

## The Role of the Equation-of-State Parameter $\omega$ in PPC Gravity

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### Abstract

The Pressure–Curvature (PPC) Law of Gravity identifies gravitational pressure as the physical cause of spacetime curvature. In PPC gravity, energy density generates gravitational pressure, and this pressure determines curvature and geodesic motion. The equation-of-state parameter governs the relationship between pressure and energy density:

$$P_g = \omega E_d.$$

When  $\omega = 1$ , Then

$$P_g = E_d.$$

Where  $P_g$  is the Gravitational Pressure.

$E_d$  is the Energy density.

$\omega$  is the Equation-Of-State (EOS) parameter.

$\omega$  determines how one transforms into the other.

### Meaning of the Equation-of-State Parameter $\omega$ :-

The value of  $\omega$  determines the physical nature of the matter or energy and how its pressure contributes to curvature. Different forms of matter correspond to different values of  $\omega$  :

<b>Physical System</b>	<b>Pressure-Energy Relation</b>
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Cold matter (dust)	No Pressure Contribution ( $\omega=0$ ) ( $P_g=0$ )
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Radiation	Relativistic Pressure ( $\omega=1/3$ )
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$$P_g = \frac{1}{3}(E_d)$$

Stiff matter	Maximum Pressure $(\omega=1)$ $P_g = E_d$
Dark energy	Negative Pressure $(\omega=-1)$ $P_g = -E_d$
Exotic fields	Super-negative Pressure $(\omega < -1)$ $P_g < -E_d$

Thus,  $\omega$  describes the physical character of the matter content and the pressure it produces.

## 1. Introduction

The Pressure–Curvature (PPC) Law of Gravity proposes that gravitational phenomena arise not merely from mass-energy, but from the pressure produced by mass-energy, which physically bends spacetime. The PPC causal chain is:

$$E_d \rightarrow P_g \rightarrow \text{Curvature} \rightarrow \text{Motion}$$

In this framework, pressure is the direct source of curvature. The relationship between pressure and energy density is governed by the equation-of-state parameter  $\omega$ :

$$P_g = \omega E_d.$$

Because pressure determines curvature in PPC gravity, the parameter  $\omega$  becomes a central physical quantity controlling gravitational behavior.

This paper presents a standalone treatment of the role of  $\omega$ , focusing especially on the fundamental case  $\omega=1$ , where pressure and energy density are equal.

## 2. Special Case $\omega = 1$

When  $\omega=1$ ,

Then Equation becomes,

$$P_g = E_d$$

Gravitation Pressure becomes equivalent to Energy density.

This is a fundamental PPC identity.

$$P_g = E_d$$

### **Physical Interpretation:**

#### **1. Maximum pressure state.**

Energy density is fully converted into gravitational pressure.

#### **2. Maximum curvature for a given energy density.**

Curvature grows in direct proportion to pressure.

#### **3. Strongest gravitational effects.**

Time dilation, redshift, and curvature are maximized.

#### **4. Occurs in ultra-dense matter.**

Such as neutron stars, quark matter, or early-universe epochs.

This regime represents the pure pressure–gravity equivalence predicted by PPC.

### **3. $\omega$ and Curvature in PPC Gravity.**

The Einstein field equations show that:

$$G_{\mu\nu} \propto (\rho + 3P_g/c^2)$$

Substituting  $P_g = wE_d$ , curvature becomes:

$$G_{\mu\nu} \propto E_d(1 + 3w)$$

Therefore:

- **For**  $w = 1 \rightarrow$  curvature is strongest:

$$G_{\mu\nu} \propto 4E_d$$

- **For**  $w = 0 \rightarrow$  curvature is weakest:

$$G_{\mu\nu} \propto E_d$$

This demonstrates the central PPC claim:

**Pressure amplifies curvature far more strongly than mass density alone.**

**(Pressure increases curvature three times more strongly than mass density alone.)**

#### **4. Importance of $\omega$ in the PPC Causal Chain**

The PPC Law expresses gravity through the causal sequence:

Energy Density → Pressure → Curvature → Motion

The role of  $\omega$  is to determine how strongly energy density transforms into gravitational pressure, influencing:

- Strength of curvature
- Time dilation rate
- Pressure-wave propagation
- Structure of compact stars
- Cosmic expansion behavior
- Wormhole formation conditions
- Entropy configuration

Thus,  $\omega$  is the bridge between the physical state of matter and the geometry it creates.

The PPC chain:

$$E_d \rightarrow P_g \rightarrow \text{Curvature} \rightarrow \text{Motion}$$

depends critically on  $w$ .

**Low  $w$ :**

Weak pressure  $\rightarrow$  weak curvature  $\rightarrow$  weak gravity.

**High  $w$ :**

Strong pressure  $\rightarrow$  strong curvature  $\rightarrow$  strong gravity.

$w = 1$ :

Maximum curvature for the matter present.

**Thus,  $w$  is the tuning parameter of gravitational strength.**

## **5. Influence of $\omega$ on Physical Phenomena in PPC**

Because pressure drives curvature, the parameter  $\omega$  influences all gravitational processes.

### **5.1 Time Dilation**

Higher  $\omega \rightarrow$  higher pressure  $\rightarrow$  slower time.

With  $\omega = 1$ :

- extreme time dilation occurs near compact objects,
- clocks slow maximally in stiff-matter environments.

### **5.2 Pressure Waves**

In PPC, gravitational waves are pressure waves.

When  $\omega=1$ , pressure fluctuations couple strongly to curvature, creating:

- stronger wave amplitudes,
- unique modes of pressure oscillation.

### **5.3 Compact Stars**

Neutron stars and quark stars may reach states where  $\omega=1$

PPC predicts:

- stronger gravitational fields,
- higher maximum mass limits,
- different radius–mass relations.

### **5.4 Cosmic Expansion**

In the early universe, if  $\omega = 1$ :

- enormous pressure,
- rapid expansion,
- faster-than-GR early dynamics.

In late universe regimes where average pressure decreases:

- curvature weakens,
- expansion accelerates due to reduced inward pressure.

### **5.5 Entropy and Information**

High-pressure environments store more curvature information.

Thus,  $\omega = 1$  systems:

- have higher gravitational entropy,
- contain more curvature-encoded information,
- influence wormhole throat stability.

### **6. PPC Predictions From $\omega = 1$ :-**

**When  $\omega = 1$ , PPC predicts:**

- Strongest gravitational redshift
- Maximum time dilation
- Enhanced pressure-wave activity
- Larger curvature gradients
- Altered neutron-star mass limits
- Unique signatures in gravitational waves
- Early-universe ultra-fast expansion

These results emerge because pressure and energy density become identical geometric sources.

## 7. Summary and Conclusions

The equation-of-state parameter  $\omega$  plays a fundamental role in PPC gravity. It defines how energy density converts into gravitational pressure, which in turn generates curvature. The case  $\omega = 1$  yields:

$$P_g = E_d,$$

representing the maximal-pressure regime where curvature is entirely pressure-driven.

This regime has profound implications for time dilation, compact objects, gravitational waves, cosmic expansion, and entropy. The parameter  $\omega = 1$  therefore acts as a universal controller of gravitational behavior in the PPC framework.

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