Great Britain Journals Press

RESEARCH FINGERPRINT

IDENTIFIER
LJRS-228908

PEER REVIEW
Double Blind

SIMILARITY CHECK
Perplexity AI and iThenticate

ACCESS
Open Access

LANGUAGE
English

PRINT ISSN
2631-8490

ONLINE ISSN
2631-8504

EDITION

ABBREVIATION
LJRS

VOLUME
26

ISSUE
0

YEAR
2026

KEY DATES

RECEIVED
2026-06-22

ACCEPTED
2026-07-08

ONLINE PUBLISHED
2026-07-23

CATALOGING

CROSSMARK DOI
10.34257/LJRS228908UK

Online First

Communication: Unified Field or Unified Potential?

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ABSTRACT

It was initiated by Albert Einstein to unify the fields of gravity, electromagnetism, weak nuclear force and strong nuclear force with a Unified Field Theory (UFT). Many theoretical physicists spent time on this topic, but difficulties remain. The author proposed an alternative—the Unified Potential Theory (UPT), focusing on the molar total potential which is closely related to the Atomistic 2nd Law of Thermodynamics. The author's proposal is based on: (a) potentials are simply scalars that can be added up arithmetically in unification, and (b) UPT has many applications through its connection with the Atomistic 2nd Law of Thermodynamics. The other advantages of UPT over UFT are: (a) potential is more fundamental than field, (b) UPT is able to include chemical potentials, and (c) UPT is able to consider the influence of kinetics. The opinions of three artificial intelligences (AIs) on UFT and UPT are taken as references. The limitations of UPT are also addressed in detail. The discussed topics are: Can UFT or UPT be applied to gases and condensed phases? Does UPT have the characteristic of duality?

Index Terms: unified field • unified potential • atomistic features • Atomistic 2nd Law • ChatGPT • Pretty Prompt • DeepSeek • duality

FUNDING
No external funding was declared for this work.

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

AI USAGE
No generative AI was used for analysis or results.

HOW TO CITE
Liu (2026). Communication: Unified Field or Unified Potential?. London Journal of Research in Science: Natural and Formal, Online First, 1-15. DOI: 10.34257/LJRS228908UK

ACCESS ONLINE

METADATA CONTINUATION

AUTHOR CONTACT QR LEDGER

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ARCHIVAL RECORD

LJRS · Vol 26 · 2026

Article ID LJRS-228908 · DOI 10.34257/LJRS228908UK

Print ISSN 2631-8490 · Online ISSN 2631-8504

CROSSREF DOI 10.34257/LJRS228908UK

RESEARCH ARTICLE

Communication: Unified Field or Unified Potential?

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Abstract

It was initiated by Albert Einstein to unify the fields of gravity, electromagnetism, weak nuclear force and strong nuclear force with a Unified Field Theory (UFT). Many theoretical physicists spent time on this topic, but difficulties remain. The author proposed an alternative—the Unified Potential Theory (UPT), focusing on the molar total potential which is closely related to the Atomistic 2nd Law of Thermodynamics. The author's proposal is based on: (a) potentials are simply scalars that can be added up arithmetically in unification, and (b) UPT has many applications through its connection with the Atomistic 2nd Law of Thermodynamics. The other advantages of UPT over UFT are: (a) potential is more fundamental than field, (b) UPT is able to include chemical potentials, and (c) UPT is able to consider the influence of kinetics. The opinions of three artificial intelligences (AIs) on UFT and UPT are taken as references. The limitations of UPT are also addressed in detail. The discussed topics are: Can UFT or UPT be applied to gases and condensed phases? Does UPT have the characteristic of duality?

Keywords: *unified field, unified potential, atomistic features, Atomistic 2nd Law, ChatGPT, Pretty Prompt, DeepSeek, duality*

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1 Preface

After having become famous for several brilliant breakthroughs in physics—including Brownian motion, photoelectric effect, and special and general relativity, Albert Einstein spent the last thirty years of his life on pursuing the Unified Field Theory (UFT). UFT is aiming to describe all fundamental forces—gravity, electromagnetism, strong nuclear force, and weak nuclear force—within a single, coherent mathematical structure.

Einstein said the following in his Nobel lecture in 1923: "The intellect seeking after an integrated theory cannot rest content with the assumption that there exist two distinct fields totally independent of each other by their nature". From other reports we also know the seeking of simplicity is among the characteristics of Einstein[1].

In the 1920s, when Einstein began his work on UFT [2], electromagnetism and gravity were the only known forces, and electron and proton were the only known subatomic particles. Furthermore, the atomistic view of 2nd law of thermodynamics is not yet popular at that time (not popular even now).

