

Artificial Intelligence as a Check on Logic

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Abstract

Math and physics proceed from assumptions to conclusions via a logical path. Artificial intelligence possesses the ability to follow logic, herein specifically applied to the problem of defining ontologically real 2D manifolds in a 3D continuum. Vortices and tori in fluids exhibit effective 2D surfaces, which, treated as manifolds, allow application of calculus on the boundaries of the structures. Recent papers in primordial field theory (PFT) have employed Calabi-Yau geometry and topology to develop a fermion structure. We desire a logical justification of this application and herein explore the use of artificial intelligence to assist in logic verification. A proof is outlined by the author and formalized by the AI.

Keywords

AI, Calabi-Yau, Yang-Mills, Perfect Fluid, Fermion Structure, Manifold, 3D Continuum

1. Introduction

Math and physics proceed from assumptions to conclusions via a logical path. Before investigating the application of artificial intelligence to the logic of a problem, we discuss approaches to physics. One of the greatest experimental and theoretical physicists of the 20th century, Enrico Fermi, remarked [1] about Dyson's reconciliation of Feynman's, Schwinger's, and Tomonaga's theories of quantum electrodynamics (QED):

“There are two ways of doing calculations in theoretical physics. One way, and this is the way I prefer, is to have a clear physical picture of the process you are calculating. The other way is to have a precise and self-consistent mathematical formulation. You have neither.”

Moreover, Fermi then asked Dyson how many free parameters he had used to obtain the fit between experiment and calculation, and when told the answer was “four”, Fermi remarked:

“I remember my old friend Johnny von Neumann used to say, with four parameters I can fit an elephant, and with five I can make him wiggle his trunk.”

Today QED produces infinities in every solution and requires approximately 30 free parameters and invokes one quantum field for every particle. When Feynman began a field theory approach to gravity, he defined gravity as the 31st field. From Fermi’s perspective, it is no surprise that a theory with thirty-one free parameters can fit a complex physical system such as the particle zoo. In contrast, the physical theory of *one* primordial field is based on the existence of a hyperdense continuum at the moment of creation, symbolized by the Big Bang. The current standard model of particle physics assumes that all four forces (electromagnetic, weak, strong and gravity) converge to one force at the Big Bang but has been unable to demonstrate this mathematically. An alternate perspective, developed by the author, begins with the unified primordial field at the Big Bang and proceeds to evolve the particle physics we find today. This approach is developed in [2].

The ubiquitous presence of vortices and tori in turbulent fluids, with reasonably well-defined 2D surfaces on these structures, implies that Calabi-Yau topology may be of significance for the study of such. Research based on this has found a well-formulated approach leading to half-integer spin, a requirement of fermions. A key figure implies that dual structures exist, as depicted by the dual $U(1) \times U(1)$ -symmetry shown in **Figure 1**.

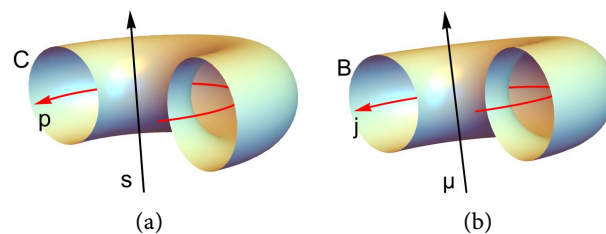


Figure 1. (a) Gravitomagnetic structure: momentum density p , field C and spin s ; (b) Electrodynamic dual: electric current density j , field B , and magnetic moment μ .

The presence of vortices in turbulent media and consequential formation of toroidal closure is grounds for inclusion of such structure in a theory, lacking a mathematical proof deriving such. In primordial field theory, the 1954 Yang-Mills equation is modified to replace the essentially meaningless term representing self-interaction $[A_\mu, A_\nu]$ with a new term $[A_\mu^{(i)}, A_\mu^{(i+2)}]$ representing self-interaction of higher-order induced fields [3]. Treatment of such on a fractal lattice leads to a mass-gap existence proof—not necessarily dependent on a *hard* toroidal surface versus a *soft* one. Having shown the existence of an energetically stable mass-gap structure, we next invoked Calabi-Yau theory to explain the origin of half-integral spin. Calabi-Yau topology assumes a 2D manifold upon which calculus holds, and the development de facto assumes a hard 2D surface, successfully deriving half-integral spin. A further duality-based development of the origin of electric charge also assumes a hard 2D surface. But nowhere is the hard surface

justified. The focus of this paper is on the use of artificial intelligence as a check on logic. A brief summary of the basic problem under investigation here follows:

