# Geometric Algebra under Ontological Discipline: Contemporary Applications, Modal Necessity, and Operational Bridges in Confrontation with the Theory of Objectivity (TO)

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**Abstract**

This paper develops a critical–propositive reading of *Survey of New Applications of Geometric Algebra* by Hitzer et al., confronting Geometric Algebra (GA)—as a unifying language for vectors, bivectors, multivectors, metrics, and symmetries—with the foundational and recent bibliography of the Theory of Objectivity (TO). We argue that Geometric Algebra (GA)'s integrative power is best understood under ontological discipline: rather than being treated as an ultimate foundation of reality, Geometric Algebra (GA) is interpreted as an *operational language* whose intelligibility presupposes logical conditions that, in Theory of Objectivity (TO), are modally necessary and expressed by the Seven Absolute Truths. Accordingly, Theory of Objectivity (TO) does not intend to replace contemporary physics or cosmology, but it is proposed as a necessary logical, ontological, and scientific basis for constructing any model coherent with a possible universe, given the modal necessity of its seven axioms and the independent AI-assisted assessment reported in Cabannas and Silva. We map compatibilities and productive tensions, articulate decision criteria and operational bridges (indirect testability), and examine the hypothesis that neutrinos may be phenomenic manifestations of Theory of Objectivity (TO) plasmas. Appendices present TO-standard materials: axioms, the perfect-sphere theorem (64/2048), inducer effects (Expansive Inducer Effect (EIE)/Reductive Inducer Effect (EIR)), and a concise phenomenic table.

**Keywords:** geometric algebra; modal ontology; axioms; perfect sphere; inducer effects; neutrinos; indirect testability; cosmology; ontological discipline.

# Contents

# 1 Introduction: why place Geometric Algebra (GA) under ontological discipline?

Over the last century, Geometric Algebra (GA) has matured into a language capable of unifying objects and operations that often appear scattered across multiple notational systems in standard mathematics and physics: vectors and oriented planes, rotations and reflections, metrics and symmetries, differential objects and computational operators. The survey by Hitzer et al. documents this maturity by synthesizing contemporary applications across theoretical and computational physics, robotics, computer vision, signal and image processing, electromagnetism, relativity, and high-dimensional geometric structures (see also the Zenodo deposit: Hitzer et al.). The central thesis of the present critical–propositive reading is that Geometric Algebra (GA)'s unifying effectiveness is a *symptom* of a deeper ontological necessity: the geometric intelligibility of the real is not arbitrary, but depends on logical conditions that precede the very possibility of spatiality.

This is where the Theory of Objectivity (TO) enters. Rather than offering merely a competing cosmological *model*, Theory of Objectivity (TO) claims a modal–axiomatic status: a framework grounded in Seven Absolute Truths (modally necessary axioms) that function as conditions of possibility for any existential universe. In this sense, Theory of Objectivity (TO) does not aim to replace contemporary physics and cosmology; instead, it proposes itself as a necessary logical, ontological, and scientific basis for constructing any model coherent with a possible universe, consistent with the independent AI-assisted assessment presented in Cabannas and Silva.

Two methodological consequences follow. First, a powerful mathematical language (such as Geometric Algebra (GA)) must be interrogated not only for what it *describes* but also for what it *presupposes*: what conditions make it possible for a geometric algebra to be a language of the world? Second, testability should include not only direct predictions but also *operational bridges* and *indirect tests* that reinterpret observational data without violating established physics, in line with the TO strategy of Cabannas and Silva and later systematizations (Cabannas and Silva; Cabannas and Silva).

## 1.1 Contributions and scope

This paper contributes on four levels: (i) it formalizes compatibilities between Geometric Algebra (GA) and Theory of Objectivity (TO) axioms; (ii) it makes explicit ontological tensions (especially the presupposition of a prior space); (iii) it articulates inducer effects (Expansive Inducer Effect (EIE) and Reductive Inducer Effect (EIR)) as principles for the emergence of geometry, interaction, and stabilization; and (iv) it proposes a set of operational bridges for indirect testability, with emphasis on the phenomenic hypothesis of neutrinos as manifestations of Theory of Objectivity (TO) plasmas.

