Article

Cosmic Expansion-Atomic Expansion: A Novel Molecular Evolution Perspective on Petroleum Generation

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Cosmic Expansion-Atomic Expansion: A Novel Molecular Evolution Perspective on Petroleum Generation

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Abstract

For a long time, the "biogenic theory" of petroleum origin has dominated mainstream thinking, positing that petroleum forms from the burial and thermal evolution of ancient microbial, plant, and animal remains in sedimentary environments. However, traditional theories cannot fully explain how complex biological macromolecules precisely crack into relatively simple hydrocarbon small molecules over geological time scales, and controversies remain regarding the energy sources and kinetic mechanisms of the cracking process. Integrating the core physical principle that cosmic expansion induces atomic expansion [1,3], we can construct a novel petroleum generation mechanism: petroleum is a product of sedimentary organic matter derived from microbial, plant, and animal remains, which undergoes gradual cracking and recombination of molecular structures under the sustained action of atomic expansion driven by cosmic expansion over hundreds of millions of years, ultimately transforming from complex macromolecules into hydrocarbon small molecules.

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I. Core Theoretical Foundation: Atomic and Molecular Evolution Driven by Cosmic Expansion

According to the hypothesis of the microscale effects of cosmic expansion [1], cosmic expansion acts not only at the galactic scale but also synchronously affects the internal structure of atoms—with the increase of the cosmic scale factor, the electron radius of atomic orbits continuously expands, and the atomic packing density gradually decreases. This process brings two key impacts:

1. Attenuation of intermolecular forces: Atomic expansion leads to increased bond lengths and weakened bond energies within molecules, while intermolecular interactions such as van der Waals forces and hydrogen bonds are significantly reduced, providing a thermodynamic basis for the cracking of macromolecules [8].
2. Long-term evolution of material structure: Over geological time scales (millions to hundreds of millions of years), the cumulative effect of atomic expansion reduces the spatial structural stability of complex macromolecules, which gradually undergo fragmentation and recombination, transforming into more stable small-molecule structures [3].

This principle is supported by physical models [1]: atomic radius increases with cosmic expansion, and molecular bond energy is negatively correlated with atomic radius—i.e., the greater the atomic expansion, the easier it is for molecular bonds to break. Dirac's Large Numbers Hypothesis suggests that physical constants may change with the age of the universe, indirectly confirming the dynamic nature of atomic structure evolution with cosmic development [2]. Hubble confirmed the core conclusion of cosmic expansion through observations of galactic redshift, and subsequent detections of cosmic microwave background radiation by the COBE satellite further verified the continuity of this long-term evolutionary process [1]. For organic matter deposited underground, this atomic expansion process spanning geological history serves as the core driving force for the transformation of macromolecules into small molecules [4].

II. Three-Stage Evolutionary Process of Petroleum Generation

Based on the cosmic expansion-atomic expansion principle [1,3], petroleum generation does not rely on the high temperature and pressure of sedimentary environments but undergoes a long-term three-stage process of "deposition of biological remains → accumulation of atomic expansion → cracking and recombination of macromolecules."

(I) Stage 1: Deposition of Biological Remains and Enrichment of Organic Matter

During geological history, biological remains such as marine plankton, terrestrial plants, and animal corpses were transported by rivers or deposited independently into low-lying environments such as lakes and oceans. Under anoxic and light-free sedimentary conditions, these biological remains avoided rapid decomposition and mixed with sediments such as sand and mud to form sedimentary organic matter [9]. At this stage, the organic matter is dominated by complex macromolecules such as proteins, cellulose, and lipids, with molecular weights ranging from several thousand to tens of thousands of Daltons, featuring dense structures and high stability that make direct petroleum formation difficult. Kerogen, the core form of sedimentary organic matter, originates from insoluble organic polymers initially polymerized from these biological macromolecules of plant, animal, and microbial origin through early diagenesis [9].

(II) Stage 2: Long-term Atomic Evolution Driven by Cosmic Expansion

The sedimentary organic matter is covered by subsequent sediments, entering sedimentary rock formations several kilometers underground and experiencing an extremely long geological age (usually tens of millions to hundreds of millions of years). During this period, the microscale effects of cosmic expansion persist [1]:

1. Accumulation of atomic expansion: According to the relational model between atomic radius and cosmic time [1], the time scale of hundreds of millions of years is sufficient for a significant expansion of atomic radii in sedimentary organic matter, reducing atomic packing density and gradually accumulating spatial tension within molecules.
2. Decreased molecular stability: Carbon-carbon bonds and carbon-hydrogen bonds in complex macromolecules (e.g., lignin, proteins) experience increased bond lengths and weakened bond energies due to atomic expansion, leading to the emergence of "weak links" in originally stable cyclic and chain structures, preparing for cracking [8]. Atomistic simulation studies have shown that the structural stability of biological macromolecules such as lignocellulose is directly related to atomic packing density, and expanded atomic spacing can significantly reduce their pyrolysis activation energy [5].
3. Synergistic effect of environmental factors: Although moderate high temperatures (50-150°C) in sedimentary environments are not the primary driving forces, they can accelerate the molecular bond breaking induced by atomic expansion, forming a synergistic effect of "atomic expansion as the main driver and temperature as auxiliary factors" [6]. Studies on the thermal evolution of low-maturity shale organic matter have shown that molecular structure changes under moderate temperature and pressure conditions are more consistent with the characteristics of gradual cracking rather than violent thermal cracking reactions [6].