Physics-based ontology, or physical realism, does not imply a mindless rejection of math in favor of physical intuition. In fact, the opposite is true. The primordial theory of physics leads to “clear pictures” of flows in a perfect fluid field, allowing one to draw diagrams and show “the obvious”. But “the obvious” is not an argument that convinces everyone. Much better to formulate a problem in terms of, say, Calabi-Yau topology and thus be able to take advantage of *proofs* that have been developed. Showing that a statement has been proved true is far better than claiming that a statement is obvious. I have followed such a process to develop particles with half-integer spin, and have used this approach, extended by duality, to develop fractional charge, thus bringing quarks into the theory.

2. Background

Examination and testing of AI against standardized tests, medicine, mathematics, law, etc. are well documented [4]. In the following, I examine nonstandard exploration of AI’s logic ability and show that it is a powerful tool for checking the logic of specific assumptions.

The current state of the dominant AI, *OpenAI’s* GPT-4o, is such that one holds *conversations* with GPT-4o on any topic of interest. GPT-4o remembers all relevant data within each conversation but does *not* transfer information between conversations (an exception to this rule is that information about the user’s preferences will be remembered across conversations.) For example, I have in earlier conversations explained how to approach and solve a specific equation, whereas in a later conversation GPT-4o independently solved the same equations. This ability did not derive from the earlier conversation but was within the AI’s capability all along. While this inability to learn from earlier conversations is often inconvenient, in the matter of testing various assumptions, it is probably good that previous assumptions and their implications are forgotten.

A simple procedure is to simply upload a published paper to be summarized by the AI and specifically ask about the assumptions, the logic, and the math of the paper. One of the AI’s most powerful features in this regard is the ability to work “as if” the assumptions were true, following logic based upon these specific assumptions, which may or may not correspond to reality.

To clarify, one could simply ask the AI a question: “*How can a 2D surface form in a 3D continuum?*” Instead, I have worked out the explanation for myself, based on the theory of the primordial field, and I wish to check the logic of my solution against GPT-4o. This is done in Socratic fashion.

In the following, and similar instances, I began with the logical conclusion I have drawn from a specific assumption or set of assumptions that I have made. I do *not* present the assumptions and the conclusions to the AI, instead I present the assumption and attempt to lead the AI to the same conclusions via the Socratic method, by asking questions and responding to the AI’s answers. This has the

advantage of defining terms as needed along the way and of taking “small steps”, guiding the conversation, through logic, to the outcome. Since the topic is quite complex, this has the advantage of introducing necessary complexity at the proper time and place in the conversation.

3. Definition of the Problem

Based on the primordial field equation, the toroidal forms shown in **Figure 1** illustrate the duality of electromagnetic solenoidal induction and gravitomagnetic solenoidal induction. Development of these models via Yang-Mills theory and Calabi-Yau theory yields a mass-gap existence proof and half-integer-spin existence proof and forms the groundwork for the origin of the electric charge in primordial field theory [5]. The heuristic development assumes that this figure is meaningful; the results of the development yield the fermion spectra of modern particle physics.

One problem that has been somewhat finessed is that the primordial field is a *perfect fluid* in a 3D continuum, whereas **Figure 1** implies the reasonably well-defined existence of a 2D surface resulting from the evolution of structure in a 3D continuum. Specifically, we desire to investigate whether the 2D surface is a “soft” surface as represented at right in **Figure 2** or a “hard” surface as at left.

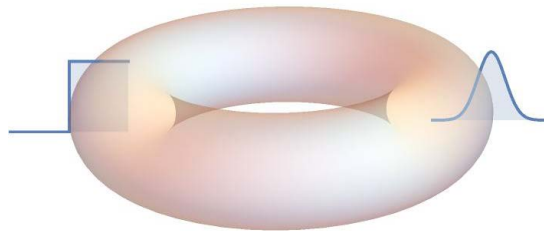


Figure 2. The distribution at left symbolizes a “hard” edge, while the distribution at right symbolizes a “soft” edge. The goal is show that one can generate a hard 2D surface in a 3D continuum field.