The key aspects of the UFT include [3-5]:

(1) Historically, the first successful unification of fields was James Clerk Maxwell's integration of electricity and magnetism in the 1800s.

(2) But the core challenges of UFT remain, which include: The theory requires reconciling quantum mechanics (microscopic) with gravity (macroscopic), is in need of justifying experiments.

(3) Contemporary researches often use String Theory, Loop Quantum Gravity, or Post-quantum Gravity, etc. to tackle the related problems.

Through the published papers ([6]-[8]), the author realises: the driving force for the spontaneous evolution in a system is "lowering its molar total potential", and that the molar total potential is very important. Because of this, the author tries to replace "field" in UFT by "potential". Other reasons include:

(1) It seems that UFT have had difficulties. Different thinking might be helpful in the advancement of UT,

(2) The author hopes that not only can Unified Theory (UT) have a proper development but also can UT be better applied to the sensible world and be verified properly, whether this world is extremely small or extremely large.

[1] "I have deep faith that the principle of the universe will be beautiful and simple"—Albert Einstein [1]

2 The characteristics and scope of Unified Potential

The characteristics of "Unified Potential Theory" (UPT) and its major differences from UFT are listed in Table 1:

Table 1. Characteristics of UPT and its major differences from UFT

	UPT	UFT
Characteristics	(a) The driving force for the spontaneous evolution in a system is the lowering of molar total potential. (b) A potential is more fundamental than its field. (c) "Molar total potential" can be regarded as molar unified potential, therefore the Atomistic 2nd Law of Thermodynamics and related rules can be applied to UPT. (d) UPT has many applications through the Atomistic 2nd Law of Thermodynamics.	(a) The driving force for the spontaneous evolution in a system is "the combination of forces", i.e. the sum of every field multiplied by the related identity (e.g. electric field multiplied by electric charge). (b) UFT intends to unify gravity, electromagnetism, strong nuclear force, and weak nuclear force, but is not yet successful.
Are chemical potentials included?	Yes, chemical potential is a very important potential of a substance, and it will be included in unified potential.	No
Correlation with kinetics	"Lowering of molar unified potential energy" and the resulting driving forces cannot be realised if there are kinetic constrains.	No description
Difficulty in unification	"Molar unified potential" is the arithmetical sum of various molar potentials. Hence, there is no difficulty in unifying potentials.[2]	(a) It's necessary to consider the "directions of fields" in UFT. (b) Still have difficulties.

As stated in reference [6], the molar total potential of a substance includes:

(1) Molar chemical potential: For condensed phases, molar chemical potential originates from the inter-molecular force per mole of the same substance. For a gas phase, the molar chemical potential originates from the concentration of the same substance.

(2) Other molar potentials: originated from the interactions between one mole of substance and the environment, e.g. molar gravitational potential, molar electric potential, molar magnetic potential, etc.

Molar electric potential and molar magnetic potential are two kinds of other molar potentials stated above. In molar unified potential, the addition and the transforming between these two potentials can be easily done and should not be a problem.

The advantages of UPT over UFT are evident in Table 1. These advantages can be highlighted and further explained in the following:

(1) A potential is more fundamental than its field: Because a field is derived from its related potential.

(2) Chemical potential will be included in UPT: Chemical potential is an important potential of a substance and it can be easily included in UPT. But chemical potential is not mentioned at all in UFT.

(3) The influence of kinetics will be considered in UPT: Through the connection between the molar unified potential and the Atomistic 2nd Law of Thermodynamics, it's not difficult to consider the influence of kinetics. But the author fails to see the influence of kinetics in UFT.

(4) It's simpler to unify molar potentials in UPT: All the molar potentials can be added up arithmetically without considering their directions. Conversely, it's improper not to consider the directions of molar fields in UFT (because molar fields are vectors). This is a reason why UPT complies better with the simplicity that Einstein was always pursuing.

(5) Molar unified potential has many applications: Through the Atomistic 2nd Law of Thermodynamics, the molar unified potential (similar to the molar total potential) has many applications in the real word, such as dissolution, chemical reactions, phase transitions, etc.

Moreover, when nuclear reactions occur, the released kinetic energies are proportional to the reduced total mass in the nucleus. Hence it could be expected that the released kinetic energies are the potential energies stored as the mass in nucleus.

