Emergent Gravity and Mass as a State of Spacetime:
The Tensed Brane Model in Higher Dimensions

Arkadiusz Okupski

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Abstract

This paper presents a hypothesis in which the phenomena of gravity and the existence of mass emerge from fundamental interactions occurring in 5-dimensional spacetime (CP5D). We postulate the existence of two coupled branes: the matter brane (B_{ma}) and the antimatter brane (B_{an}). Their mutual gravitational repulsion in CP5D tensions the B_{ma} brane, imparting to it a global gravitational background. Mass is interpreted as a local "thickening" or "compression" of the spacetime structure – a region of elevated energy density that, in response to global tension, creates a local indentation in the metric (curvature). In this geometry, whose description remains fully consistent with the equations of GR, the motion of test bodies is perceived as gravitational force. This model complements GR by adding a dynamic mechanism of curvature formation without changing its fundamental equations. The model offers a unified explanation for the origin of gravity, the existence of mass, and matter-antimatter asymmetry, suggesting they are manifestations of higher-dimensional geometry. The model allows for an estimation of the fundamental gravitational constant in 5 dimensions ($G_5 \sim 10^{26} \mathrm{m}^4/(\mathrm{kg} \cdot \mathrm{s}^2)$), suggesting that the apparent weakness of 4D gravity results from its suppression by the vast scales of higher-dimensional geometry.

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1 Introduction: From Gravity to Higher-Dimensional Geometry

Classical General Relativity (GR) describes gravity as the local curvature of 4-dimensional spacetime (CP4D) by mass-energy. However, questions remain about the origin of mass-energy itself and the nature of the gravitational constant G. This hypothesis proposes that gravity is an emergent effect, arising from interactions within a fundamental, 5-dimensional spacetime (CP5D).

2 Basic Assumptions of the Model

The hypothesis is based on the following pillars:

- **CP5D:** Fundamental spacetime with 4 spatial dimensions + 1 time dimension.

- **Brane Structure:** Two parallel, coupled 4-dimensional branes exist in CP5D:

  - Matter brane (B_{ma}) – our observable universe.
  - Antimatter brane (B_{an}) – a universe dominated by antimatter.

- **Fundamental Interaction:** The branes interact via a *repulsive*, new quasi-gravitational force. Both matter and antimatter possess positive mass and energy, in accordance with GR.

  Antimatter, due to its unique quantum properties, couples differently to the spacetime metric. This differential coupling is the source of the apparent repulsion between matter and antimatter configurations.

  The analogy is the behavior of a polystyrene ball (analog of antimatter) and a pin (analog of matter) on the water surface. Both are attracted by Earth's gravity (analog of GR gravitational attraction). However, the ball, due to buoyancy and the fact that adhesion forces between water and polystyrene exceed water's cohesion forces (analog of differential quantum coupling), causes the formation of an inverse meniscus ("hill" type) around itself. Consequently, the meniscus around the ball repels from the meniscus around the pin ("depression" type), creating a phenomenological effect of apparent repulsion between the objects. Estimates for the scale of the constant G_5 are presented in Section 4.

$$F_{5D} = G_5 \frac{\mathcal{M}_{ma} \cdot \mathcal{M}_{an}}{r^3}$$

- **Nature of Matter:** Mass-energy on the B_{ma} brane is identified with a local "thickening" or "compression" of its 4-dimensional structure. Matter creation and annihilation processes correspond to "compression" and "decompression" of spacetime, respectively.

  The analogy is a crumpled paper sheet and a flat paper sheet. Both states are the same unity – the paper. Matter is essentially compressed spacetime, just like a crumpled paper sheet that can be completely flattened (annihilation) or partially flattened. To "compress" spacetime into the form of matter, an enormous amount of energy $E = mc^2$ is required, which becomes trapped in this complex configuration.

  In summary, spacetime and matter are inextricably linked at the most fundamental, geometrical level of existence. Matter is not a "foreign" body in spacetime, but its specific, energetic state of aggregation.

