**The Origin of Ultra-High-Energy Gamma Rays: A Direct Production Mechanism via Field Combination Collapse in Neutron Stars and Energy Transfer**

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**Abstract:**  
This paper presents a complete and self-consistent theoretical model for the origin of ultra-high-energy gamma rays in deep space, based on the Li Zhijun ABC theory. The core thesis posits that ultra-high-energy gamma rays originate from a topological phase transition of the field combination state of atomic nuclei (baryons) on the surface or within the magnetosphere of compact objects such as neutron stars, under extreme gravitational conditions. During this process, the color charge field B and the Higgs field C undergo “collapse,” directly transferring energy to the electromagnetic vortex field A, thereby generating high-energy bosons with nearly pure A-field excitation—i.e., ultra-high-energy photons (gamma rays). We rigorously demonstrate:  
1. The extreme gravitational environment of neutron stars is described by general relativity. Its metric

induces gravitational redshift and energy-level compression, significantly altering the effective binding energy of the nucleon field combination state :

2. Field combination collapse constitutes a topological phase transition process characterized by the effective potential at finite density and temperature. When the gravitationally induced chemical potential exceeds the critical value the global minimum of shifts, and the order parameters of the color charge field B and Higgs field C relax to their vacuum expectation values releasing binding energy   
3. The direct energy transfer mechanism is governed by the coupled field equation where the current terms and act as strong sources near the phase transition point, efficiently converting into excitation energy of the electromagnetic field A.  
4. The final product consists of high-energy photons: The process directly yields high-energy photons with the field combination state Owing to their zero rest mass and lack of coupling to the Higgs field their interaction cross-section with nuclear matter is small ( mbarn), and the mean free path far exceeds the neutron star radius. Consequently, they readily escape the extreme gravitational field and are observed as ultra-high-energy gamma rays. This model circumvents the gravitational binding issue associated with high-energy proton production and offers a novel, highly self-consistent physical framework for explaining isotropic ultra-high-energy gamma-ray radiation.

**Keywords:** ABC theory; Neutron star; Field combination collapse; Topological phase transition; Effective potential; Energy transfer; Ultra-high-energy gamma rays; Direct production

1. **Introduction**The origin of ultra-high-energy gamma rays (energies in the TeV to PeV range) represents a central challenge in modern high-energy astrophysics. Conventional models involving leptonic synchrotron radiation or hadronic decay struggle to account for certain isotropic phenomena lacking strong associated sources. The Li Zhijun ABC theory provides an innovative framework for reexamining this issue, proposing that all entities in the universe comprise three fundamental vortex fields: the electromagnetic vortex field A, the color charge vortex field B, and the Higgs vortex field C. Building on this theory, this paper introduces a groundbreaking mechanism: ultra-high-energy gamma rays are not generated through acceleration but instead arise from a fundamental restructuring of matter’s field combinations under extreme gravitational conditions in compact objects (e.g., neutron stars)—specifically, field combination collapse and direct energy transfer. This process directly transforms the binding energy accumulated by matter in the gravitational field into the energy of high-energy photons via field couplings.
2. **Neutron Star Environment and General Relativistic Description of Baryon Field Combinations**

2.1 Spacetime Metric of Neutron Stars  
The intense gravitational field produced by neutron stars necessitates description within general relativity. The metric for a static, spherically symmetric spacetime is:

where:  
\* with denoting the mass enclosed within radius r.

* is determined by the Tolman-Oppenheimer-Volkoff (TOV) equation:

where signifies pressure. This metric results in gravitational redshift, relating the energy measured by a distant observer to the local energy via:

For a typical neutron star , the surface gravitational redshift factor approximates .

2.2 Gravitational Modification of Nucleon Field Combinations  
The field combination state of a neutron (or proton) is In flat spacetime, its rest energy equals In curved spacetime, its local energy incorporates gravitational potential energy. For a nucleon at rest at radial coordinate r, the effective binding energy (the work required to transport it from infinity to r) is:

Given (the gravitational potential deepens toward the stellar center), . This implies enhanced nucleon binding in strong gravitational fields, placing the system in a lower-energy, more compact bound state. The increase in binding energy

furnishes the energy reservoir for the subsequent phase transition.

1. **Field Combination Collapse: Topological Phase Transition and Effective Potential**  
   Extreme gravitational conditions can trigger a topological phase transition in the nucleon field combination, i.e., the “collapse” of the color charge field B and Higgs field C.

3.1 Effective Potential at Finite Temperature and Density  
Under finite density (nuclear matter) and finite temperature (internal neutron star temperature), the effective potential for the color charge field B and Higgs field C undergoes modification. Incorporating one-loop corrections and source terms (e.g., chemical potential), its form is:

where:  
\* represents the zero-temperature tree-level potential.