(III) Stage 3: Cracking of Macromolecules into Petroleum Hydrocarbon Small Molecules

When the cumulative molecular bond breaking induced by atomic expansion reaches a certain threshold, complex macromolecules begin to undergo gradual cracking [3]:

1. Primary cracking: The backbone of macromolecules breaks—for example, cellulose (C6H10O5)n cracks into smaller sugar derivatives, proteins break into amino acid fragments, and lipids break into long-chain fatty acids.
2. Secondary cracking and heteroatom removal: The intermediate products after primary cracking undergo further cleavage into shorter carbon chains under the continuous action of atomic expansion, gradually removing heteroatoms such as oxygen, nitrogen, and sulfur to form hydrocarbon precursors dominated by carbon and hydrogen [4]. High-pressure hydrous pyrolysis experiments have shown that hydrocarbon generation from kerogen is accompanied by significant heteroatom removal, and this process can proceed long-term under relatively moderate temperature conditions [4].
3. Recombination and stabilization: Hydrocarbon precursors form structurally stable core petroleum components such as alkanes, cycloalkanes, and aromatics through molecular rearrangement, with molecular weights concentrated between 100-500 Daltons, consistent with the chemical composition characteristics of petroleum [7].

The key to this process lies in its "slowness and continuity": although the rate of cosmic expansion-atomic expansion is weak, the cumulative effect over geological time is sufficient to enable complete cracking and recombination of complex macromolecules, avoiding excessive cracking or carbonization that may occur under traditional high temperature and pressure conditions [1]. Theoretical models of cosmic molecular evolution indicate that the formation of small-molecule structures is the thermodynamically stable direction of long-term macromolecular evolution, which is highly consistent with the molecular characteristics of petroleum hydrocarbons [7].

III. Theoretical Support and Practical Evidence

(I) Correlation Between Molecular Size and Geological Age

Geological exploration has revealed that oilfields of greater geological age (e.g., Precambrian and Paleozoic oilfields) tend to have hydrocarbon molecules with smaller average molecular weights and higher contents of light hydrocarbons (methane, ethane). This is consistent with the cosmic expansion-atomic expansion theory [1]: sedimentary organic matter in ancient oilfields has undergone longer-term atomic expansion, leading to more complete macromolecular cracking and a higher proportion of small-molecule hydrocarbons. Comparative studies on hydrocarbon products from shales of different geological ages have confirmed a negative correlation between the burial time of organic matter and the length of hydrocarbon molecular chains [4].

(II) Residual Patterns of Biomarkers

Biomarkers retained in petroleum (e.g., phytane, pristane) are all small-molecule derivatives rather than intact fragments of original biological macromolecules. This indicates that biological macromolecules have undergone selective cracking, and the weakened bond energy induced by atomic expansion can precisely explain why the molecular fragments containing biomarkers are retained while the rest crack into small-molecule hydrocarbons [6]. Atomic force microscopy-infrared spectroscopy studies have revealed that the retention of biomarkers during the thermal evolution of organic matter is directly related to the relative stability of specific chemical bonds [6].

(III) Indirect Evidence from Material Strength Evolution

According to the cosmic expansion theory [1], ancient materials had denser atomic packing and higher strength. In the early stage (initial deposition), sedimentary organic matter exhibited exceptional stability of macromolecular structures due to high atomic density, making it difficult to decompose; as atomic expansion reduced material strength, macromolecules gradually cracked. This is consistent with the phenomenon that petroleum is mostly formed in specific geological ages (e.g., Mesozoic, Paleozoic)—the sedimentary organic matter of these ages has undergone sufficient atomic expansion without complete carbonization due to excessive time [3]. Multiscale studies on molecular evolution have shown that the mechanical strength of materials is positively correlated with atomic packing density, and atomic expansion is the core factor driving the long-term change of this property [8]. Experiments have confirmed that increased atomic packing density can significantly enhance material strength, while reduced density induced by atomic expansion weakens the stability of material structures [8].

IV. Conclusion: Reconstructing an Interdisciplinary Understanding of Petroleum Origin

Traditional petroleum genesis theories focus on the temperature and pressure conditions of sedimentary environments but overlook the long-term impact of cosmic expansion—an overarching physical process spanning geological history—on microscale molecular structures [1,3]. The new perspective based on the cosmic expansion-atomic expansion principle reveals that the core driving force of petroleum generation stems from macromolecular cracking induced by atomic evolution, improving the complete chain of "biological remains → sedimentary organic matter → cosmic expansion-driven cracking → petroleum small molecules."

This understanding not only provides a comprehensive interdisciplinary explanation (integrating physics, geology, and chemistry) for petroleum origin but also guides oil and gas exploration—by analyzing the geological age of sedimentary organic matter and the cumulative effect of atomic expansion, the distribution characteristics of hydrocarbon molecules can be predicted, improving the accuracy of oil and gas exploration [4]. In the future, with experimental verification of the atomic expansion effect (e.g., X-ray diffraction to detect atomic spacing in rocks of different geological ages [1]), this theory will be further refined, offering a novel research direction for energy science.

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