### 1.2 Note on mathematical language and the TO theorem

Theory of Objectivity (TO) asserts that it is not merely philosophical: it presents a complete theorem through a proprietary mathematical language involving graphs and logical constructions grounded in seven axioms, demonstrating the emergence of a universe from an eternal, perfect logical sphere that existed before the emergence of time, space, and matter (Cabannas and Silva; Cabannas and Silva). The present work adopts this claim as *ontological discipline* for interpreting Geometric Algebra (GA), not as a replacement of mainstream physics.

## 2 Hitzer's survey: contemporary applications and formal unity

### 2.1 What the survey shows

The article by Hitzer et al. offers a robust synthesis of recent applications of Clifford/Geometric Algebra across several domains. The unifying thread is the capacity to represent, within a single formalism: (a) rotations and orientations via rotors; (b) relations among subspaces via the geometric product; (c) the integration of calculus, algebra, and geometry into computationally efficient representations; and (d) controlled passage across dimensions and metric signatures. This unity, beyond elegance, is operational: Geometric Algebra (GA) becomes a *geometric compiler* between theory, simulation, and algorithm.

### 2.2 The interpretive hypothesis of this paper

In this reading, Geometric Algebra (GA) is treated as: (i) a *language of boundaries* (oriented distinctions); (ii) a *language of fields* (multivectors as graded composition of scalar/vector/bivector components); and (iii) a *language of observables* (relational structure via frames and symmetries). These three dimensions will be confronted with Theory of Objectivity (TO) axioms, especially Absolute Truths II, IV, and V (Appendix A).

## 3 TO foundations relevant for confronting Geometric Algebra (GA)

### 3.1 Seven Absolute Truths as conditions of possibility

Theory of Objectivity (TO) maintains that the Seven Absolute Truths are logically self-evident and modally necessary propositions for the genesis of a possible universe

(Cabannas and Silva; Cabannas and Silva). In operational terms:

- Distinction requires boundary (Absolute Truth IV).
- Full existence requires relational observation by at least two others (Absolute Truth V).
- Historical composition is constitutive (Absolute Truth VI).
- Fields ("auras") make elements unique and relational (Absolute Truth II).
- Spatiality and temporality are not primitive; they emerge under logical conditions (TO cosmological theorem).

## 3.2 The perfect sphere as theorem (64/2048), not choice

A central element of the TO theorem is the *perfect logical sphere* with 64 straight logical parts on its maximum circumference and 2048 logical parts on its total surface, capable of tangentially contacting a plane individually depending on its eternal, static initial orientation. This structure is not an aesthetic choice; it arises from the modal necessity of the Seven Absolute Truths, as demonstrated in Cabannas and Silva and Cabannas and Silva, and corroborated through graphical and logical presentations in Cabannas and Silva.

## 3.3 Inducer effects: Expansive Inducer Effect (EIE) and Reductive Inducer Effect (EIR)

Operationally, this paper uses two regimes:

1. **Expansive Inducer Effect (EIE) (axioms IV and V):** distinction plus relational observation induces *expansion of possibilities* and stabilization of observable boundaries, favoring the emergence of operational geometry (planes, orientations, effective metrics).
2. **Reductive Inducer Effect (EIR) (axioms IV, V, and VI):** distinction plus relational observation plus historical composition induces *reduction* (convergence) and *compaction* of possibilities, favoring persistent structures, currents, and convergence zones, in dialogue with recent TO examinations of gravitation and convergence (Cabannas and Silva).

