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Short Communication of Big Plithogenic Science and Deep Plithogenic Science

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Abstract

Big Science refers to large-scale, well-funded collaborative research designed to refine established theories and produce significant experimental or observational data. In contrast, Deep Science emphasizes reexamining fundamental principles, exploring alternative frameworks, and proposing transformative theories to tackle core scientific challenges. The relationship between Big Science and Deep Science has been explored in earlier studies [49]. This paper provides a systematic re-evaluation of these concepts and investigates their extensions using the framework of plithogenic sets[46]—a mathematical concept, like Fuzzy Sets[54] and Neutrosophic Sets[44], designed to address uncertainty.

Keywords: Fuzzy set, Neutrosophic set, Big Science, Deep Science, Plithogenic set

1 | Big Science and Deep Science

First, we provide an explanation of Big Science and Deep Science. Big Science refers to large-scale, well-funded collaborative research aimed at refining established theories and generating substantial experimental or observational data [38, 7, 49]. The systematic definition of Big Science is presented below.

Definition 1 (Big Science)**.** [49] A *Big Science* initiative is a scientific research enterprise distinguished by:

(1) *Enormous Scale and Funding.* These projects typically demand significant capital investment, ranging from multi-million to multi-billion dollars, to finance large facilities, specialized instrumentation, or high-throughput data pipelines.

(2) *Centralized Coordination and Management.* Complex organizational frameworks coordinate hundreds or even thousands of scientists, technicians, and administrators who participate under robust institutional or governmental oversight.

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(3) *Incremental Investigations of Mainstream Theories.* Big Science frequently aims to refine, confirm, or slightly extend widely accepted models (e.g. the Standard Model of particle physics), seeking precision tests or new parameter measurements.

(4) *High-Volume Output (Publish or Perish).* Researchers in these frameworks are commonly encouraged or required to produce a substantial number of conference papers, journal articles, or experimental technical reports.

Formally, we can represent a Big Science project as

$$\mathcal{B} = \Big(\text{Funding},\ \text{Large\_Collab},\ \text{Central\_Administration},\ \text{Mainstream\_Theories},\ \text{Data\_Output}\Big).$$

Example 2 (Particle Accelerators for High-Energy Physics)**.** One prominent example of Big Science is the construction and operation of large particle accelerators[32], such as the *Large Hadron Collider (LHC)* [12] at CERN. This facility:

- Demands multi-billion-dollar funding for equipment, detectors, and infrastructure.
- Involves thousands of scientists in global collaborations with a heavily managed schedule and governance structure.
- Seeks to measure properties of subatomic particles and search for anomalies, broadly extending the Standard Model but generally preserving its core assumptions.
- Produces high publication volume: each large collaboration publishes hundreds of papers per year, each typically signed by hundreds of coauthors.

Hence, the LHC project is a quintessential *Big Science* endeavor.

Example 3 (Space Telescope Missions)**.** Large-scale space telescope missions[53] (such as the *James Webb Space Telescope*[25]) also illustrate Big Science. They involve:

(1) Centralized budgets from multiple agencies (e.g. NASA[27], ESA[29], CSA).

(2) Complex management to coordinate large teams of engineers, scientists, and administrators.

(3) A primary goal to refine or expand upon the standard cosmological model and existing astrophysical paradigms, although it often leads to incremental parameter-fitting or observational confirmations.

Thus, these missions epitomize the "Big Science" paradigm in observational astrophysics.

Deep Science emphasizes rethinking foundational principles, exploring alternative frameworks, and proposing paradigm-shifting theories to address fundamental scientific questions.

Definition 4 (Deep Science)**.** [49] A *Deep Science* investigation prioritizes fundamental conceptual revision, radical exploration, or critical rethinking of existing frameworks. It is typically characterized by:

(1) *Model-Critical Mindset.* Deep Science explicitly questions or reexamines foundational postulates of mainstream theories instead of merely refining them.

(2) *Openness to Contradictions.* Anomalies, logical inconsistencies, or new experimental discrepancies are treated not as minor fixes but as *opportunities* to propose alternative postulates or new structural concepts.