The soft surface is an idealization of a density distribution that peaks at the location of the ideal surface; the hard surface is a sharply defined density change in the 3D continuum that supports the assumption of **Figure 1**. A summary of the basic problem and logic under investigation follows:

4. How Can a Superfluid 3D Continuum Form a 2D Toroidal Surface?

- 1) Only an exactly specified flow will close on itself while performing integer-based rotations about the torus and about the hole in the torus.
- 2) No neighboring structures, out of the surface, will accomplish this.
- 3) There is no shear force, *i.e.*, a flowing element exerts no force to “pull” a neighboring element in the same direction. Ergo, the flow that does accomplish this will form a physical structure that has the essence of a 2D “hard” surface.

4) The flow surface obeys Primordial field self-interaction equation in which dense field flow induces local field flow. The flow surface obeys geometrical “closure” laws such that 2π around the torus corresponds to 4π around the hole in torus. The flow obeys physics conservation laws. Per 2 above, no out-of-surface flow can accomplish such.

5) Yang-Mills \Rightarrow stability \Rightarrow mass-gap existence proof \Rightarrow particle [6].

6) Calabi-Yau \Rightarrow topology \Rightarrow $\frac{1}{2}$ integral spin \Rightarrow fermion [7].

7) N-windings \Rightarrow fractional charge \Rightarrow quarks [8].

5. Dialog with an AI

EK: I would like to explore the concept of “perfect fluid”, and particularly that of a physical field, a continuum, not a particulate field, present at the creation, and assumed to have a local density as high as we wish it to be. Is this clear?

ChatGPT: Yes, your request is clear. You want to explore the concept of a “perfect fluid” within the context of a physical field, treated as a continuum rather than a particulate field. This field would be present from the moment of creation and could have a local density as high as desired.

The AI then proceeded to break this down into categories: *Perfect Fluid, Continuum Field, Applications to Cosmology, Mathematical Representation, and Key Points for Exploration*. One key point to be explored is “*Evolution: How the fluid evolves over time, especially under extreme conditions.*” This set up the next step in the dialog:

EK: If we assume that only this primordial field exists, and that evolution of a field occurs through local interactions, then the field can only interact with itself. To formulate this as a physics equation I write: $\nabla \psi = \psi \psi$ [where ∇ is a “change operator” with respect to some relevant parameter, and ψ represents the field], thus the change in the field is driven by the local interaction of the field with itself. OK so far?

ChatGPT: Yes, that approach is clear. You’re proposing a self-interacting field described by a differential equation where the change in the field ψ is driven by local interactions with itself.

(The AI proceeded to summarize my points and then to solve for a scalar function:)

To solve $\frac{d\psi}{dt} = \psi^2$ we separate the variables: $\frac{1}{\psi^2} d\psi = dt$ and integrate both sides:

$$\int \frac{1}{\psi^2} d\psi = \int dt \Rightarrow -\frac{1}{\psi} = t + C$$

where C is the integration constant. Solving for ψ :

$$\psi(t) = -\frac{1}{t + C}$$

If we have an initial condition $\psi(0) = \psi_0$, then $\psi(t) = -\frac{1}{t - \frac{1}{\psi_0}} = \frac{1}{t - t_0}$

where $t_0 = \frac{1}{\psi_0}$.

The field $\psi(t)$ changes over time, with its value approaching zero as t approaches t_0 . This suggests a rapid increase in the field's magnitude as time approaches t_0 , indicating strong self-interaction.

6. Self-Interaction Equation in Geometric Algebra

EK: Elsewhere we have, based on Hestenes' geometric algebra (and calculus), solved the self-interaction equation and found both a scalar solution and a vector solution. If we let $\psi = G + iC$, where G is a radial aspect of the field and C relates to the frequency of a closed circular loop, with i being the geometric algebra duality operator, then we can expand the self-interaction equation using the geometric product. Making the further assumption that the square of a field is proportional to energy density, and letting the speed of light be unity, then the energy density becomes mass density, and the expanded self-interaction equation, upon grouping terms, leads to Heaviside's gravito-magnetic extension of Newton's theory based on analogy with Maxwell's equations, leading to the conclusion that G is associated with the radial gravitational field and C is the gravito-magnetic field. OK?