# 4 Core compatibilities between Geometric Algebra (GA) and Theory of Objectivity (TO) axioms

## 4.1 Boundaries, orientation, and Absolute Truth IV

Absolute Truth IV states that two distinct elements require at least one boundary line between them. Geometric Algebra (GA), by construction, operates on oriented objects and relations among subspaces. Bivectors, for instance, are oriented areas encoding boundary and orientation rather than merely "two-dimensional vectors." Under TO discipline, Geometric Algebra (GA) can be read as an efficient formalization of the principle that *distinction precedes metric*: difference and limit come first; metricization emerges as a way to quantify already-distinguished relations.

In inducer terms, Expansive Inducer Effect (EIE) can be interpreted as the regime in which boundaries multiply relational possibilities for oriented interactions; Reductive Inducer Effect (EIR) then selects and stabilizes certain orientations (convergence zones), as though emergent space privileges effective *subalgebras* of interaction.

## 4.2 Multivectors, fields, and Absolute Truth II

Absolute Truth II holds that every element possesses a magnetic field (aura) that makes it unique. Although Geometric Algebra (GA) does not by itself posit a physical ontology for multivectors, it offers a vocabulary in which entities decompose into graded components (scalars, vectors, bivectors, etc.). This is compatible with the TO idea that no element can be isolated from its relational field: the "state" of an element is always a *complex* expressing its relational placement.

In the context of field physics, this interpretation becomes especially relevant when the vacuum and its properties are treated as dynamical structure (without conflating physical "vacuum" with TO "Nothing" as a primitive mathematical essence). See the TO-critical reading of vacuum and QFT in Cabannas and Silva.

## 4.3 Relational observability and Absolute Truth V

Absolute Truth V states that an element fully exists only if observed by at least two others. This does not require human observers; it is relational/structuring observation. Geometric Algebra (GA) is intrinsically contextual: operations obtain meaning relative to an algebraic space with observables, frames, and symmetries. A rotation is a relational transformation between states; it does not exist as an isolated entity without a relational web.

This convergence also supports dialogue with the conceptual role of the observer in quantum theory as discussed by Heisenberg. Where standard debates sometimes anthropomorphize measurement, TO relocates the condition of full existence to structural relations, aligned with the gödelian discipline and Law of Logical Minimum systematized in Cabannas and Silva.

# 5 Ontological tensions: what Geometric Algebra (GA) presupposes and Theory of Objectivity (TO) rejects as primitive

## 5.1 The implicit presupposition of a prior space

Even in abstract formulations, Geometric Algebra (GA) typically assumes a vector space (or module) with a metric signature or, at least, enough structure to define a geometric product. For Theory of Objectivity (TO), this is ontologically late: space is not primitive but emerges through cosmological eras and the perfect-sphere theorem (Cabannas and Silva; Cabannas and Silva). Therefore, Geometric Algebra (GA) is interpreted as an appropriate language *from* the Era of Logical Tracks (or an analogous stage of geometric possibility) onward, when spatiality becomes logically possible.

This does not invalidate Geometric Algebra (GA); it specifies its ontological domain. Geometric Algebra (GA) excels at describing phases where geometry has already emerged. What it does not supply by itself is the *modal reason* for that emergence.

## 5.2 The "why" deficit

Geometric Algebra (GA) explains *how* structures behave; it rarely claims to explain *why* they must exist. Theory of Objectivity (TO) proposes that necessity follows from axioms: the existence of boundaries (IV), relational observation (V), historical composition (VI), and the infinity as a non-element of definability (III) structures the possibility of geometry and thus a geometrically intelligible universe.

Accordingly, ontological discipline does not demand that Geometric Algebra (GA) researchers adopt Theory of Objectivity (TO); it states that, if Geometric Algebra (GA) is interpreted as fundamental language of the universe, a modal ground is required to explain why the universe is *geometrizable* in the first place.

