Surface-Tension Gravity Calibrated by GPS Time Dilation

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Abstract

We summarize a "surface-tension gravity" model in which (i) a spherically symmetric compression factor $C(r)$ of a space-like medium controls an intrinsic wave speed $v(r)$ for light-like propagation, (ii) local clock rates adjust inversely with $v(r)$ so that measured light speed remains c, and (iii) compression implies density and pressure variations governed by a bulk modulus K. A single GPS gravitational time-dilation datum is used to fix the compression profile parameter α in $C(r) = 1 + \alpha/r$. A coupling constant σ is introduced to fit K so that the model reproduces $g \approx 9.8\,\mathrm{m/s^2}$ at Earth's surface. The resulting model predicts the correct $1/r^2$ scaling of $g(r)$ and yields a parameter-free prediction for the gravitational time-dilation offset at ISS altitude. In later work we promote $C(r)$ to an effective metric with reciprocal time/space scaling; this is required for correct leading-order light-propagation tests (deflection, Shapiro delay), while leaving the GPS clock-ratio calibration unchanged.

1 Introduction

In the Theory of General Relativity, gravity is not considered a force, but rather a curvature of spacetime. In recent decades, efforts have been made to reformulate the theory using aspects of fluid dynamics, imagining the pull of gravity as the flow of some non-viscous, ideal fluid. In this paper, we will examine gravity from the perspective of surface tension, which is a thermodynamic property of fluids. Focusing on surface tension as an analogy to General Relativity makes sense, because surface tension curves the surface of fluids and gravity curves spacetime. The meniscus of a fluid in particular is a good analogy for spacetime curvature, as it suggest that spacetime adheres to substances in the same way that water adheres to sides of a standing container. Surface tension is also measured in the same force units as gravity, whether dynes or in Newtons. However, despite this, very little work has been done on this subject and the author could find only one paper by Himanshu, et al. [1], which actually deals with the subject directly. In that paper, Himanshu, et al. [1] employed surface tension to describe the tangential pressure of a normal curvature in curved spacetime. Elsewhere, Callaway employed the density matrix formalism developed previously for studying the origin of black hole entropy as a means to evaluate the surface tensions of various fluids [2]. But little has been done to reverse this logic and describe gravity in terms of the equations of surface tension and much less on the meniscus, which this paper focuses on.

The reason why surface tension is not more commonly used as a description of gravity is likely due to the fact that surface tension (as its name implies) is restricted to a boundary, whereas gravity permeates a solid body. Indeed, Himanshu, et al. appear to be aware of this, as they restrict their research to the boundary of a hypersurface [1]. However, this restriction also makes sense from the point of view of modern thermodynamic views of gravity, also known as 'Entropic Gravity', which considers gravity as somehow emergent from a lower dimensional manifold. Gravity is no longer a 4-dimensional (3 + 1) force, it is two or even one dimensional (at least at the quantum scale).

The impetus for this view of gravity comes from thermodynamic research into black holes [3]. This research shows that the entropy of a black hole is linearly proportional to its horizon area,

or the area of the 'excluded region' [4, 5]. Therefore, it makes perfect sense to try and model the gravity at the event horizon as a surface tension of a hypersurface. And yet, this relation between gravity and thermodynamics makes the question of why surface tension is not employed more often in Entropic Gravity research even more perplexing, because there are thermodynamic descriptions of surface tension. Indeed, there are obvious similarities between the equations for the Unruh Temperature [6]. and Hawking Radiation (which are essentially the same) and those for the thermodynamic description of surface tension.

In this paper, we attempt to model gravity as a surface tension force in a compressible ether or space-like medium, using the equation $\gamma = F/L$, where γ is the surface tension (which in this case is equal to the Gravitational constant (G)), F is the force (with SI units N/m), and L is the circumference of the Earth (40075.017 km). Unlike the research above, this method is purely 3-dimensional and does not consider or make use of hyperspheric boundaries.