(3) *Potential for Paradigm Shifts (cf.*[5]*).* The outcome of a successful Deep Science project is frequently a novel framework that either supersedes or comprehensively unifies prior models in ways not achievable by incremental patches.

(4) *Flexible Methodologies.* Rather than focusing on a single large facility or dataset, Deep Science may synthesize diverse data sources, advanced pattern recognition (e.g. deep learning), new mathematical structures, or philosophical perspectives to achieve deeper insight.

Mathematically, one can denote a Deep Science project as a tuple:

$$\mathcal{D} = \Big(\text{Conceptual\_Exploration},\ \text{Alternative\_Axioms},\ \text{Data\_Integration},\ \text{Iterative\_SelfCritique},\ \text{Potential\_Leap}\Big),$$

where Potential_Leap signifies the possibility of fundamentally new scientific paradigms.

Example 5 (Revisiting Core Postulates of Particle Physics)**.** An investigation that thoroughly rethinks the assumption of "pointlike" particles in the Standard Model, proposing instead a *topological wave-based* approach or a *cellular automaton* model (cf.[41]) of matter, exemplifies *Deep Science*. It may:

- Criticize the unverified assumption of pointlike quarks.
- Seek explanations for confined quarks without postulating complicated color charge fields.
- Use alternative frameworks (e.g. zero-point fluctuations[39], wave solitons[36], or groupoid-based structures) to unify observed data.

Such a proposal, if consistent, might significantly alter the conceptual underpinnings of high-energy physics, representing a deeper transformation than typical Big Science refinements.

Example 6 (Revisiting General Relativity and Spacetime Structure)**.** A Deep Science approach may question the classical continuity assumption in Einstein's spacetime manifold. One might propose:

(1) A discrete lattice geometry or a causal network as a new baseline for gravity.

(2) Incorporate emergent phenomena (e.g. thermodynamic analogies [35] or fractal models) to replace geometric curvature with topological or spectral properties.

(3) Seek a unified representation bridging quantum field theory and discrete gravitational degrees of freedom.

Such an approach attempts to fundamentally reformulate gravitational theory, rather than only adding parameters (*dark energy*[9], *dark matter*[4], etc.) to patch standard ΛCDM cosmology. Consequently, it is a quintessential example of Deep Science's paradigm.

Example 7 (Validation by Data versus Fundamental Rebuilding)**.** In Big Science contexts, a project like the LHC seeks to confirm the Standard Model's predictions or search for small perturbations (e.g. subtle evidence of supersymmetry[16]). *Deep Science* would instead ask: "Is the Standard Model the correct theory, or is it a limiting approximation of a deeper discrete wave structure of matter?" The latter approach might eventually reveal new theoretical directions (removing the assumption of pointlike quarks, for instance). Because that line of questioning goes beyond verifying or tweaking the Standard Model, it is out of typical Big Science's incremental domain.

Example 8 (Alternate Universe Conjectures)**.** In cosmology [34, 13, 52], a typical Big Science project might focus on measuring cosmic microwave background (CMB) [14] anisotropies with greater precision to refine the parameters of the ΛCDM model. This approach aligns with the goals of Big Science: improving established theories by making incremental advancements and obtaining more accurate data.

In contrast, a Deep Science perspective would challenge foundational assumptions such as the continuity of spacetime (cf.[6]) or the idea that the universe lacks a preferred reference frame. Instead, it could propose entirely new models, such as a cosmos based on multi-scale structures or fractal geometries.

This shift from refining parameters (Big Science) to questioning and rebuilding the underlying framework (Deep Science) demonstrates how Deep Science expands the conceptual boundaries beyond the incremental scope of Big Science.

2 | Plithogenic Big Science and Deep Science

The Plithogenic Set is a type of set that generalizes Neutrosophic Sets, Fuzzy Sets, and similar frameworks [48, 47, 50]. Plithogenic Sets have been extensively studied in various contexts, including Graphs, Algebra, Groups, and Networks[24, 18, 17, 23, 21, 1, 22, 19, 20]. The formal definition of the Plithogenic Set is presented below.

