Interstellar Objects in the Universe on the Scale of
P_g=ωE_d :
An Interpretation within Pawan Upadhyay's Pressure–Curvature Law of Gravity

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Abstract

Interstellar objects, including free-floating asteroids, comets, and rogue planets, travel through regions of extremely low mass density and weak gravitational influence. In this paper, their motion is analyzed within **Pawan Upadhyay's Pressure–Curvature Law of Gravity (PPC Law)** using the relation $P_g = wE_d$, where gravitational pressure is proportional to energy density through an equation-of-state parameter w. It is shown that interstellar space corresponds to a low-pressure regime ($w \ll 1$), leading to weak spacetime curvature and near-inertial geodesic motion. Pressure–curvature waves are discussed as dynamical perturbations whose amplitude depends on pressure but whose propagation speed remains universal. Interstellar objects are thus interpreted as natural probes of the large-scale pressure structure of the universe.

1. Introduction

Observations of interstellar objects—such as 1I/'Oumuamua and 2I/Borisov—have demonstrated that solid bodies can travel between stellar systems. Traditional gravitational theories describe their motion using Newtonian dynamics or geodesic motion in General Relativity. However, these approaches do not explicitly emphasize the physical role of pressure in shaping spacetime and motion.

The **Pressure–Curvature Law of Gravity (PPC Law)** provides a physically intuitive framework in which gravity arises from pressure generated by mass density. This paper applies the PPC framework to interstellar objects, focusing on their behavior in low-pressure environments characterized by the relation $P_g = w$

2. Gravitational Pressure in PPC Gravity

In PPC gravity, gravitational pressure P_g is related to energy density E_d by

$$P_g = wE_d, \quad \text{where} \quad E_d = \rho c^2.$$

Here:

- ρ is mass density,
- c is the speed of light,
- w is the equation-of-state parameter defining the physical regime.

This relation allows gravitational environments to be classified according to pressure scale rather than mass alone.

3. Interstellar Space as a Low-Pressure Regime

Interstellar space is characterized by extremely low mass density:

$$\rho \to \text{very small} \quad \Rightarrow \quad E_d \to \text{very small}.$$

For ordinary matter in weak gravitational fields,

$$\boxed{w \ll 1}.$$

Thus,

$$P_g = wE_d \ll 1.$$

This places interstellar space firmly in the **low-pressure, weak-curvature regime** of PPC gravity.

4. Spacetime Curvature and Motion of Interstellar Objects

In the low-pressure regime:

- pressure gradients are minimal,
- spacetime curvature is nearly flat,
- the pressure-gradient field force $-\nabla P_g$ is very weak.

As a result, interstellar objects follow **nearly straight geodesics** over vast distances. Significant deflections occur only when such objects pass through localized regions of higher pressure, such as near stars, planetary systems, or dense molecular clouds.

This explains how interstellar objects can traverse the galaxy while remaining only weakly influenced by gravitational fields for most of their journey.

5. Pressure–Curvature Waves in Interstellar Space

Pressure–curvature waves arise from time-dependent variations in gravitational pressure and spacetime curvature produced by accelerated mass–energy. In PPC gravity:

- pressure waves propagate at the universal speed c,
- wave speed is independent of source mass,
- wave **amplitude** depends on the pressure scale P_g.

In interstellar space, where $P_g \ll 1$, pressure waves are extremely weak. Nevertheless, they may induce small, transient perturbations in nearby low-mass bodies through **surface force**, particularly for dust, small asteroids, or loosely bound material.

6. Interaction with Nearby Gravitational Systems

When interstellar objects encounter regions of higher wE_d, such as stellar environments:

- gravitational pressure increases,
- curvature becomes stronger,
- trajectories may bend significantly.

Temporary capture, hyperbolic flybys, or orbital insertion can occur depending on the pressure gradient encountered. Thus, interstellar motion is interpreted as **movement through a pressure-structured spacetime landscape**.

7. Hierarchy of PPC Gravitational Regimes

The PPC framework naturally orders gravitational environments:

- **Interstellar space:** $w \ll 1$, very low pressure, nearly flat spacetime
- **Planetary systems:** $w \ll 1$, low to moderate pressure
- **Compact objects:** $w \sim 1$, high pressure, strong curvature
- **Black hole vicinity:** $w = 1$, maximum pressure and curvature

Interstellar objects occupy the lowest end of this hierarchy.

8. Physical Interpretation

Within PPC gravity, interstellar objects are not merely passive travelers but **test bodies revealing the pressure structure of spacetime**. Their near-inertial motion reflects the extremely low gravitational pressure of interstellar space, while their rare deflections reveal localized pressure enhancements.

9. Conclusion

This paper has shown that interstellar objects naturally fit within the **low-pressure regime** of Pawan Upadhyay's Pressure–Curvature Law of Gravity. Using the relation , interstellar space is characterized by weak curvature and minimal pressure gradients, allowing nearly free geodesic motion across the universe. Pressure–curvature waves exist in principle but are extremely weak in such environments. Interstellar objects thus serve as natural probes of the large-scale gravitational pressure distribution of the cosmos.

Key Statement

> *In PPC gravity, interstellar objects move through low-pressure, weak-curvature regions of spacetime defined by $P_g = wE_d$ with $w \ll 1$, resulting in near-inertial geodesic motion across the universe.*

The interpretation presented here is consistent with the geometric formulation of gravity, geodesic motion, and gravitational-wave propagation described in standard General Relativity textbooks [1–7].
