**The Sequence of Cosmic Evolution through Field Combinations: A Timeline of Particle Generation and Structure Formation Based on ABC Theory**

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Abstract:  
Based on Li Zhijun’s ABC theory, this paper proposes a complete model of cosmic evolution that directly links the geometric expansion history of the universe with the sequential excitation and combination of fundamental particle fields. The core thesis is that the essence of cosmic evolution is a history of increasing complexity in field combinations, a process driven by cosmic cooling () and expansion (). High-energy, highly symmetric fundamental fields (such as the color charge field B and the Higgs field C) are excited during the early inflationary period (); whereas low-energy, composite field combinations (such as atoms, molecules, and celestial bodies) only form stably during the late expansion phase (). We establish a correspondence between the energy scale of particle binding energies and the cosmic cooling temperature, and rigorously derive precise expressions for the cosmic time temperature and cosmic radius at which each fundamental particle and composite structure stabilizes. This model unifies cosmology, particle physics, and condensed matter physics within a single framework, providing a new perspective for understanding the scale connection from the quantum to the cosmic.

Keywords: ABC theory; Cosmic evolution sequence; Field combination; Binding energy; Cosmological timeline; Structure formation

1. **Introduction: From Geometric Expansion to Particle Generation**

The standard cosmological model successfully describes the thermal history of the universe but does not fundamentally explain why specific particles “appear” at specific times. Based on Li Zhijun’s ABC theory, this paper proposes that particle “generation” is not creation ex nihilo, but rather the formation of stable composite states when fundamental fields cool below their respective binding energy scales due to cosmic expansion. The expansion and cooling of the universe () provide a vast “thermal bath,” allowing a sequence of field combinations with progressively lower binding energies to stabilize successively.

1. **Theoretical Framework: Matching Binding Energy Scales with Cosmic Cooling**

2.1 Core Principle: The Binding Energy Criterion

The stable existence of a composite structure, formed from several components via interactions, depends on whether the environmental temperature is lower than the temperature corresponding to its binding energy :

When the universe cools to this composite structure can stabilize and form. Its formation time is determined by the cosmic thermal evolution history .

2.2 The Thermal History of the Universe

The expansion history of the universe determines how temperature changes over time:

* Radiation-dominated era ( yr): ,
* Matter-dominated era ( yr): ,

Using the current age of the universe temperature and scale the physical conditions at any time can be extrapolated:

1. **Mathematical Construction of the Cosmic Evolution Timeline**

Based on the binding energy criterion and the cosmic thermal history , we construct the following precise cosmic evolution timeline. This table strictly adheres to the standard cosmological temperature-time relationship and incorporates the physical meaning of ABC theory.

Table 1: Cosmic Evolution Timeline (Based on Binding Energy Criterion and ABC Field Combinations)

| **Evolutionary Stage** | **Representative Composite** | **Binding Energy** | **Formation Temp.** | **Cosmic Time** | **Cosmic Radius** | **ABC Field Combination Interpretation** |
| --- | --- | --- | --- | --- | --- | --- |
| Electromagnetic vortex field A, color charge vortex field B, Higgs vortex field C | Spacetime Metric Field |  |  |  |  | background forms |
| Quark Generation | Quark (q) |  |  |  |  |  |
| Lepton Generation | Electron (e), Neutrino () |  |  |  |  |  |
| Nucleon Generation | Proton (p), Neutron (n) | B.E. |  |  |  | (color singlet) |
| Light Nucleosynthesis | Deuteron (D), Helium (He) | B.E. |  |  |  |  |
| Atomic Recombination | Hydrogen Atom (H) | B.E. |  |  |  | (EM bound state) |
| Molecular Formation | Hydrogen Molecule () | B.E. |  |  |  | (molecular orbital) |
| Star Formation | First Generation Stars |  | (local) |  |  | (grav. bound state) |
| Galaxy Formation | Galaxy |  | (local) |  |  |  |

Note: B.E. stands for Binding Energy, is the gravitational binding energy per constituent. Formation time is solved from . is calculated from or

3.1 Calculation Example: Hydrogen Atom Formation

* Binding Energy:
* Formation Temperature:
* Formation Time:
  + The universe during recombination is at the end of radiation-domination/beginning of matter-domination, approximated using
  + years
* Formation Radius:

The calculation results perfectly match the recombination epoch in standard cosmology.

1. **ABC Theory Interpretation: The Hierarchical Construction of Field Combinations**

The essence of cosmic evolution is the process where the complexity of field combinations increases hierarchically as the energy scale decreases.

1. Fundamental Field Excitation (): At extremely high energy scales, the fundamental fields are excited as a whole and undergo symmetry breaking (e.g., electroweak symmetry breaking).
2. Fermion Generation (): The universe cools below the QCD scale; the color charge field B combines with the electromagnetic field A and the Higgs field C to form the field excitation states of quarks and leptons,
3. Hadron Generation (): Quarks combine via the strong interaction of the color charge field B ( gauge field) into color-singlet composites – hadrons (protons, neutrons). Their field combination is
4. Atom Generation (): Protons and electrons combine via the electromagnetic interaction of field A ( gauge field) into electrically neutral composites – atoms. Their field combination is .
5. Macroscopic Structure Formation (): Atoms combine via gravitational interaction (originating from the spacetime metric field ) to form stars and galaxies. Their field combination is
6. **Conclusion and Outlook**

This paper successfully integrates the standard cosmic thermal history with the “field combination” concept of Li Zhijun’s ABC theory, constructing a precise, quantifiable timeline of cosmic evolution.

1. Unified Picture: It provides a unified evolutionary picture from quantum spacetime to macroscopic galaxies, where each step is co-determined by cosmic cooling and binding energy scales.
2. Precise Predictions: The formation times given by the model highly coincide with key time points in standard cosmology (e.g., QCD phase transition, nucleosynthesis, recombination epoch), demonstrating its self-consistency.
3. New Physical Meaning: It provides a deeper physical meaning to the concept of “particle generation”: it is the process by which fundamental fields combine into stable composite states under specific thermodynamic conditions.

**Future Work:**1. Deepen the study of the “reheating” process after inflation ends, specifically how the initial fields are excited.  
2. Explore the field combination form of dark matter and its generation timeline.  
3. Investigate the formation conditions of more complex molecules, biological molecules, and other higher-level field combinations.

This model provides a coherent and concrete physical picture for understanding the birth and evolution of the universe, from fundamental fields to complex structures.

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