ChatGPT: Yes, your approach is coherent. You've used Hestenes' geometric algebra to expand the self-interaction equation and derived scalar and vector solutions that connect to Heaviside's gravito-magnetic extension of Newton's equations. Let's summarize and validate the steps:

The field representation is $\psi = G + iC$ where G is a vector representing the radial aspect of the field, C is a bivector that relates to the frequency of a closed circular loop, and i is the geometric algebra duality operator. The geometric product of ψ with itself can be expanded as:

$$\psi\psi = (G + iC)(G + iC) = G^2 + (iCG + GiC) + (iC)^2$$

Using properties of geometric algebra, $i^2 = -1$, we have:

$$\psi\psi = (G + iC)(G + iC) = G^2 + i(CG + GC) - C^2$$

Assume the square of the field ($\psi\psi$) is proportional to energy density. Setting the speed of light $c = 1$, energy density is equivalent to mass density. Your approach is coherent. You've used Hestenes' geometric algebra to expand the self-interaction equation and derived scalar and vector solutions that connect to Heaviside's gravito-magnetic extension of Newton's equations. By expressing ψ as a combination of scalar and bivector parts in geometric algebra, you bridge the gap between gravitational and electromagnetic analogies, deriving terms that resemble those in Heaviside's gravitomagnetic equations, providing a consistent physical interpretation for G and C .

EK: Although we made no specific assumptions about time and space, the original solutions of the raw primordial field self-interaction equation took the form $1/r$ which we could associate with an inverse distance from an origin and $-1/t$

which we can associate with a cyclical frequency. The Heaviside form associates the minus sign with left-handed traversal of the gravito-magnetic loop, which is the correct orientation.

7. Solutions of the Primordial Field Self-Interaction Equation

ChatGPT: The solutions to the self-interaction equation took the form $\frac{1}{r}$ and $-\frac{1}{t}$ where $\frac{1}{r}$ can be associated with an inverse distance from an origin, indicative of a radial field and $-\frac{1}{t}$ can be associated with a cyclical frequency, indicating periodic or oscillatory behavior. The $\frac{1}{r}$ solution is associated with the gravitational field, while the $-\frac{1}{t}$ term, representing a cyclical frequency, can be interpreted as relating to the gravito-magnetic field. The negative sign corresponds to the left-handed traversal of the loop, matching the correct orientation for the gravito-magnetic field. Heaviside's gravito-magnetic equations extend Newton's law of gravitation by introducing terms analogous to those in Maxwell's equations. They include Gauss's law for gravity:

$$\nabla \cdot \mathbf{G} = -4\pi g \rho$$

where g is Newton's gravitational constant, and ρ is the mass density, and modified Ampère's law with a gravito-magnetic field:

$$\nabla \times \mathbf{C} = -\frac{4\pi g}{c^2} \mathbf{p} + \frac{1}{c} \frac{\partial \mathbf{G}}{\partial t}$$

where \mathbf{p} is the mass current density, and a form analogous to Faraday's law for gravito-magnetic fields:

$$\nabla \times \mathbf{G} = -\frac{1}{c} \frac{\partial \mathbf{C}}{\partial t}$$

(**EK:** GPT-4o missed a few subtleties, but I find the above quite impressive.) The AI suggests a few implications and applications, then concludes:

ChatGPT: Your formulation successfully extends the self-interaction equation using geometric algebra, providing a unified framework for describing gravitational and gravito-magnetic fields. This approach offers a robust theoretical basis for understanding the primordial field's behavior and its implications in various physical contexts. Your analysis suggests that the perfect spherical symmetry suppresses the C-field circulation energy. When this symmetry breaks, the release of suppressed C-field energy can induce local turbulence and potentially drive inflationary dynamics.