In physical models of surface tension, tension is modelled as a pull force. In the centre, or bulk of a fluid, this pull is acting on a single molecule of the fluid in all directions equally. Closer to the surface (near the interface of the liquid and the air), this pull force becomes unbalanced; leading to the surface tension, meniscus and capillary actions. In this paper, gravity (or space curvature) is the result of the surface tension of the ether or space like fluid. The idea is that in free space there is a pressure acting from all directions on a point. When a massive body is introduced, it blocks this pressure on one side causing a pressure differential on the other, which is the surface tension model of gravity. This surface tension compresses space at the boundary of the massive object. Unlike surface tension models in a fluid, which is a 'pull force', in the Surface Tension Gravity (STG) conception, gravity is modelled as a 'push force'. This makes it conceptually similar to Le Sage's "push gravity / shadowing pressure" models; however, there are clear distinctions, as there are no particles mediating the force in STG.

In the Theory of General Relativity, gravity is purely geometric and therefore not a force. In STG, however, gravity can be considered as either a real force, or a geometric curvature/compression of space (and/or spacetime). The amount of compression regulates the speed of light, which in turn regulates the speed of time. Therefore, surface tension gravity only deals with curved space, time dilation is a byproduct of how curved space effects the speed of light. In this paper, we attempt to reverse this conceptual process, by calculating the amount of curvature (compression) by the amount that time dilates (which is the variability of the speed of light) and associating that with our gravitational force $9.8m/s^2$. However, the end result only deals with considerations like proper and coordinate time and is therefore fully compatible with Metric Theory and (from that standpoint) with General Relativity.

2 Methodology

Empirical input

GPS satellites exhibit a well-known gravitational clock-rate offset of about $+45.7\,\mu s/day$ relative to clocks on Earth's surface (separate from the special-relativistic velocity effect). Define the fractional gravitational rate difference

$$\epsilon_{\text{GPS}} \equiv \frac{\Delta\dot{\tau}}{\dot{\tau}} \approx \frac{45.7 \times 10^{-6}}{86400} \approx 5.289 \times 10^{-10}. \tag{1}$$

Core postulates

1. **Compression field:** space/ether has a dimensionless compression factor $C(r)$ with $C(\infty) = 1$.

2. **Grid-frequency law (with $\beta = 2$):** intrinsic propagation speed scales as

$$v(r) \propto C(r). \tag{2}$$

3. **Clock-speed reciprocity:** proper time rate scales inversely with $v(r)$,

$$\frac{d\tau(r)}{dt} \propto \frac{1}{v(r)} \propto \frac{1}{C(r)}. \tag{3}$$

Hence for two radii r_1, r_2,

$$\frac{\tau(r_2)}{\tau(r_1)} = \frac{C(r_1)}{C(r_2)}. \tag{4}$$

4. **Isotropic compression:** density scales as $\rho \propto C^3$.

5. **Linear bulk modulus:** pressure changes obey $\Delta P \approx K\,\Delta\rho/\rho$.

Compression profile and calibration

Assume the minimal spherically symmetric profile

$$C(r) = 1 + \frac{\alpha}{r}, \qquad C(\infty) = 1. \tag{5}$$

From (4), the GPS datum implies

$$\frac{C(R_E)}{C(r_{\mathrm{GPS}})} - 1 = \epsilon_{\mathrm{GPS}}. \tag{6}$$

Using $R_E = 6.378\,137 \times 10^6$ m and $r_{\mathrm{GPS}} \approx 2.66 \times 10^7$ m gives

$$\alpha \approx 4.44 \times 10^{-3}\,\mathrm{m}. \tag{7}$$

Gravity scaling (Option B)

Option B treats γ as a boundary property and $g(r)$ as a local field determined by the spatial variation of the compression profile. Since

$$\frac{\mathrm{d}C}{\mathrm{d}r} = -\frac{\alpha}{r^2}, \tag{8}$$

any local coupling of the form $g(r) \propto |dC/dr|$ yields

$$g(r) = g(R_E)\left(\frac{R_E}{r}\right)^2, \tag{9}$$

matching the familiar $1/r^2$ scaling.