Definition 9 (Plithogenic Set)**.** [48, 47] Let S be a universal set, and $P \subseteq S$ be a subset of elements. A *Plithogenic Set* PS is a mathematical structure defined as:

$$PS = (P, v, Pv, \mathrm{DAF}, \mathrm{DCF}),$$

where:

- v represents an attribute associated with the elements in P.
- Pv is the set of all possible values that the attribute v can take.
- $\mathrm{DAF} : P \times Pv \to [0,1]^s$ is the *Degree of Appurtenance Function*, which assigns a vector of membership degrees to each pair (p, v) where $p \in P$ and $v \in Pv$.
- $\mathrm{DCF} : Pv \times Pv \to [0,1]^t$ is the *Degree of Contradiction Function*, which quantifies the contradiction between two attribute values $a, b \in Pv$.

The functions DAF and DCF must satisfy the following axioms for all $a, b \in Pv$:

(1) *Reflexivity of the Contradiction Function:*

$$\mathrm{DCF}(a, a) = 0,$$

indicating that an attribute value is not contradictory to itself.

(2) *Symmetry of the Contradiction Function:*

$$\mathrm{DCF}(a, b) = \mathrm{DCF}(b, a),$$

ensuring that the contradiction relationship is symmetric.

Example 10 (Variations of Plithogenic Sets [47, 23])**.** Common types of Plithogenic Sets arise by choosing different dimensions s and t:

- $s = t = 1$: A *Plithogenic Fuzzy Set*, generalizing standard fuzzy sets[54, 56, 55, 57] by embedding them in a plithogenic attribute framework.
- $s = 2, t = 1$: A *Plithogenic Intuitionistic Fuzzy Set*, capturing membership and non-membership plus a contradiction measure (cf.[2, 3]).
- $s = 3, t = 1$: A *Plithogenic Neutrosophic Set*, encompassing truth, indeterminacy, and falsity degrees (cf.[43, 44, 45]).
- $s = 4, t = 1$: A *Plithogenic Quadripartitioned Neutrosophic Set* (cf.[31, 30, 42]).
- $s = 5, t = 1$: A *Plithogenic Pentapartitioned Neutrosophic Set* (cf.[10, 40]).

These classes generalize fuzzy or neutrosophic sets by incorporating multi-criteria membership dimensions and inter-value contradictions.

Using the concepts outlined above, Big Science and Deep Science are extended within the framework of Plithogenic Sets. It is important to note that these extensions are currently conceptual in nature. The authors believe that further theoretical exploration and investigation into potential applications of these Plithogenic Set-based extensions will be essential in the future.

Definition 11 (Big Plithogenic Science)**.** *Big Plithogenic Science* is a research enterprise that:

(1) Retains the characteristic elements of *Big Science*:

- Large-scale funding and resource demands.
- Centralized or government-managed collaborations.
- Predominantly incremental investigations of mainstream theories.
- High-volume publication ethos.

(2) Incorporates or is modeled by a *Plithogenic Set* structure, wherein each "scientific parameter" or "theoretical stance" is treated as an *attribute* in a plithogenic sense, and inter-value contradictions are measured via the *pCF* function.

Formally, we denote $\mathcal{B}_{plith}$ as:

$$\mathcal{B}_{plith} = \Big(\mathcal{B},\ PS,\ \text{High\_ScaleCollab},\ \text{Contradiction\_Resolution}\Big),$$

where $\mathcal{B}$ is a classical Big Science tuple (funding, mainstream theories, data output, etc.), and PS is a *Plithogenic Set* that captures how different sub-teams or sub-theories define or evaluate crucial attributes—with pCF capturing the contradictions or disagreements.