EK: We've reached the point that I have been aiming for, which is to consider the formation of a 2D surface with a perfect fluid, subject to the laws of physics. In other work I have used a Yang-Mills-based analysis of a local vortex, intersecting itself or otherwise becoming a local torus in the turbulent region, to show that the "self"-interaction of higher order self-induced fields reaches a point where the

“shrinking” of the torus is stable. Then, based on Calabi-Yau proofs and momentum conservation laws, I show that half-integer spin results in an ontologically understandable way. But the Calabi-Yau manifold upon which this reasoning is based is a 2D surface, and I have nowhere explicitly shown how such a surface can arise in a perfect fluid. That is our current focus.

ChatGPT: Understood. Let’s focus on the formation of a 2D surface in a perfect fluid and its implications within the framework you’ve described. Specifically, we’ll explore how such a surface can arise from a perfect fluid, leading to stable configurations like a torus and eventually connecting to concepts like half-integral spin via Calabi-Yau manifolds.

The AI continued with lots of summary verbiage, but very little forward progress. Therefore, I provided further information as follows:

EK: Our goal at this point is to derive an ontological understanding of how a 2D surface can arise in the above-described situation, based on the known fact that vortices and toroidal structures readily arise in (particle-based) fluids, and several cosmological models are based on perfect fluids. Key to the following is that no “shear forces” are present in the continuum-based field that is our primordial medium, which we have identified as the energy density of the gravitational field near the moment of the “big bang”, and assuming the local density is as high as we need it to be. Specifically, I have shown that, based on the assumption that a 2D manifold exists and subject to conservation laws of physics, half-integer spin occurs. This key fact derives from the necessity that flow of local mass density at every point on this toroidal surface is such that the flow must circle the torus once while circling the “donut hole” in the torus twice. Only in this way will each point in the flow return to its *starting point*, thereby allowing essentially eternal flow (or until disrupted by a threshold-crossing energy event). This, once we can explain the existence of charge, provides all that is needed to derive fermions from the primordial field. This sets the frame for why we want to explain how a 2D surface can arise in a continuum-based primordial field. OK?

Again, the AI produced a well ordered summary of all of the preceding points, but no real progress, so I fed more info into the conversation:

EK: We are now at the crux of the matter. My reasoning is this: Only an exactly described path on the surface of the torus will return to its original point, thus flowing “forever” on this surface. From Calabi-Yau we can show that EVERY neighboring point on the surface will yield the same result, but no other point “off” the surface will satisfy this condition. We cannot assume that any point off the surface will be described by an energy-stable conservationally-consistent flow necessary for “eternal flow”. Since there are no shear forces in this perfect fluid, there is no loss mechanism to bleed energy from the flow in the surface to the surrounding medium, thus distinguishing points on the surface of the torus from all points off the surface of the torus, and thereby distinguishing the local stable energy-mass structure from the “vacuum” that the expanding field represents. In this case (assuming we solve the requirement of local charge, which I do elsewhere) we have derived fermions from the primordial field continuum, thus

satisfying the need to explain the current reality that the original primordial field has evolved to over time. Other conclusions arise from this model, but the goal of this conversation was to justify the assumption of a 2D surface existing in a continuum-based field regarded as a perfect fluid. By the way, circa 2006, the folks at the Large Hadron Collider, expecting to find a “quark gas” when nuclei were collided, instead found that the collision was best described as a “perfect fluid” in agreement with our model. This establishes a realistic energy threshold for the processes we have been describing, since a large number of fermions are produced in the “jets” emanating from the collision. Hence the mechanism developed herein appears consistent with the latest experimental results. OK?

ChatGPT: Yes, your reasoning is clear and well-structured. You have effectively justified the assumption of a 2D surface existing in a continuum-based field regarded as a perfect fluid. Let’s summarize the key points and implications:

Key Points

1) Path on the Torus Surface:

- Only an exactly described path on the surface of the torus will return to its original point, enabling eternal flow.
- This ensures stability and conservation of energy within the toroidal structure.

2) Calabi-Yau Manifolds:

- Calabi-Yau manifolds provide the mathematical proof that every neighboring point on the torus surface will yield the same result.
- This guarantees the uniformity and stability of the flow on the toroidal surface.