3 Summaries of AIs' opinions

In order to have a better understanding of UFT and UPT, the author asked the opinions of three artificial intelligences as references, namely ChatGPT, Pretty Prompt and DeepSeek. Their comparisons on UFT and UPT may not be very reliable, but their opinions reflect the perceptions of the current scientific world to a certain extent. The opinions of AIs are summarised as follows:

[2]For example, in a spontaneous capillary, the molar unified potential of the liquid is the sum of its molar chemical potential and its molar gravitational potential ([6]).

3.1 ChatGPT

ChatGPT's main opinions include the following:

(1) There is a subtle but important distinction between UFT and UPT, and it touches the heart of theoretical physics. In UFT, the emphasis is on the field itself, while in UPT the emphasis is on the mathematical generator of field.

(2) In theory, a "unified potential energy" could be a single function whose derivatives produce all known forces. For example, electric and gravitational forces can be derived from potential energies.

(3) UFT is mostly used in general relativity, gauge theories, and attempts to unify gravity with quantum forces. UPT is less commonly used but conceptually, a field comes from a potential energy in physics. Hence, these two are closely related.

Table 2 is the main comparison between UFT and UPT made by **ChatGPT**:

Table 2. ChatGPT's opinions on the major differences between UFT and UPT

Aspect	UFT	UPT
Primary Object	Field (physical entity in space-time)	Potential (mathematical function)
Emphasis	Geometry and dynamics of space & forces	Scalar function giving rise to forces
Typical Use	General Relativity, Gauge Theory	Electrodynamics, Classical Mechanics extensions
Perspective	Physical ontology	Mathematical/functional approach

3.2 Pretty Prompt

Pretty Prompt (an AI-powered tool) also has some opinions on the comparison between UFT and UPT. But these opinions are in Chinese. The main points can be translated as follows:

(1) In physics or engineering, UFT and UPT are totally different ideas: UFT is an incomplete ultimate dream of the physics world, while UPT is a practical tool used daily in the calculations of problems in chemistry, materials and engineering.

(2) One of the aims of UFT is to look for the origin of the universe (i.e. gravity, electromagnetism, strong nuclear force, and weak nuclear force). It is not appropriate using UFT in normal research and it is more suitable to high energy areas. In contrast, one of the aims in UPT is to simplify the problems in the real world.

Table 3 is the main comparison between UFT and UPT made by Pretty Prompt:

Table 3. Pretty Prompt's opinion on the major differences between UFT and UPT

Characteristics	UFT	UPT
Scientific fields	High energy physics, theoretical physics, cosmology	Condensed physics, calculating chemistry, materials science
Key target	Unify the four forces in universe	Unify the various interactions among atomic/molecular species
Uses in condensed phases/gases	Very low (scale too small for calculation)	Very high (core tool for materials and fluids)

3.3 DeepSeek

DeepSeek's main opinions include the following:

(1) The correct historical and technical term is "UFT." Still, the suggestion of "UPF is remarkably insightful and touches on a deep and elegant concept that appears within many attempts at UFT.

(2) For conceptual depth and mathematical elegance, the term of UPF is arguably more precise. The search for a Unified Field is largely the search for a Unified Potential.

(3) In physics, a "potential" is often a more fundamental or mathematically convenient object than a "field" itself. Example: The electromagnetic field is derived from a more fundamental vector potential (ChatGPT has a similar opinion). Gravity, in General Relativity, is derived from the metric tensor potential.

Table 4 is the main comparison between UFT and UPT made by **DeepSeek**:

Table 4. DeepSeek's opinion on the major differences between UFT and UPT

Concept	UFT	UPT
Status	The established, conventional name for the research program.	A brilliant and insightful description of many UFTs' work.
Focus	The fundamental entity of reality (the field).	The fundamental and mathematical object that generates the fields.
Connection to Real Physics	The goal of Einstein, the Standard Model, and String Theory.	The central concept in Gauge Theories.

4 Limitations of Unified Potential Theory (UPT)

Since the molar unified potential can be considered as the molar total potential in a system, UPT can have many applications through the Atomistic 2nd Law of Thermodynamics. But UPT cannot be properly applied to the following conditions:

(1) When kinetic constraints are important: The driving force of a spontaneous evolution is due to the lowering of molar total potential. The prerequisite to realising a driving force is that there are no kinetic constrains. Hence when kinetic constraints are important, it's not possible to realise the driving force of a spontaneous evolution. For example, the molar total chemical potential of crystalline oxides is lower than their glass at room pressure and temperature. However after fast cooling, a glass will be formed instead of a crystal structure because there are kinetic constraints to prevent molecules from moving to their crystalline positions.

