized positive Laplacian-type coupling was introduced. In the long-wavelength limit, the resulting dispersion relation takes a relativistic-type form. In the gapped case, propagation is dispersive. In the gapless case, however, the dispersion relation becomes linear and the group velocity is constant.

The main result is therefore conditional but nontrivial. If the undisturbed UEF admits a regular large-scale relational sector and if the relevant free-disturbance sector is gapless, then small disturbances propagate with a universal constant speed. This constant is not yet the speed of light in spacetime. It is a primitive propagation constant within the UEF framework, and it may become relevant to later work on emergent causal and metric structure.

15. Conclusions and future work

This paper has studied one dynamical sector of the scalar relational UEF model: the propagation of small free disturbances around the undisturbed background. The result is conditional, but conceptually important. Under linearization, spectral decomposition, a regular large-scale relational sector, and normalized positive Laplacian-type coupling, the model yields a well-defined free-propagation law. In the gapless long-wavelength sector, the group velocity becomes constant.

This constant speed should be interpreted carefully. It is not introduced as the speed of light in a pre-existing spacetime, nor does the present paper claim to derive full relativistic physics. Rather, it is a primitive analog of c: a universal propagation rate defined within the pre-spatiotemporal relational UEF framework. If spacetime, causal order, and metric structure later emerge from the UEF, this constant may provide one of the ingredients from which the familiar role of c can be recovered.

The value of the result lies in showing that the scalar relational UEF model is not limited to static condensate formation. It also contains a free-disturbance sector with propagation structure. This is significant because any proposed substratum ontology must account not only for the emergence of stable entities, but also for the transmission of disturbances, correlations, and causal influence.

Several limitations remain. The regular large-scale sector has been assumed rather than derived. The effective dimensionality of that sector has not yet been fixed by the primitive model. The gapless condition has been identified as necessary for constant-speed propagation, but its deeper origin remains to be explained. Finally, the present treatment is linear and applies only to small disturbances around the undisturbed background.

Future work should therefore proceed in four directions. First, the interaction between two condensed UEF entities should be developed, with special attention to the distinction between bounded condensate cores and the UEF deformation fields they induce. Second, the collective-coordinate theory of drifting condensates should be used to test whether primitive analogs of inertia and mass can be derived. Third, the effective $\chi(\lambda)$ regime law should be studied to clarify the cosmological role of threshold structure. Fourth, the stability and bifurcation analysis of stationary condensates should be carried out to strengthen the mathematical basis of the model.

The present paper thus establishes a limited but necessary step. It shows that, within the scalar relational UEF framework, a primitive constant-speed propagation sector can arise under clear assumptions. That result provides a foundation for subsequent work on interaction, inertia, gravitation analogs, and the possible emergence of spacetime-like structure.

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Appendix

Glossary

Condensate (Condensed Entity) - A stable localized formation of organized UEF energy. In the present scalar relational model, a condensate is represented by a stationary profile and functions as the model's generic counterpart of a particle-like entity, without assuming that ordinary spacetime already exists.

Energism (Energistic Ontology) - A monistic ontological position according to which the fundamental substratum of physical reality is energy, rather then matter. Matter is treated as an organized form or manifestation of this substratum, while the matter-energy distinction is understood as dependent on the level and mode of description.

Primitive Ordering Parameter (λ) - A pre-spacetime ordering parameter used to describe succession in the UEF dynamics. It plays a role analogous to time in the formal equations, but it is not yet physical time as measured in emergent spacetime.

Quantum Energy Entity - A stable, coherent energetic formation arising within the UEF. It corresponds to the conventional notion of a quantum object or particle only at the emergent level; in the present ontology it is understood as an organized condensate of the substratum.

Regime Parameter (χ) - A primitive parameter that controls the dynamical regime of the UEF. It enters the relational coupling structure and the site-local nonlinear potential, and it helps determine whether condensation and stable entity formation are possible.

Relational Coupling Matrix (Kij) - The matrix that encodes the strength and structure of primitive relations among UEF differentiations. It defines the relational topology of the model and replaces any assumption of a pre-given spacetime geometry at the primitive level.

Scalar Relational Model - The present simplified UEF model in which the primitive state variable is scalar and the dynamics is defined by relational couplings, local nonlinear self-structure, and a regime parameter. It is intended as a first formal layer, not as a complete physical theory.

Universal Energy Field (UEF) – Within the postulated energistic ontology, the proposed pre-spatiotemporal energetic substratum from which condensed entities, propagation structure, and possibly spacetime-like relations may emerge. It is not a field on an already existing spacetime manifold.

Universal Energy Field (UEF) Model - The formal framework used to describe the UEF and its dynamics. In this paper, the model is restricted to a scalar relational version focused on free disturbance propagation and two-entity interaction.