* constitutes the thermal correction, with as the effective degrees of freedom.
* embodies the density correction, linked to the baryon chemical potential Within the mean-field approximation, $V\_{}() -\_b ^$.

The gravitational field indirectly modulates and T by influencing the local baryon number density and temperature , thereby altering the minimum position of

3.2 Critical Conditions and Phase Transition  
When the gravitational potential descends below a critical threshold the global minimum of transitions from to , typically approaching the vacuum expectation values . This first-order phase transition necessitates quantum tunneling or thermal activation to overcome the potential barrier.  
The phase transition rate derives from instanton computations or the Arrhenius formula:

where denotes the Euclidean action, and the barrier height.  
Upon phase transition, fields B and C relax from the condensed state (confined within nucleons) to the vacuum state, liberating substantial binding energy

1. **Energy Transfer Mechanism: From B/C Fields to A Field**  
   The released binding energy must be transferred to excite the electromagnetic vortex field A. This process is delineated by coupling terms in the field equations.

4.1 Coupled Field Equations  
The dynamics of the electromagnetic field color charge field and Higgs field are captured by the following coupled equations:

where:  
\* serves as the source term from the color charge field B to the electromagnetic field.

* functions as the source term from the Higgs field C to the electromagnetic field.

During rapid relaxation of and (where is substantial), they emerge as potent sources for the electromagnetic field vigorously exciting it.

4.2 Energy Transfer Efficiency  
The energy transfer efficiency is defined as the ratio of the energy ultimately channeled to excite field A to the released binding energy :

Under resonant conditions (e.g., when oscillation frequencies of fields B/C coincide with an eigenfrequency of field A), the efficiency can approach unity.

1. **Direct Production and Escape of High-Energy Photons**Post energy transfer, a highly excited electromagnetic field quantum is directly produced—an ultra-high-energy photon (gamma ray) with the field combination state:

This state is energy-rich and exhibits intrinsic properties:

* Zero color charge : Incapable of engaging in strong interactions.
* No coupling to the Higgs field : Zero rest mass

These attributes are pivotal for the photon’s ability to evade the extreme neutron star environment.

5.1 Escape Mechanism and Observational Viability  
1. Absence of Strong Interactions: Photons interact with neutron star nuclear matter predominantly through electromagnetic processes (e.g., Compton scattering, electron-positron pair production). Their interaction cross-section at ultra-high energies () is approximately mbarn, and the corresponding mean free path vastly exceeds the neutron star radius . Hence, photons are highly improbable to be absorbed immediately after generation.  
2. Gravitational Redshift and Escape: Although photons experience general relativistic effects—their trajectories curve, and their energies undergo gravitational redshift —their zero rest mass ensures that, provided their initial velocity is not precisely radial inward, they possess a high likelihood of escaping to infinity rather than being gravitationally captured. While capture by a black hole event horizon is feasible, complete gravitational binding and accretion by a neutron star are exceedingly rare.

Thus, directly produced high-energy photons can exit the neutron star environment virtually unimpeded, traverse deep space, and eventually be detected by terrestrial instruments (e.g., LHAASO, H.E.S.S., MAGIC) as point-like or extended sources of high-energy gamma rays.

5.2 Contrast with Proton Production  
Should the final state comprise high-energy protons , the scenario would differ markedly:  
\* Strong Interactions: The interaction cross-section between protons and neutron star matter is considerable ( mbarn), and their mean free path is exceedingly short. They would undergo multiple scatterings promptly after production, rapidly dissipating energy.

* Gravitational Binding: Protons possess a substantial rest mass . The depth of the neutron star’s gravitational potential well suffices to tightly confine them. Escape demands exceedingly high kinetic energy, but multiple scatterings would thermalize their energy spectrum, precluding their emergence as ultra-high-energy cosmic rays. Consequently, direct production of high-energy photons stands as the sole physically self-consistent escape pathway.

1. **Conclusion**This paper advances a novel mechanism for the origin of ultra-high-energy gamma rays:

1. Source Objects: Compact entities such as neutron stars.

2. Trigger Mechanism: Extreme gravity instigates collapse (topological phase transition) of nucleon field combinations (B and C fields).

3. Energy Source: Binding energy liberated by the phase transition.

4. Energy Transfer and Product: Energy is directly conveyed to electromagnetic field A through field coupling, directly yielding ultra-high-energy photons (gamma rays).

5. Escape: Photons, by virtue of their massless and weakly interacting nature, readily escape the gravitational field, manifesting as observable signals.

This model sidesteps the inescapability dilemma tied to high-energy proton production and furnishes a novel, highly self-consistent physical framework for elucidating isotropic ultra-high-energy gamma-ray radiation.

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