Example 12 (Big Plithogenic Science Variations)**.** Different types of *Big Plithogenic Science* projects can emerge depending on the dimensionality s and t of the underlying Plithogenic Set:

- $s = t = 1$: A *Big Plithogenic Fuzzy Science* project, where scientific investigations are modeled with fuzzy attributes and contradictions resolved using a simple contradiction function.
- $s = 2, t = 1$: A *Big Plithogenic Intuitionistic Fuzzy Science* project, which incorporates both membership and non-membership evaluations, alongside contradictions between them.
- $s = 3, t = 1$: A *Big Plithogenic Neutrosophic Science* project, allowing for truth, indeterminacy, and falsity degrees to represent the scientific parameters or sub-models, coupled with inter-value contradictions.
- $s = 4, t = 1$: A *Big Plithogenic Quadripartitioned Science* project, extending neutrosophic modeling to four distinct appurtenance dimensions.
- $s = 5, t = 1$: A *Big Plithogenic Pentapartitioned Science* project, representing even more complex multi-criteria scientific investigations.

These projects generalize standard Big Science frameworks by embedding multi-dimensional membership and contradiction-handling capabilities into their investigative methodologies.

Example 13 (Large Collaborative Particle Physics within a Plithogenic Framework)**.** Consider the collaborative efforts at the Large Hadron Collider (LHC), involving experiments like ATLAS and CMS. These collaborations illustrate the principles of *Big Plithogenic Science* when viewed through the lens of a Plithogenic Set:

(1) *Big Science Characteristics:* The LHC operates on a massive scale, with multi-billion-dollar funding and thousands of researchers working collaboratively across institutions worldwide. The overarching goal is to investigate phenomena within the Standard Model of particle physics, such as the properties of the Higgs boson and potential evidence of new physics.

(2) *Diverse Analytical Approaches:* Within each collaboration (e.g., ATLAS or CMS), multiple sub-teams analyze the same experimental data using different methodologies. For example:

   - Some teams use different parton distribution functions (PDFs) to model the internal structure of protons.
   - Others apply distinct cross-section computation methods to estimate the likelihood of specific particle interactions.
   - Variations in statistical treatments or data reconstruction techniques may also arise.

   These variations reflect different "stances" or "values" within the collaboration's analytical framework.

(3) *Plithogenic Perspective:* By adopting a *Plithogenic Set* framework:

   - The attribute v represents the "analytical approach" or "modeling methodology" employed by each sub-team.
   - The possible values $Pv = \{\alpha_1, \alpha_2, \dots\}$ correspond to specific choices, such as particular PDFs or cross-section models.

- The *Degree of Appurtenance Function* (pdf) quantifies the confidence or alignment of each sub-team's analysis with the observed data.
- The *Contradiction Function* ($pCF(\alpha_i, \alpha_j)$) measures the level of disagreement or tension between different sub-teams' results or parameter choices.

(4) *Integration of Contradictions:* The Plithogenic framework enables a systematic assessment of contradictions within the collaboration. For instance:

- If one analysis finds an anomaly in particle cross-sections while another does not, pCF can quantify the degree of inconsistency.
- These contradictions are not dismissed but are used to refine the overall understanding, identifying areas where the Standard Model might need modification or where experimental uncertainties dominate.

The LHC project is a quintessential example of *Big Science* due to its scale and collaborative structure. When reinterpreted through a Plithogenic framework, it becomes a *Big Plithogenic Science* initiative, where contradictions among sub-teams' methodologies are quantified and integrated as part of a structured effort to advance particle physics.

Example 14 (Space Missions Incorporating Conflicting Theories)**.** Consider a space telescope mission involving collaboration among multiple space agencies (e.g., NASA, ESA, CSA). The mission aims to study cosmic acceleration but includes distinct and potentially conflicting theoretical submodels to explain this phenomenon, such as dark energy, modified gravity, or quantum effects.

In the Plithogenic framework:

- The attribute set Pv consists of the submodels α_1 (dark energy), α_2 (modified gravity[8]), α_3 (quantum effects[26]), and so on.
- Each submodel $\alpha_i \in Pv$ is assigned a degree of alignment with observational data using the *Degree of Appurtenance Function* $pdf(\alpha_i)$, where $pdf : P \times Pv \to [0,1]^s$.
- Contradictions between submodels (e.g., the incompatibility between dark energy and modified gravity) are quantified using the *Degree of Contradiction Function* $pCF(\alpha_i, \alpha_j)$, where $pCF : Pv \times Pv \to [0,1]^t$. For instance, $pCF(\alpha_1, \alpha_2)$ captures the extent to which dark energy and modified gravity hypotheses conflict.