Fit of K (requires a coupling constant)

To fix an absolute scale, introduce a universal coupling σ (dimensions m^2/kg) such that the surface gravity is generated by a characteristic pressure scale:

$$g(R_E) = \sigma\,\Delta P_{\mathrm{GPS}}. \tag{10}$$

With isotropic compression and linear bulk modulus,

$$\Delta P_{\mathrm{GPS}} \approx K\,(3\epsilon_{\mathrm{GPS}}), \tag{11}$$

so

$$K = \frac{g(R_E)}{3\epsilon_{\mathrm{GPS}}\,\sigma}. \tag{12}$$

For $\sigma = 1\,\mathrm{m}^2/\mathrm{kg}$ and $g(R_E) = 9.806\,65\,\mathrm{m/s}^2$,

$$K \approx 6.18 \times 10^9\,\mathrm{Pa}. \tag{13}$$

ISS prediction (parameter-free once α is fixed)

At ISS altitude $h \approx 400\,\text{km}$ (so $r_{\text{ISS}} = R_E + h$), the model predicts

$$\epsilon_{\text{ISS}} = \frac{C(R_E)}{C(r_{\text{ISS}})} - 1 \approx 4.106 \times 10^{-11} \tag{14}$$

corresponding to about

$$\Delta\tau_{\text{ISS}} \approx \epsilon_{\text{ISS}} \times 86400 \text{ s} \approx 3.55\,\mu\text{s/day} \tag{15}$$

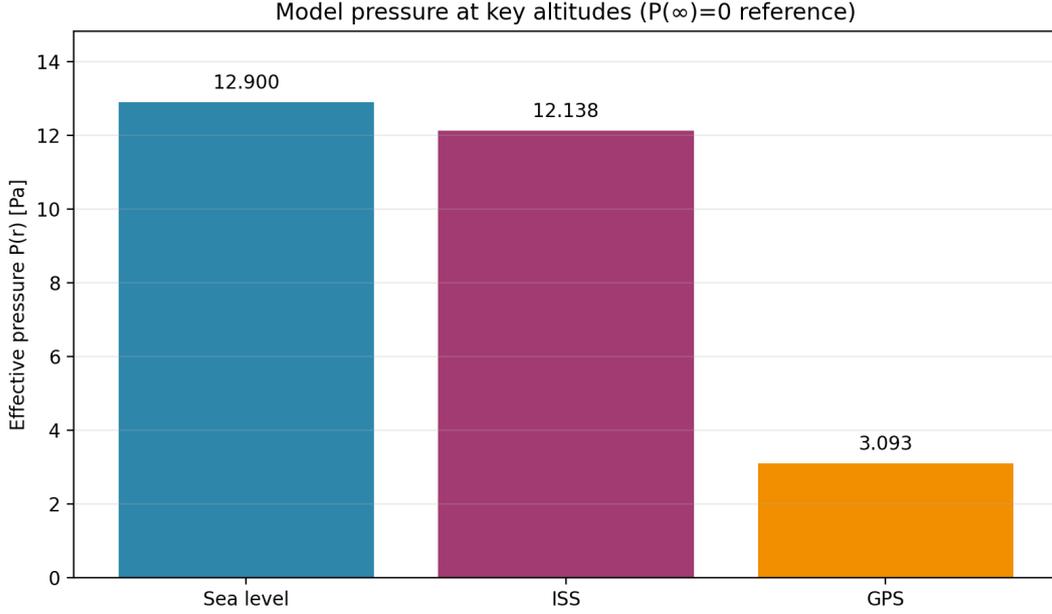(gravitational component only).

Figure 1: Absolute pressure bar chart.

