**Cosmic Expansion in PPC Gravity**

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**Abstract**

This paper develops a pressure-based explanation of cosmic expansion using the PPC (Pawan Upadhyay–Pressure–Curvature) Law of Gravity. In PPC theory, energy density produces gravitational pressure, pressure generates forces, and these forces shape spacetime curvature. Cosmic expansion emerges naturally from the interaction between gravitational pressure, pressure gradients, and inertial responses of spacetime. During the early universe, extremely high energy density created enormous gravitational pressure, driving rapid expansion. As the universe expanded and energy density decreased, gravitational pressure weakened, reducing inward curvature and allowing outward inertial effects to dominate, leading to accelerated expansion. This work presents a unified, physically intuitive interpretation of cosmology in which cosmic expansion—both early and late—is governed by the dynamics of the gravitational pressure field.

## 1. Introduction

Cosmic expansion is one of the most significant observations in modern cosmology. Traditionally described by the FLRW metric and Friedmann equations, expansion is understood as the stretching of spacetime driven by energy density and negative pressure components such as dark energy. However, the mechanisms underlying these contributions remain conceptually abstract.

The PPC Law of Gravity offers a new physical interpretation of cosmic expansion by treating gravitational pressure as the causal agent of curvature and cosmic dynamics. In PPC, energy density generates gravitational pressure, pressure gradients produce forces, and these forces shape the curvature that governs motion. When applied to cosmology, PPC predicts that the universe expands because gravitational pressure evolves with energy density, and pressure gradients drive large-scale outward motion.

This paper develops a full PPC-based model of cosmic expansion, covering early inflation-like expansion, mid-phase deceleration, and late-time acceleration.

## 2. Foundations of PPC Gravity

The PPC Law of Gravity rests on three foundational principles:

1. Energy Density → Gravitational Pressure

Energy density  produces an equivalent gravitational pressure . Pressure, not mass alone, is the physical cause of curvature.

2. Pressure → Forces

Gravitational pressure produces two fundamental forces:

Field Force: arising from pressure gradients

Surface Force: pressure acting across a finite area

These forces represent the mechanical origin of curvature and motion.

3. Forces → Curvature and Expansion

Spacetime curvature forms in response to pressure forces. Expansion or contraction arises when pressure forces dominate over inward or outward inertial tendencies.

Thus PPC provides a physical mechanism for cosmic evolution.

**3. Gravitational Pressure in the Early Universe**

The early universe had extremely high energy density. In PPC terms, this means:

gravitational pressure was enormous,

curvature was extremely strong,

pressure forces were immense.

3.1 Pressure-Driven Expansion

In the earliest moments:

uniform pressure was extremely high,

slight pressure fluctuations created strong outward forces,

spacetime could not maintain such pressure without expansion.

Therefore:

The early universe expanded because gravitational pressure exceeded the capacity of spacetime to remain compact.

This creates a natural PPC analogue to inflation without requiring hypothetical scalar fields.

**4. Pressure Gradient Forces and Cosmic Expansion**

Spatial differences in gravitational pressure produce Field Force, which accelerates matter and spacetime away from high-pressure regions.

$F = \nabla P_g$

In the universe:

early pressure gradients were enormous,

outward pressure forces acted everywhere,

expansion was inevitable and isotropic.

This explains why the universe expanded uniformly on large scales.

**5. Surface Forces in Cosmic Volumes**

Every finite region in the early universe experienced Surface Forces, because gravitational pressure acts across the boundary of any spatial volume.

$F_p = P_g A$

Surface forces contributed to:

uniform outward expansion of space,

growth of all cosmic regions simultaneously,

preservation of large-scale homogeneity.

Thus, every comoving volume expanded due to internal gravitational pressure.

**6. Pressure Waves and Dynamic Evolution**

The early universe was filled with pressure waves—oscillations in gravitational pressure caused by rapid changes in energy density.

These waves:

propagated outward,

carried curvature information,

influenced expansion rate,

later contributed to cosmic microwave background anisotropies.

Pressure waves provide a physical mechanism behind features often attributed to acoustic oscillations or primordial fluctuations.

**7. Transition from Early Rapid Expansion to Slower Expansion**

As the universe expanded:

energy density decreased,

gravitational pressure weakened,

pressure gradients diminished.

This produced:

slower outward pressure forces,

reduced curvature steepness,

gradual transition from rapid expansion to slower expansion.

Thus PPC naturally explains the shift from early fast expansion to a long period of deceleration.

**8. Late-Time Accelerated Expansion in PPC Gravity**

Modern cosmology reports accelerated expansion, typically explained by “dark energy” with negative pressure. PPC provides a different mechanism:

8.1 Weakening Pressure → Weakening Curvature

As average energy density becomes low:

gravitational pressure becomes very weak,

inward curvature reduces,

outward inertial effects dominate.

8.2 Inertia Outruns Pressure

When inward gravitational pressure is too weak to maintain curvature:

Spacetime expands faster because there is not enough pressure to hold curvature inward.

This produces the observed late-time acceleration without exotic components.

8.3 Pressure Field Flatness

Extremely low pressure gradients allow even small outward inertial tendencies to accelerate expansion.

Thus PPC explains cosmic acceleration through:

pressure reduction,

curvature weakening,

dominance of outward inertia.

**9. PPC Cosmological Sequence**

Below is the complete cosmic evolution cycle in PPC gravity:

Early Universe:
Extremely High Energy Density
↓
Extremely High Gravitational Pressure
↓
Strong Pressure Forces → Rapid Expansion

Mid Universe:
Decreasing Pressure
↓
Reduced Pressure Forces → Slower Expansion

Late Universe:
Very Low Pressure, Weak Curvature
↓
Outward Inertia Dominates → Accelerated Expansion

This sequence aligns with all major cosmological eras.

**10. Compatibility with Observations**

The PPC description is consistent with:

isotropy and homogeneity of large-scale universe,

expansion history measured by supernova data,

cosmic microwave background pressure oscillations,

structure formation from pressure variations,

accelerated expansion without introducing exotic energy fields.

PPC provides the physical cause behind the geometric behavior seen in standard cosmology.

**11. Conclusion**

Cosmic expansion in PPC gravity is a pressure-driven process, not merely a geometric one. The evolution of gravitational pressure—from extremely high in the early universe to very low today—governs the entire cosmic expansion history.

**Key conclusions:**

Early expansion results from enormous gravitational pressure.

Pressure gradients generate outward field forces.

Surface forces expand every cosmic volume.

Decreasing pressure weakens curvature, accelerating expansion.

Inertia and pressure dynamics together produce the modern expanding universe.

Thus:

Cosmic expansion is the natural consequence of the gravitational pressure field defined by the PPC Law of Gravity.

This offers a unified physical interpretation of cosmology that is intuitive, internally consistent, and compatible with observational data.

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