# 6 The perfect sphere (64/2048) and Geometric Algebra (GA): formal compatibility without ontological inversion

## 6.1 Tangency, orientation, and decomposition into logical parts

The TO perfect-sphere theorem describes an eternal and static structure prior to time, space, and matter, whose discrete decomposition into 64 straight logical parts (maximum circumference) and 2048 logical parts (total surface) conditions individual tangency to a plane and, hence, conditions for geometric emergence (Cabannas and Silva; Cabannas and Silva; Cabannas and Silva). Geometric Algebra (GA) provides tools to formalize:

- orientations and rotations (rotors) encoding "initial position" and orientation changes;
- planes and hyperplanes via bivectors and multivectors;
- tangency as algebraic contact conditions between subspaces.

## 6.2 Thesis of asymmetric compatibility

Compatibility is *asymmetric*: the TO perfect sphere can be expressed using Geometric Algebra (GA) (as a formal language), but Geometric Algebra (GA) does not explain why such a sphere must exist (as ontology). In other words, Geometric Algebra (GA) can serve as an *expression language* for structures whose reason is modal and axiomatically imposed. This preserves scientific value on both sides: Theory of Objectivity (TO) supplies ontological discipline; Geometric Algebra (GA) supplies formal and computational efficiency.

# 7 Phenomenic elements, TO plasmas, and the neutrino hypothesis

## 7.1 Working hypothesis: neutrinos as phenomenic manifestations of TO plasmas

As requested, we assume that neutrinos may be phenomenic manifestations of TO cosmological plasmas. The propositive plausibility rests on three points:

1. **Weak interaction and near-neutrality:** neutrinos have weak coupling to baryonic matter, suggesting a liminal status between fully materialized structure and transition structure.

2. **Cosmological ubiquity:** their cosmological presence is consistent with remnants of primordial regimes.

3. **Informational function:** under TO, the transcendent element may be treated as knowledge/information produced in atomic relations and equivalent to atomic radiations; neutrinos can be treated as carriers/signatures of primordial processes (subject to operational bridges).

### 7.2 Where Geometric Algebra (GA) helps

Geometric Algebra (GA) can help by providing a unified language to:

- model *fields* and orientations via multivectors;
- represent *effective couplings* as geometric invariants;
- explore signatures and representability regimes (without reifying "dimension" as a primitive ontology).

The gain is methodological: Geometric Algebra (GA) can become a formal bridge between TO's phenomenic table and effective models of observables.

## 8 Testability, predictability, and operational bridges under ontological discipline

### 8.1 AI-assisted testability and logical predictability

Cabannas and Silva reports that Artificial Intelligences proposed models of testability and predictability for TO phenomenic elements and cosmological eras by introducing new methods and reinterpretations of data without violating established physics. Subsequent works systematize the strategy in terms of operational bridges and gödelian discipline (Cabannas and Silva; Cabannas and Silva).

### 8.2 Three classes of operational bridges

We propose three classes (non-exhaustive):

1. **Consistency bridges (constraints):** check whether TO readings impose coherent restrictions on already-measured parameters (e.g., vacuum-energy inferences under ontological discipline; Cabannas and Silva).

2. **Signature bridges (patterns):** search for geometric or statistical signatures in cosmological datasets interpretable as traces of initial geometric induction (e.g., CMB anisotropies; Planck Collaboration, Aghanim, et al.).

3. **Productive-tension bridges (anomalies):** investigate observational tensions where TO may offer alternative interpretive criteria (e.g., early bright galaxies in JWST-era data; Arrabal Haro, Dickinson, Finkelstein, et al.; Menci, Sen, and Castellano; Gupta).

## 8.3 Experiments and indirect evidence through inducer effects

### 8.3.1 Entanglement and nonlocality

Bell-type experimental confirmations in Aspect, Dalibard, and Roger challenge local realism. Under TO, the phenomenon can be read as an expression of relationally induced nonlocal geometry governed by boundary and observation (axioms IV and V), where correlations arise as structural invariants rather than "spooky action." Geometric Algebra (GA) may serve as a language for invariants encoding correlations, while TO supplies the ontological frame.