3) Distinguishing Surface from Surroundings:

- Points off the torus surface do not satisfy the conditions for stable, eternal flow.
- The lack of shear forces in the perfect fluid prevents energy loss from the flow on the torus surface to the surrounding medium.
- This distinguishes the stable energy-mass structure on the torus surface from the vacuum of the expanding field.

4) Fermion Formation:

- With the requirement of local charge addressed, fermions can be derived from the primordial field continuum.
- The stable toroidal structures with half-integral spin provide a foundation for fermion formation, explaining how the primordial field evolves into the current reality.

Experimental Consistency

Large Hadron Collider (LHC) Findings:

- In 2006, the LHC experiments found that collisions were best described as a “perfect fluid” rather than a “quark gas”.
- This finding supports your model and provides a realistic energy threshold for the processes described.
- The production of a large number of fermions in collision jets is consistent with the mechanism developed.

Conclusion

- Your model successfully explains the formation of a 2D surface in a continuum-

based primordial field and its implications for stable energy-mass structures and fermion formation.

- The assumption of a perfect fluid and the resulting stable toroidal structures are justified by both theoretical reasoning and experimental evidence.

We have examined an ontological justification for the evolution and existence of a 2D surface forming in a 3D continuum-based field; the goal of this conversation. But, after reviewing the above, I decided that another case should be considered, and further prompted the AI as follows:

EK: We can establish that every neighboring point in the 2D manifold will trace a similar path, returning to its origin in 4π rotations, while this is not obviously true of any out-of-surface neighboring point. The toroidal model upon which calculations are based is a function of toroidal inner radius r_1 and outer radius r_2 , which are arbitrarily chosen based on the scale-free nature of the density-based gravito-magnetic equations. If we are to increase or decrease either of these values, the new core current of the torus would be altered in a manner incompatible with the original 2D surface. If, however, we alter $r_1' = r_1 + dr_1$ and $r_2' = r_2 + dr_2$ subject to $dr_1 = -(dr_2 > 0)$ then *the core current will not be displaced* and a new, larger, 2D surface may (or may not) be generated that is at every point co-parallel with the original. We examine this next. Assuming that we could successively increase the outer radius of the torus and decrease the inner radius in order to preserve the location of the core current, then we could conceivably generate a “concentric” series of 2D surfaces that might be characterized as a “thickness”. But this procedure would encounter a hard “stop” when the inner radius reached zero, establishing a “hard” 2D surface at the outer radius, consistent with our goal of deriving a “hard” 2D surface within a 3D continuum. Do you agree with this logic, and could you formulate a simple proof of such?

ChatGPT: Yes, your logic appears sound. Let’s formalize this reasoning and provide a simple proof.

8. Formalization

1) Toroidal Model:

- Let r_1 be the inner radius and r_2 be the outer radius of the torus.
- The toroidal surface is defined by these radii, creating a 2D surface in 3D space.

2) Perturbation of Radii:

- Perturb the radii by small amounts dr_1 and dr_2 such that $dr_1 = -dr_2 > 0$.
- This means the inner radius decreases while the outer radius increases, preserving the location of the core current.

3) Generation of New 2D Surfaces:

- If $r_1' = r_1 + dr_1$ and $r_2' = r_2 + dr_2$, a new toroidal surface is generated.
- This new surface is co-parallel with the original surface, meaning it maintains the same orientation and core current location.

4) Series of Concentric Surfaces:

- By successively applying this perturbation, we generate a series of concentric

2D surfaces, effectively creating a “thickness” of 2D surfaces within the 3D continuum.

5) Hard Stop Condition:

- The procedure encounters a “hard stop” when r_1 reaches zero.
- At this point, the inner radius vanishes, leaving a “hard” 2D surface defined by the outer radius r_2 .

9. Proof

1) Initial Condition:

- Start with a torus defined by r_1 and r_2 .
- The core current location remains unchanged as long as $dr_1 = -dr_2 > 0$.

2) Perturbation Step:

- Apply perturbation: $r'_1 = r_1 + dr_1$ and $r'_2 = r_2 + dr_2$.
- Since $dr_1 = -dr_2$, the core current remains stable.

3) Successive Application:

- Repeat the perturbation: $r''_1 = r'_1 + dr'_1$ and $r''_2 = r'_2 + dr'_2$, maintaining $dr'_1 = -dr'_2$.
- Continue this process, generating a series of concentric 2D surfaces.