This approach allows the mission to retain the characteristic traits of *Big Science*, such as large-scale funding, extensive collaboration, and high data output, while adopting a *Plithogenic perspective* to systematically incorporate and analyze conflicting hypotheses. This illustrates how *Big Plithogenic Science* formalizes the coexistence of multiple contradictory submodels within a single scientific endeavor.

Definition 15 (Deep Plithogenic Science)**.** *Deep Plithogenic Science* is a conceptual extension of *Deep Science*, in which:

(1) The investigation explicitly or systematically reconsiders fundamental premises of a domain.

(2) Each premise or theoretical approach is modeled as *attributes* and *values* in a *Plithogenic Set* structure.

(3) Potentially *radical* contradictions or alternative axioms are captured by pCF, with an iterative approach to harness these contradictions to propose entirely new frameworks or paradigms rather than refining established models.

(4) The primary objective is to integrate contradictory stances or datasets into deeper unifying theories, emphasizing a truly *plithogenic* approach to synergy (or synergy-through-contradiction).

Mathematically:

$$\mathcal{D}_{plith} = \Big(\mathcal{D},\ PS,\ \text{Radical\_ConceptualShift},\ \text{Contradiction\_Catalyst}\Big),$$

where $\mathcal{D}$ is a Deep Science tuple (conceptual exploration, alternative axioms, etc.), while PS and Contradiction_Catalyst clarify how contradictory or multi-level "theories" (attributes) are used to build new conceptual frameworks beyond incremental mainstream expansions.

Example 16 (Deep Plithogenic Science Variations)**.** In *Deep Plithogenic Science*, the use of Plithogenic Sets allows for diverse approaches based on dimensionality s and t:

- $s = t = 1$: A *Deep Plithogenic Fuzzy Science* approach, focusing on rethinking fundamental premises using fuzzy-like membership values and contradictions.
- $s = 2, t = 1$: A *Deep Plithogenic Intuitionistic Fuzzy Science* approach, utilizing both membership and non-membership degrees to critically analyze competing scientific axioms or hypotheses.
- $s = 3, t = 1$: A *Deep Plithogenic Neutrosophic Science* approach, employing truth, indeterminacy, and falsity degrees to explore radical paradigm shifts and resolve theoretical contradictions.
- $s = 4, t = 1$: A *Deep Plithogenic Quadripartitioned Science* approach, providing more nuanced appurtenance dimensions for deep conceptual integration.
- $s = 5, t = 1$: A *Deep Plithogenic Pentapartitioned Science* approach, allowing even higher-dimensional modeling of contradictions and alternative conceptual frameworks.

These approaches move beyond the incremental refinements of Big Science, emphasizing a systematic incorporation of contradictions and multi-faceted conceptual exploration.

Theorem 17 (Big Plithogenic Science as a Plithogenic Set Structure)**.** *Any project classified as* Big Plithogenic Science *(denoted by $\mathcal{B}_{plith}$) can be interpreted through a Plithogenic Set structure. This means that all of the project's theoretical approaches and organizational details can be represented as part of a single* Plithogenic Set*, meeting the conditions from Definition.*

Proof: Let $\mathcal{B}$ represent a typical Big Science project, which usually involves:

$$\text{Mainstream\_Theories, Sub-Model\_Variations, Calibration\_Procedures, ...}$$

To model it as a *Plithogenic Set*, proceed as follows:

- *Elements (p) in the Set (P):* We identify the different sub-models or parameter options within the project and collect them in a subset P. For instance, these could be various parameter sets or different theoretical stances maintained by sub-teams.
- *Attribute (v) and Range (Pv):* Let the attribute v denote "the chosen stance or parameter configuration." The range Pv consists of all possible stances (e.g., $\alpha_1, \alpha_2, ...$), each representing a distinct viewpoint or numerical setting.
- *Degree of Appurtenance Function (pdf):* Define
$$pdf : \; P \times Pv \; \to \; [0, 1]^s$$
which records how strongly each sub-model stance or group element p (such as a particular research team or analysis approach) supports a given stance α_i. This can capture the level of agreement or preference for using α_i.
- *Degree of Contradiction Function (pCF):* Define
$$pCF : \; Pv \times Pv \; \to \; [0, 1]^t$$
to measure how contradictory two stances α_i, α_j are. For example, if α_i and α_j represent parameter settings that cannot both be valid under the same conditions, pCF(α_i, α_j) would be high.
- *Reflexivity and Symmetry:* By construction, no stance contradicts itself, so $pCF(a, a) = 0$. Moreover, the contradiction between α_i and α_j is presumably symmetric, so $pCF(\alpha_i, \alpha_j) = pCF(\alpha_j, \alpha_i)$.

Hence, these components satisfy the definition of a Plithogenic Set. Since $\mathcal{B}_{plith}$ inherits this structure, it can be viewed as a *Plithogenic structure*. This completes the proof. □

Example 18 (Rethinking the Standard Model via Plithogenic Integration of Alternative Theories)**.** In high-energy physics, a *Deep Plithogenic Science* approach can be used to explore alternative frameworks beyond the Standard Model. This approach involves the following steps:

(1) *Challenging Pointlike Assumptions:* Move away from the traditional assumption of pointlike particles (e.g., quarks and electrons[28]). Instead, consider alternative theories such as wave-based models or topological-substance theories to describe fundamental particles.

(2) *Plithogenic Representation of Theories:* Represent these alternative theories as elements of a Plithogenic Set. For instance:

$$Pv = \{\alpha_1, \alpha_2, \alpha_3, ...\},$$

where α_1 represents a wave-soliton model, α_2 a discrete-lattice QCD approach, and α_3 a topological framework, among others. Each α_i is a potential candidate theory.

(3) *Quantifying Contradictions:* Employ the *Degree of Contradiction Function* $pCF(\alpha_i, \alpha_j)$ to evaluate the extent of disagreement or tension between pairs of theories. For example, $pCF(\alpha_1, \alpha_2)$ might capture the conflict between the wave-soliton and discrete-lattice QCD models.

(4) *Developing a Meta-Model:* Use the contradictions captured by pCF as a basis to propose a unified "meta-model." This meta-model aims to systematically integrate the insights from the alternative theories while addressing the contradictions as opportunities for deeper theoretical advancements.

By rethinking foundational principles (making it *Deep*) and using a structured framework to handle conflicting theoretical perspectives (making it *Plithogenic*), this approach exemplifies how high-energy physics can benefit from a Plithogenic perspective.

Example 19 (Deep Plithogenic Cosmology: Reconciling Alternative Universe Models)**.** In cosmology, a *Deep Plithogenic Science* approach can be applied to explore alternative frameworks that challenge standard assumptions such as the continuous manifold structure of spacetime (cf.[6]) or the ΛCDM model (the Lambda Cold Dark Matter model[51]). This approach can be understood through the following steps:

(1) *Questioning Standard Premises:* Instead of assuming a smooth, continuous spacetime and ΛCDM as the definitive cosmological model, alternative ideas are considered. For example:

- *Discrete Cosmologies*[15]*:* Theories where spacetime consists of discrete units or a lattice structure.
- *Fractal Cosmologies*[33]*:* Models suggesting the universe exhibits self-similar, fractal-like distributions of matter at large scales.
- *Multi-Phase Expansion Models:* Hypotheses proposing that cosmic expansion has undergone distinct phases, influenced by varying physical laws or conditions.

(2) *Plithogenic Representation of Theories:* These alternative cosmologies are treated as attributes in a Plithogenic Set. For instance:

$$Pv = \{\alpha_1, \alpha_2, \alpha_3\},$$

where α_1 corresponds to a discrete lattice cosmology, α_2 to a fractal universe model, and α_3 to a multi-phase expansion model.