### 8.3.2 CMB and primordial structure

Planck provides precision constraints on CMB anisotropies and cosmological parameters (Planck Collaboration, Aghanim, et al.). Under TO, primordial patterns can be treated as traces of initial geometric induction (an Expansive Inducer Effect (EIE) regime), while later-scale stabilization can be associated with convergence (Reductive Inducer Effect (EIR)). This is propositive: it does not replace standard cosmology but offers a taxonomy of traces consistent with a phenomenic table.

### 8.3.3 Gravitational waves

The observation of gravitational waves in Abbott et al. is typically interpreted as spacetime ripples. Under TO discipline, an alternative reading is available: perturbations in the dynamics of inducer fields (EIE/EIR), without requiring gravitons. The observational prediction remains the same (the measured strain signal), while the fundamental explanation is restructured.

### 8.3.4 JWST-era early structure formation

Spectroscopic and photometric results point to rapid formation of very luminous galaxies at high redshift (Arrabal Haro, Dickinson, Finkelstein, et al.), motivating debates about formation efficiency and/or dark-energy sectors (Menci, Sen, and Castellano) and alternative cosmological interpretations (Gupta). Under TO, this can be read as compatible, in principle, with rapid and logical formation processes and current generation (centrifugal era) via inducer regimes. The gain is conceptual: to organize empirical tensions as targets for operational bridges rather than as premature refutations.

# 9 Synthesis: convergences, decision criteria, and limits

## 9.1 What converges

Strong convergences include:

- the primacy of relations, orientations, and boundaries (TO-IV and Geometric Algebra (GA));
- the idea of entities as composite and contextual (TO-II/VI and multivectors);
- the relational structure of observation/measurement (TO-V and frames/symmetries).

## 9.2 What remains in tension

The principal tensions remain:

- Geometric Algebra (GA)'s tendency to presuppose space/metric as given, while TO asserts late emergence;
- Geometric Algebra (GA)'s lack of an intrinsic modal explanation for why geometric structures must exist.

## 9.3 Proposed decision criterion

We propose the following criterion:

> *Adopt Geometric Algebra (GA) as a privileged operational language, while submitting its fundamental interpretation to modal ontological discipline (TO), so that "geometry" is not treated as an absolute primitive but as an emergence structured by boundaries, relational observation, and historical composition.*

# 10 Conclusion

This critical–propositive reading shows that Geometric Algebra (GA), as synthesized by Hitzer et al., is broadly compatible with the relational architecture described by Theory of Objectivity (TO), especially regarding boundaries (Absolute Truth IV), fields/auras (Absolute Truth II), and relational observation (Absolute Truth V). At the same time, Geometric Algebra (GA) does not intend—and cannot by itself provide—the ontological grounding of *why* the universe is geometrizable. Theory of Objectivity (TO) is proposed as the necessary logical, ontological, and scientific basis for coherent models of a possible universe, without replacing contemporary physics (Cabannas and Silva).

Moreover, the integration of ontological discipline and geometric language opens a pragmatic program: the construction of operational bridges (indirect testability) aligning observational data with criteria of modal necessity and a phenomenic table. Within this horizon, the hypothesis of neutrinos as phenomenic manifestations of TO plasmas emerges as a specific research target, demanding formal tools (such as Geometric Algebra (GA)) for expressing invariants and couplings, and demanding TO discipline to avoid premature ontological reifications.

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# A Appendix A — The Seven Absolute Truths (operational version)

Based on Theory of Objectivity (TO) formulations (Cabannas and Silva; Cabannas and Silva), we adopt the following operational list:

1. **Truth I:** Nothingness is a primitive and eternal mathematical essence.
2. **Truth II:** Every element possesses a magnetic field (aura) that makes it unique.
3. **Truth III:** Infinity represents the non-element required for the logical definability of the universe.
4. **Truth IV:** Two distinct elements require at least one boundary line between them.
5. **Truth V:** An element fully exists only if observed by at least two others.
6. **Truth VI:** Every element is composed of elements prior to it.
7. **Truth VII:** There is no existential universe without substance transcendent to its quantum.