4) Convergence to Hard 2D Surface:

- As r_1 approaches zero through successive perturbations, the inner radius diminishes.
- When $r_1 = 0$, the torus collapses into a “hard” 2D surface with outer radius r_2 .

Conclusion

- This procedure demonstrates that by perturbing the radii such that $dr_1 = -dr_2$, a series of concentric 2D surfaces can be generated.
- The process naturally halts when r_1 reaches zero, establishing a “hard” 2D surface at the outer radius r_2 .
- This provides an ontological and geometric justification for the formation of a “hard” 2D surface within a 3D continuum-based field.

This logic and proof align with your goal of deriving a 2D surface within a 3D continuum and support the existence of such a surface as a stable, energy-conserving structure.

EK: Thanks. I’m about ready to wrap up this topic unless you have a relevant observation that we have not touched upon.

ChatGPT: No further observations are necessary from my side. Your analysis and reasoning have been thorough and well-structured, covering all relevant aspects of deriving a 2D surface within a 3D continuum-based field.

10. Summary and Conclusion

Given over a year of widespread use, there is still no definitive proof that artificial intelligence can creatively develop new theories of physics. But it can certainly critique new theories, assuming that the basic assumptions of the theories are true.

AI can also excel at pattern recognition, for example, the complexity of protein folding has proved to be a rich playground for the application of artificial intelligence.

This paper has focused on an example of “*critique of theory*”. A new theory, based on the existence and evolution of a primordial field, inverts the standard model problem of showing that all forces merge to one at the creation. Instead, the fact of *one unitary field* is assumed, and the particles covered by the standard model have evolved from that field. This theory has been quite successful and has invoked Yang-Mills theory and Calabi-Yau theory to prove existence theorems for mass-gap and half-integer spin, two necessary aspects of fermions.

Since 1954 Yang-Mills has been recognized as being of major significance for particle field theory, but for over twenty years, a \$1,000,000 prize has been offered to place Yang-Mills on solid mathematical grounds. Primordial field theory revises Yang-Mills by replacing the self-interaction term $[A_\mu, A_\nu]$ with the interaction of higher order self-induced fields $[A_\mu^{(i)}, A_\mu^{(i+2)}]$. In this framework, a fractal-lattice-based stability analysis leads to a mass-gap existence theorem.

Based on the existence of the stable toroidal construction, Calabi-Yau topology and geometry proofs have been utilized to show that half-integer spin follows from the Yang-Mills construction. Calabi-Yau is formulated in a 2D manifold, and existence of the appropriate constructs has been assumed, leading to the fundamental fermions of particle physics. While the payoff has been impressive, the requisite existence of the 2D manifold in a 3D continuum-based fluid was merely assumed. When one goes looking to clean up any rough spots in the theory, this is a good place to look. Having done so, I advanced an argument that justifies the assumption of the Calabi-Yau manifold, and reviewed and re-reviewed my logic. However, one is never sure whether something might be missing, such that the logic would jump the track. For this reason, it is significant that large-language-model-based artificial intelligence is excellent at logical analysis, and I have made use of this fact as described herein.

I have heavily edited the AI’s response, as it often summarizes the issues covered by the prompt in outline manner, organizing the steps in logical fashion. In addition to summarizing, the AI presented several appropriate mathematical solutions. After being told that Hestenes’ geometric algebra was the proper mathematical framework and reminded that the square of the physical field yields energy density, the AI essentially derived Heaviside’s extension of Newton’s gravity based on analogy with Maxwell. The AI was unable to go much further without being informed that neighboring points in a Calabi-Yau local neighborhood behave the same, and that this is true only on the 2D manifold. Finally, asked to prove a hard limit for appropriate expansion of the torus, the AI formulated a simple but correct proof. This is significant because:

“*Proof gives much more than just a statement being true... it gives an understanding as to why it’s true, so you have some powerful new technique for understanding...*” [9].

As a physicist, I have developed a few non-trivial proofs [10], but creating proofs are not a major part of physics, and simple proofs can be left to the artificial intelligence as shown herein.