Boundary surface tension (computed once)

Using Young–Laplace for a spherical interface, $\Delta P = 2\gamma/R_E$, choose a boundary condition $\Delta P_{\text{boundary}} \approx P(R_E)$ with $P(\infty) = 0$. From the bulk-modulus integration,

$$P(r) = 3K \ln C(r), \tag{16}$$

so $P(R_E) \approx 12.90\,\text{Pa}$ and

$$\gamma = \frac{R_E}{2} P(R_E) \approx 4.11 \times 10^7\,\text{N/m}. \tag{17}$$

The corresponding circumference force is $F = \gamma(2\pi R_E) \approx 1.65 \times 10^{15}\,\text{N}$.

3 Full pipeline (detailed and explicit)

3.1 Definitions and parameters

Let r denote radius from Earth's center. Define:

- $C(r)$: dimensionless compression factor of the medium.

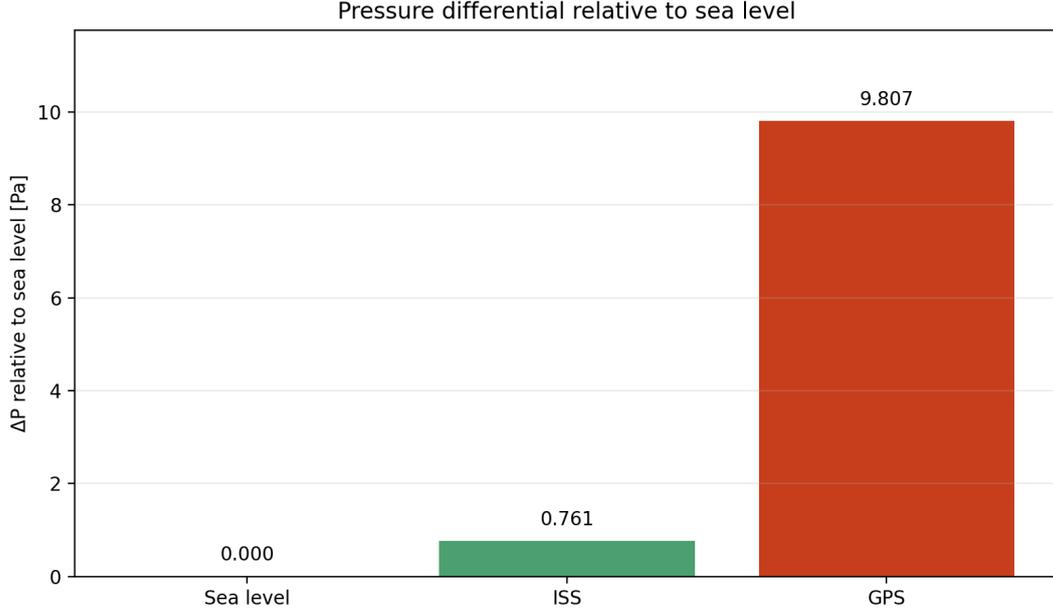- $v(r)$: intrinsic propagation speed in the medium.

Figure 2: Pressure differential relative to sea level.

- $\tau(r)$: proper time measured by a local clock.

- K: bulk modulus of the medium (assumed constant here).

- $\rho(r)$: effective density of the medium.

- $P(r)$: effective pressure in the medium.

- R_E: Earth reference radius; take $R_E = 6.378\,137 \times 10^6$ m.

- r_{GPS}: GPS orbital radius; take $r_{\mathrm{GPS}} \approx 2.66 \times 10^7$ m.

- $h_{\mathrm{ISS}} \approx 400$ km so $r_{\mathrm{ISS}} = R_E + h_{\mathrm{ISS}}$.

3.2 Step 1: Grid-frequency law ($\beta = 2$) and intrinsic speed

Motivating picture: a light-like mode alternates energy between neighboring cells; compressing the cell size increases oscillation frequency. A generalized law is $f \propto C^\beta$. Combined with a characteristic step length scaling as $a \propto 1/C$, the intrinsic speed scales as $v \sim af \propto C^{\beta-1}$. Choosing $\beta = 2$ yields Eq. (2).