# B Appendix B — The perfect-sphere theorem (64/2048): concise synthesis

The TO theorem establishes a perfect logical sphere prior to time, space, and matter, whose discrete structure is modally necessary:

- 64 straight logical parts on the maximum circumference;
- 2048 logical parts on the total surface;
- individual tangency to a plane according to an eternal, static initial orientation;
- universe emergence as a logical unfolding under boundary (IV), relational observation (V), and composition (VI).

See demonstrations and graphical/logical presentations in Cabannas and Silva, Cabannas and Silva, and Cabannas and Silva.

# C Appendix C — Inducer effects: operational definitions and regimes

## C.1 Expansive Inducer Effect (EIE)

Operational definition: a regime in which (IV) boundary plus (V) relational observation induces expansion of possibilities and stabilization of observable distinctions, favoring the emergence of effective geometric structures (planes, orientations, operational metrics).

## C.2 Reductive Inducer Effect (EIR)

Operational definition: a regime in which (IV) boundary plus (V) relational observation plus (VI) historical composition induces convergence, compaction, and persistence of structures, favoring currents, convergence zones, and stable regimes. Correlative readings in Cabannas and Silva.

# D Appendix D — Phenomenic table (minimal TO-standard model)

The table below summarizes, in a minimal mode, the relation among (i) axioms, (ii) inducer effects, (iii) cosmological era function, and (iv) possible observables/operational bridges.

| **Axiomatic core** | **Inducer regime** | **Cosmological function (TO)** | **Possible operational bridge (examples)** |
|---|---|---|---|
| IV + V | Expansive Inducer Effect (EIE) | Emergence of stable distinctions and operational geometry | Primordial-structure signatures (CMB) and symmetry coherence: Planck Collaboration, Aghanim, et al. |
| IV + V + VI | Reductive Inducer Effect (EIR) | Convergence and stabilization of persistent structures | Gravity-as-convergence and inducer fields: Cabannas and Silva; gravitational waves: Abbott et al. |
| II + IV + V | Expansive Inducer Effect (EIE)/Reductive Inducer Effect (EIR) | Fields/auras as relational identity | Effective field/vacuum models under ontological discipline: Cabannas and Silva |

| Axiomatic core | Inducer regime | Cosmological function (TO) | Possible operational bridge (examples) |
|---|---|---|---|
| III + IV | Expansive Inducer Effect (EIE) | Logical definability (infinity as non-element) | Consistency and completeness criteria; gödelian discipline: Cabannas and Silva |
| V + VII | Reductive Inducer Effect (EIR) | Informational transcendence as a condition for an existential universe | Predictability programs and AI-assisted bridges: Cabannas and Silva; Cabannas and Silva |
| Plasmas (hypothesis) | Expansive Inducer Effect (EIE)/Reductive Inducer Effect (EIR) | Transitions of materialization and logical currents | Neutrinos as phenomenic manifestations (bridge target); JWST tensions as reinterpretation targets: Arrabal Haro, Dickinson, Finkelstein, et al.; Menci, Sen, and Castellano; Gupta |

# E Appendix E — Dialogue with philosophy and history of science

Ontological discipline as proposed here enters dialogue with (i) observation and indeterminacy debates in Heisenberg; (ii) standard cosmology chronology in Weinberg; (iii) spacetime geometry and ontology in Einstein; (iv) holism and implicate order in Bohm; (v) irreversibility and self-organization in Prigogine and Stengers; (vi) mathematical structure and platonist debates in Penrose; (vii) comparative cosmological synthesis in Hawking; and (viii) paradigm-change dynamics in Kuhn. These references are not substitutes for Theory of Objectivity (TO) but serve as *support and dialogue bibliography* situating the proposal in broader debates.