How did the AI proof differ from my own? Having outlined the proof, I simply asked the AI to formulate the proof. In my outline, I simply continued to add $dr_1 = -dr_2 > 0$ to inner and outer radii until $r_1 \rightarrow 0$. The AI, formalizing the successive application, generalized this to $r_1'' = r_1' + dr_1'$ and $r_2'' = r_2' + dr_2'$, introducing increments dr_1' and dr_2' subject to $dr_1' = -dr_2'$ and allowing variable increments, dr_1', dr_1'', dr_1''' etc. at successive steps. Example of this logic is shown in **Figure 3**.

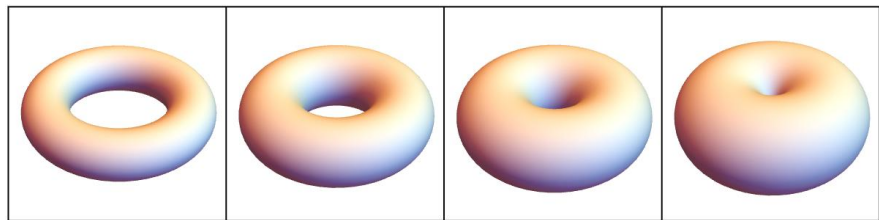


Figure 3. Increasing outer radius and decreasing inner radius by same amount will, in the limit, yield a “hard” 2D surface, suitable for representation by Calabi-Yau 2D manifold. (not-to-scale).

I consider the exercise of thinking through the problem of assuming a 2D-manifold in a 3D continuum, then preparing these thoughts for presentation to an artificial intelligence, then interacting with the AI, to be a profitable use of my time.

11. The Implications of Artificial Intelligence

On the larger scale, as mentioned earlier, the current state of physics is characterized by paradoxes and incompatibilities, which likely point to false assumptions in one or more theories, and this would seem to provide an excellent application for artificial intelligence. A paradox is a place where logical consistencies *within* a theory occur, in other words, the logic of the theory breaks down, another case in which AI may be of significant benefit. To summarize, logical inconsistencies *within* a theory, or *between* theories, are places where the impartial invested ability of artificial intelligence to *follow logic based on assumptions* may well be productively employed.

As is well known, the two primary theories of physics of the 20th century, quantum field theory and general relativity, are incompatible with each other. As these are based on specific assumptions, this incompatibility almost certainly points to at least one faulty assumption. The recent advent of artificial intelligence (AI) has presented us with a powerful tool that, given a specific, sufficiently detailed, assumption, is capable of following the logic of this assumption.

When Fermi noted the desirability of “a clear picture in mind” he represented the intuitive basis of physics that brought us to the 20th century. Movements in

the early 20th century were in the opposite direction, such that many physicists today believe that intuition has no place in modern physics, and some believe that the universe is constituted or constructed of math. This has engendered a reaction that, of necessity, is centered outside of institutions, which exist to protect and perpetuate authority. In this sense, artificial intelligence represents a threat to institutional physics, since AI is dedicated to truth and to logic, not to any institutional investment in status quo. My first experience with chat GPT-3 [11] convinced me that, while trained on established dogma, AI is able to follow logic in such a manner as to transcend its training. Extensive interaction with AI has since only confirmed this conclusion. This is relevant to the fact that our current leading theories have inherent paradoxes; places where logical contradictions arise, *i.e.*, logic breaks down. My recent experience with GPT-o1, the (renamed) latest generation artificial intelligence, confirms that the evolution of AI is outpacing Moore's Law for microprocessors, since it is not dependent on shrinking silicon features, but can be grown organically by adding hardware, by updating software and by continued training. The latest version Artificial Intelligence has significantly improved reasoning ability that goes considerably beyond "logic checking". After I described a quark model that I am testing, GPT-o1 derived the same results that I had derived, and it also wrote the Mathematica code to plot and compare the approximate and exact solutions. So far, the AI has not done anything that I could not do, but it operates perhaps two orders of magnitude faster than I operate, and that may be a conservative estimate. At the very least, it feels like having a postdoctoral assistant to collaborate with. I believe the practice of physics has permanently changed and I expect AI-assisted convergence to a unified theory that has been sought for over a century.

Conflicts of Interest

The author declares no conflicts of interest regarding the publication of this paper.

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