3 Mechanism of Emergence of Gravity and Mass

The process of forming observed gravity is three-stage:

1. **Global Tension:** Mutual repulsion of the B_{ma} and B_{an} branes in CP5D tensions the B_{ma} brane, imparting to it a fundamental, global "gravitational background". This is a necessary condition – analogous to inflating a balloon.

2. **Local "Thickening" Response:** A local concentration of energy (mass) on the B_{ma} brane is a "stiffer" region. In response to global tension, the "stiff" thickening *lags behind* the stretching, "soft" surroundings, creating a local **indentation** (negative curvature) in the CP4D metric.

3. **Force Manifestation:** The motion of test bodies occurs along the geodesics of this locally deformed metric, which we observe as the gravitational force described by GR. Two "thickenings" (masses) attract each other, seeking to minimize the elastic energy of the tensed brane.

4 Estimation of G_5: How Strong is Fundamental Gravity?

The model allows for a heuristic estimation of the scale of the fundamental gravitational constant in 5 dimensions (G_5). The goal is to show how the apparent weakness of gravity in 4D ($G_4 \sim 10^{-11}$) can emerge from a much stronger interaction in 5D, suppressed by the enormous scales of compactification.

4.1 Calibration on the Scale of the Observable Universe

We assume that the global tension of our brane (B_{ma}), which manifests as a gravitational background, originates from interaction with the antimatter brane (B_{an}) in CP5D. We take the weight (F) felt by a human on Earth ($F = mg$) as the calibration point. The key assumption is that this force is a direct manifestation of the interaction between the branes. In other words, this fundamental interaction in 5D is *the same phenomenon* as gravity in 4D, only described in different reference frames:

$$\text{Force in 5D:} \quad F_{5D} = G_5 \frac{M \cdot m}{r^3}$$
$$\text{Force in 4D:} \quad F_{4D} = mg$$
$$\text{We assume:} \quad F_{5D} \approx F_{4D}$$

Where:

- M - mass content of the observable Universe (estimated as $M \approx 10^{54}$ kg),

- r - radius of the observable Universe ($r \approx 4.4 \times 10^{26}$ m), identified here with the distance between branes in CP5D.

- m - test mass (human, $m = 70$ kg),

- g - Earth's gravitational acceleration ($g = 9.81$ m/s²).

4.2 Calculation

Substituting the assumed values into the relation $F_{5D} \approx F_{4D}$ and solving for G_5, we get:

$$G_5 = \frac{F_{4D} \cdot r^3}{M \cdot m} = \frac{(mg) \cdot r^3}{M \cdot m} = \frac{g \cdot r^3}{M}$$
$$= \frac{(9.81) \cdot (4.4 \times 10^{26})^3}{10^{54}}$$

Calculating the value of the expression $(4.4 \times 10^{26})^3$:

$$(4.4)^3 \times (10^{26})^3 = 85.184 \times 10^{78} \approx 8.52 \times 10^{79}$$

Continuing the calculations:

$$G_5 \approx \frac{9.81 \cdot 8.52 \times 10^{79}}{10^{54}} = \frac{8.36 \times 10^{80}}{10^{54}}$$
$$\approx 8.36 \times 10^{26} \ \mathrm{m}^4/(\mathrm{kg} \cdot \mathrm{s}^2)$$

4.3 Interpretation of the Result

The obtained value $G_5 \sim 10^{26}$ is **astronomically large** compared to $G_4 \sim 10^{-11}$. This means the gravitational interaction in fundamental, 5-dimensional space is **extremely strong**.

Its apparent weakness in our 4-dimensional reality results from:

1. The suppressing distance dependence in the 5D gravity law $(1/r^3)$.

2. The enormous scale of the distance r between branes, identified with the size of the observable Universe. This identification suggests a potential link between the brane tension mechanism and Hubble expansion.

3. A mechanism of compactification or projection, whereby we "feel" only a fraction of the full interaction force.

This estimation, although highly speculative, demonstrates the **dimensional consistency** of the model and offers a qualitative explanation for the hierarchy between the gravitational constants. It also presents the emergent nature of scale: the size of the Universe and the "weakness" of gravity are inextricably intertwined within this model.