3.3 Step 2: Clock-speed reciprocity

Assume local clock rates adjust inversely with the intrinsic propagation speed so that observed light speed is fixed:

$$\frac{d\tau(r)}{dt} = \mathcal{N}\,\frac{1}{C(r)}, \tag{18}$$

with a constant normalization $\mathcal{N}$ that cancels in ratios. This yields Eq. (4).
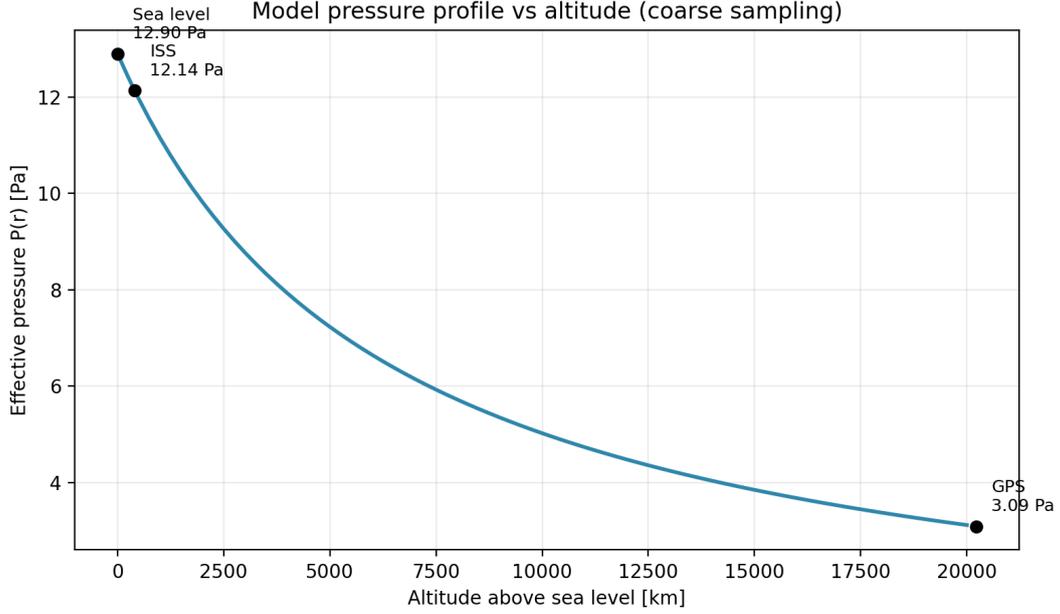
Figure 3: Pressure profile vs altitude from 0 to GPS altitude.

3.4 Step 3: Extract a compression profile from GPS

Use the GPS gravitational clock offset $+45.7\,\mu\text{s/day}$ (gravitational component). This implies

$$\frac{\tau(r_{\text{GPS}})}{\tau(R_E)} \approx 1 + \epsilon_{\text{GPS}}, \qquad \epsilon_{\text{GPS}} \approx 5.289 \times 10^{-10}. \tag{19}$$

By Eq. (4),

$$\frac{C(R_E)}{C(r_{\text{GPS}})} \approx 1 + \epsilon_{\text{GPS}}. \tag{20}$$

Assume the minimal one-parameter spherically symmetric profile Eq. (5). Solve

$$\frac{1 + \alpha/R_E}{1 + \alpha/r_{\text{GPS}}} - 1 = \epsilon_{\text{GPS}} \tag{21}$$

to obtain

$$\alpha \approx 4.44 \times 10^{-3}\,\text{m}. \tag{22}$$

3.5 Step 4: Predict time dilation at a new altitude (ISS)

Given α and Eq. (5),

$$\epsilon(r) \equiv \frac{\tau(r)}{\tau(R_E)} - 1 = \frac{C(R_E)}{C(r)} - 1. \tag{23}$$