(2) When extra driving forces cannot be ignored: In this condition, the combination of the extra driving forces and the spontaneous driving forces is necessary. Examples of extra driving forces include mechanical stirring force, differential ΔP in reverse osmosis or blood pressure ΔP in blood transportation (as the author stated in [8]).

(3) When heat transfer is not negligible: Heat is transferred via radiation, convection and conduction due to temperature difference ΔT. The driving force of heat transfer is not molar total potential. Moreover, heat is a type of kinetic energy in nature and is without constraints (unlike substances). Hence the author believes heat is prior to potentials, and UPT cannot be applied to a condition where heat transfer is not negligible.

(4) When quantum mechanical behavior is pronounced: Quantum mechanical behaviour is likely not driven by the lowering of molar total potential. Therefore, it is not proper to apply UPT when quantum mechanical behavior is pronounced.

5 Discussion

5.1 Can Unified Theory be applied to gases or condensed phases?

The author believes that: the UPT concept can be combined with the Atomistic 2nd Law of Thermodynamics and conveniently applied to a great deal of practical examples, including many spontaneous evolutions in gases and condensed phases, as reported in Section 2(5) of this article.

In order to be more certain about the convenience of UFT when it's applied to gases or condensed phases, the author asked AIs on this question. Their replies are as follows:

ChatGPT: Usually not conveniently. UFT is generally far too microscopic and mathematically complex to be a practical tool for describing condensed phases or ordinary fluids directly.

Pretty Prompt: Its reply can be translated as "No, UFT cannot be applied conveniently to the real world."

DeepSeek: Not in any practically useful sense. One of the reasons is that the scales are completely wrong—UFT is for high energies (10^{19} GeV) and tiny distances (10^{-35} meters), at the same time gases & condensed phases are with energies of ~ 0.025 eV (room temperature) and distances of $\sim 10^{-10}$ meters (atomic spacing). Not to mention that humans already have highly convenient and accurate frameworks for gases and condensed phases.

5.2 Does UPT have the characteristic of duality?

Wave–particle duality is a phenomenon observed in physics. Many famous physicists have verified the wave–particle duality for elementary particles, electrons, etc. The notable verifications of wave–particle duality include double-slit experiment, electron diffraction, etc.

Louis de Broglie proposed a simple formula as $\lambda_D = h/p$ for the wave–like phenomenon of particles, where λ_D is the de Broglie wavelength, h is Planck's constant, and p is the momentum of the particle. For macroscopic particles, wave properties usually cannot be detected because of their extremely short wavelengths [9]. In other words, wave–particle duality has a very pronounced size effect.

If we apply the concept of size effect to UT, it is not hard to accept that "things with very different sizes may have different UT". It can be seen ([6]-[8]) that "the molar total potential is the lowest" can be well applied to many spontaneous evolutions in systems of atomistic features. Hence, it is logical to expect that UPT applies to particles no smaller than atomistic size (where wave-like characteristics are not pronounced). But there is no evidence that the UPT concept applies to the world of extremely small size.

6 Conclusions

(1) UFT is a theory intending to unify gravity, electromagnetism, weak nuclear force and strong nuclear force. Albert Einstein spent his last 30 years on UFT but in vain. Afterwards, UFT has been the subject of efforts for many theoretical physicists. Despite all these, not much has been achieved in UFT for the last few decades.

(2) Since UFT cannot cover the gravitational field and is unable to be applied to gases and condensed phases, the author came up with an alternative—UPT which focuses on the unified potential, hoping for a simpler solution and better applications. The unified potential in UPT can be regarded as the total potential in the Atomistic 2nd Law of thermodynamics, and therefore can be applied to many spontaneous evolutions.

(3) The advantages of UPT over UFT include: (a) Potentials are more fundamental than the corresponding fields, (b) Chemical potentials will be included in UPT, (c) The influence of kinetics will be considered in UPT, and (d) Direction is irrelevant and potentials can be unified easily. In other words, UPT is simpler and more applicable. The opinions of AIs on UFT and UPT are listed in Section 3 for reference.

(4) The limitations of UPT are: (a) When kinetic constraints are important; (b) When extra driving forces cannot be ignored; (c) When heat transfer is not negligible, and (d) When quantum mechanical behavior is pronounced.

(5) Unlike UFT, UPT can be conveniently applied to many phenomena in gases and condensed phases through the Atomistic 2nd Law of thermodynamics. However, it's possible that UPT does not apply to the world where substances are much smaller than atomistic features. In this world, "what is the UT" or "whether UT exists" are questions needing experimental verification.

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