5 Energetic Balance: The Thermodynamic Cost of Curvature Creation

A key element of the model is explaining the origin of the energy necessary to "bulge" spacetime and create curvature. In the standard GR treatment, this issue is omitted. In this hypothesis, we model the process of curvature formation around a mass m as an "endothermic" reaction, where the "system" is spacetime and mass, and the "surroundings" are an external energy source.

5.1 States and Energies

The process of transition from flat to curved spacetime around a mass can be described by three energy states:

- **State 1 (Separated):** Flat spacetime (with energy E_1) and mass m (with energy $E_m = mc^2$) exist independently. The analogy is a pin above water.

- **State 2 (Adhesion):** The process of spacetime "adhering" to mass/energy occurs. Analogy: we place the pin on the water. The pin starts touching the water.

- **State 3 (Curved):** Curved spacetime with the metric $\tilde{g}_{\mu\nu}$ (e.g., Schwarzschild) is formed, with energy E_3. Analogy: the pin floats on the water. A meniscus forms around it.

5.2 Balance Equation and Energy Source W

The energy conservation principle for this process is written as:

$$E_3 - E_1 = W \tag{1}$$

where W is the work supplied to the system from the outside.

The "bulging" process is endothermic ($E_3 > E_1$), which implies $W > 0$. This means the **system absorbs energy from the outside**:

$$W = E_3 - E_1 > 0 \tag{2}$$

The value W is the "bulging" energy introduced during curvature formation.

We postulate that the source of this energy is the fundamental interaction in CP5D between the matter brane (B_{ma}) and the antimatter brane (B_{an}).

Their mutual repulsion is a continuous source of energy that "drives" the geometry of our universe, forcing the bulging (curving) process of spacetime around masses.

As stated earlier, the role of mass is purely passive – it is merely a "template" or "geometric charge" that determines *where* spacetime should bulge. The external energy provides the impulse, telling it *that* it should do so.

5.3 Balance Summary

The energy balance (1) closes the model, providing a consistent description of the "cost" of creating curvature. It shows that the Einstein field equation $G_{\mu\nu} = \kappa T_{\mu\nu}$ describes the *final state* (*already curved* geometry) of a dynamic, endothermic process whose drive requires the existence of an external energy source.

6 Consequences and Predictions of the Model

- **Origin of Gravity:** The force $F = mg$ is an emergent effect of geometry, not a fundamental interaction.

- **Weakness of Gravity:** As shown in the estimates (Section 4), the apparent weakness of the G_4 constant emerges from an extremely strong interaction in 5D ($G_5 \sim 10^{26}$), suppressed by the enormous inter-brane distance scale.

- **Matter-Antimatter Asymmetry:** The model naturally solves the segregation problem by separating matter and antimatter onto distinct branes.

- **Nature of Mass:** Mass is a structural property of spacetime, not an independent entity.

- **Prediction:** The model predicts that precise measurements of the gravitational constant G at different distance scales could reveal residuals of the global brane tension influences.

Summary

The presented hypothesis offers a bold, unifying vision where gravity, mass, and matter-antimatter asymmetry emerge from higher-dimensional geometry. The proposed mechanism of the "tensed brane and thickenings" provides

a consistent picture, connecting physical intuition with the mathematical formalism of GR. Further work should focus on the rigorous formulation of the field equations for this model and on identifying its possible observational signatures.

References

[1] R. Randall, R. Sundrum. *Large Mass Hierarchy from a Small Extra Dimension.* Phys. Rev. Lett. 83, 3370 (1999).

[2] T. Kaluza. *Zur Unitätsproblem der Physik.* Sitzungsber. Preuss. Akad. Wiss. Berlin (Math. Phys.) 1921, 966 (1921).

[3] J. A. Wheeler. *Geons.* Phys. Rev. 97, 511 (1955).

[4] A. Okupski. *The Emergent Gravity from Substrate Phase.* https://github.com/ArkOkupski-WAT/Hypothesis-of-Emergent-Gravity-from-Substrate-Phase, 2024.

[5] A. Okupski. *G-2 Force: Spacetime Adhesion Model.* https://github.com/ArkOkupski-WAT/G-2-Force-Spacetime-Adhesion-Revised-Model, 2024.