At $r = r_{\text{ISS}} = R_E + 400\,\text{km}$,

$$\epsilon_{\text{ISS}} \approx 4.106 \times 10^{-11} \quad \Rightarrow \quad \Delta\tau_{\text{ISS}} \approx \epsilon_{\text{ISS}} \times 86400\,\text{s} \approx 3.55\,\mu\text{s/day}. \tag{24}$$

3.6 Step 5: Compression → density

Assume isotropic compression in three spatial dimensions:

$$\rho(r) = \rho_0\,C(r)^3. \tag{25}$$

For small differences between two radii, $\Delta\rho/\rho \approx 3\,\Delta C/C$.

6

3.7 Step 6: Density → pressure via bulk modulus

Using the linear bulk-modulus relation for small changes,

$$\Delta P \approx K \frac{\Delta \rho}{\rho}. \tag{26}$$

Differentially, $dP = K\, d\rho/\rho = 3K\, dC/C$, which integrates to Eq. (16) with $P(\infty) = 0$.

3.8 Step 7: Fit K using $g(R_E)$ (introducing σ)

To relate the medium pressure scale to observed surface gravity, introduce a universal coupling parameter σ with dimensions m^2/kg:

$$g(R_E) = \sigma\, \Delta P_{\mathrm{GPS}}, \tag{27}$$

where ΔP_{GPS} is the pressure difference implied between R_E and r_{GPS}. Using the small-change relation with isotropic compression,

$$\Delta P_{\mathrm{GPS}} \approx K\, (3\epsilon_{\mathrm{GPS}}). \tag{28}$$

Substituting into Eq. (27) yields Eq. (12). For $\sigma = 1\,\mathrm{m}^2/\mathrm{kg}$,

$$K \approx 6.18 \times 10^9\,\mathrm{Pa}. \tag{29}$$

3.9 Step 8: Boundary surface tension (Young–Laplace) and force

Apply the Young–Laplace relation for a spherical interface,

$$\Delta P_{\mathrm{boundary}} = \frac{2\gamma}{R_E}. \tag{30}$$

A minimal boundary condition is to take the pressure inside the massive body as the reference ("shielded") level $P_{\mathrm{in}} \approx 0$ in the gauge where $P(\infty) = 0$, so $\Delta P_{\mathrm{boundary}} \approx P(R_E) = 3K \ln C(R_E)$. Then

$$\gamma = \frac{R_E}{2} P(R_E) \approx 4.11 \times 10^7\,\mathrm{N/m}. \tag{31}$$

The corresponding force around the boundary (circumference $L = 2\pi R_E$) is

$$F = \gamma L = \gamma\,(2\pi R_E) \approx 1.65 \times 10^{15}\,\mathrm{N}. \tag{32}$$

3.10 Step 9 Field scaling: recovering $1/r^2$

With Eq. (5),

$$\frac{\mathrm{d}C}{\mathrm{d}r} = -\frac{\alpha}{r^2}. \tag{33}$$

If gravitational acceleration is locally proportional to the gradient magnitude, $g(r) = \kappa\,|dC/dr|$, then

$$g(r) = g(R_E) \left(\frac{R_E}{r} \right)^2, \tag{34}$$

where κ cancels after fixing $g(R_E)$. At ISS altitude this gives $g_{\mathrm{ISS}} \approx 8.68\,\mathrm{m/s}^2$.

4 Notes, limitations, and next tests

- The pipeline above is deliberately minimal: one GPS datum fixes α; one coupling choice (σ) fixes K; Option B yields the correct $1/r^2$ scaling.

- The boundary condition for $\Delta P_{\text{boundary}}$ controls the absolute magnitude of γ and F but does not affect altitude scaling predictions for time dilation.

- Next empirical checks: apply the same $C(r)$ to other satellite altitudes (LEO, GEO) and compare predicted gravitational clock offsets; compare predicted $g(r)$ scaling to measured g; and test whether a single σ can remain universal across materials.

References

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