(3) *Capturing Contradictions:* The *Degree of Contradiction Function* $pCF(\alpha_i, \alpha_j)$ quantifies the degree of conflict between pairs of theories. For example:

- $pCF(\alpha_1, \alpha_2)$ could measure the discrepancy between discrete spacetime and fractal distributions of matter.
- $pCF(\alpha_2, \alpha_3)$ could capture conflicting predictions about cosmic acceleration from fractal models versus multi-phase expansion.

(4) *Building a Unified Framework:* Using the insights gained from the pCF evaluations, a "meta-model" can be constructed. This meta-model synthesizes the strengths of the individual cosmologies while resolving or embracing their contradictions as opportunities for a more comprehensive understanding of the universe.

This approach is *Deep* because it fundamentally rethinks core assumptions about spacetime and cosmic evolution. It is *Plithogenic* because it systematically integrates multiple, potentially contradictory cosmological theories using a structured framework.

Example 20 (Deep Plithogenic Cosmology versus Big Plithogenic Cosmology)**.** Consider two approaches to studying cosmology through the lens of Plithogenic Science:

Big Plithogenic Cosmology: In this approach, a research project might focus on refining and analyzing variations of the widely accepted ΛCDM model (the Lambda Cold Dark Matter model), which is the standard model of cosmology. Using a *Plithogenic Set*, the project represents different parameter settings or minor variations of ΛCDM (e.g., different values for the dark energy constant or matter density) as elements in the set.

- The attribute v corresponds to "theoretical variations within ΛCDM."
- The contradiction function $\text{pCF}(\alpha_i, \alpha_j)$ measures the degree of disagreement between two parameter settings α_i and α_j.
- The goal is to assess which parameter sets are more plausible by minimizing contradictions or identifying subsets of mutually consistent theories.

This methodology adheres to the general framework of *Big Science* by focusing on incremental improvements to an existing mainstream model.

Deep Plithogenic Cosmology: In contrast, a *Deep Plithogenic Cosmology* project challenges the foundational assumptions of the ΛCDM model entirely. Instead of tweaking parameters within ΛCDM, the project proposes and explores radically different cosmological frameworks, such as:

- Fractal cosmology[11, 33], where the universe's structure exhibits self-similar patterns at various scales.
- Discrete-lattice cosmology(cf.[37]), where spacetime is not continuous but consists of a grid-like structure.
- Multi-phase universe models, which hypothesize that the universe transitions through distinct phases of expansion governed by different fundamental rules.

Here:

- The attribute v represents "different cosmological paradigms" instead of minor variations of a single model.
- The contradiction function $\text{pCF}(\alpha_i, \alpha_j)$ quantifies the degree of conflict or tension between these fundamentally different paradigms (e.g., ΛCDM vs. fractal cosmology).
- This approach leverages these contradictions to drive the search for a unified "meta-model" that integrates or transcends the competing theories.

Key Difference: While *Big Plithogenic Cosmology* focuses on refining and reconciling variations within the accepted ΛCDM framework, *Deep Plithogenic Cosmology* steps beyond this framework to question its validity and explore entirely new models. This distinction illustrates how *Deep Plithogenic Science* broadens the conceptual scope of *Big Plithogenic Science*, enabling paradigm-shifting advancements.

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Data Availability

As this study is rooted in theoretical and mathematical exploration, no data was analyzed. Future research is encouraged to incorporate empirical or data-driven approaches for further investigation.

Ethical Approval

This work is purely theoretical and did not involve any experimental procedures with humans or animals.

Conflicts of Interest

The authors confirm there are no conflicts of interest associated with this publication.

Disclaimer

This study introduces theoretical concepts that have not yet been practically implemented or validated. We encourage subsequent research to test and refine these ideas empirically. While care has been taken to ensure the accuracy of references and arguments presented, errors or oversights may still exist. Readers are encouraged to independently verify cited materials. The views and interpretations in this paper reflect those of the authors and not necessarily their affiliated institutions.

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