

Hyperverses, 5-Dimensional Gravity and Multiverses as Nested Gogberashvili Shells

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Abstract

We consider the *Hyperverses* as a collection of multiverses in 5-dimensional spacetime with gravitational constant G . Each multiverse in our simplified model is a bouquet of nested spherical Gogberashvili shells. If g_k is the gravitational constant of a thin shell S_k and ε_k , its thickness then $G \sim \varepsilon_k g_k$. The physical universe is supposed to be one of those shells inside the local nested bouquet called *Local Multiverse*. We relate this construction to Robinson-Trautman metrics describing expanding spacetimes with spherical gravitational waves. Supermassive astronomical black holes, located at cores of elliptical/spiral galaxies, are also conjecturally described within this theory. Our constructions are equally consistent with the modern theory of cosmological coupling.

Keywords

5-Dimensional Gravity, Black Hole, Multiverse, Spherical Shell

1. Introduction

According to *Newton's shell theorem*, the gravitational force, exerted on any object inside a hollow spherical shell, is zero. Consequently, in the case of nested hollow shells, one can ignore all spherical shells of greater radius.

One century ago Kaluza and Klein constructed a 5-dimensional gravitation theory unified with electromagnetism. However, the extra fifth dimension in this theory is curled up to an unobservable scale.

An alternative model with a true higher-dimensional Hyperverses where the matter is trapped on a 4-dimensional domain wall (D -brane), appeared, *e.g.*, in the paper by Rubakov and Shaposhnikov [1].

Gogberashvili constructed an exact Schwarzschild-like solution of 5-dimensional

Einstein equations, exhibiting an expanding spherical shell [2]. He also solved the *hierarchy problem*, reducing the particle theory to the same scale G (5-dimensional gravity constant).

In addition, the trapping of matter on this shell is gravitationally repulsive and the expansion of Gogberashvili's spherical shell is accelerating, solving also the problem of dark energy.

In my recent paper [3], it was argued that our Local Multiverse \mathcal{M} can be considered as a time-amalgamated product of spacetimes. Here, first of all, we pursue this idea of representing the 4-dimensional stratum of \mathcal{M} as a bouquet of nested Gogberashvili shells.

Cosmological constants around subsequent shells satisfy some recursive equations reflecting a certain *harmony of the spheres* (cf. Section 4).

In the second part of this article, we discuss intriguing relationships between astronomical black holes, spherical gravitational waves, multi-solitons/gyratons and Gogberashvili multiverses.

2. 5-Dimensional Einstein Equations

Consider the 5-dimensional Einstein equation in the following form:

$$R_{\mu\nu} - \frac{1}{2} g_{\mu\nu} R = \Lambda g_{\mu\nu} + 6\pi^2 G R_{\mu\nu} \quad (2.1)$$

Gogberashvili searched for a Schwarzschild-like solution of the form:

$$ds^2 = A(r) dt^2 - A(r)^{-1} dr^2 - r^2 d\Omega^2, \quad (2.2)$$

where r is the 4-dimensional radial coordinate and $d\Omega^2$ is the 3-dimensional volume element ([2], Equations (2)-(4)).

The solution is given in terms of metrics of inner and outer regions:

$$ds_+^2 = \left(1 - 2MG/r^2 + \Lambda_+ r^2\right) dt^2 \quad (2.3)$$

$$- \left(1 - 2MG/r^2 + \Lambda_+ r^2\right)^{-1} dr^2 - r^2 d\Omega^2, \quad (2.4)$$

$$ds_-^2 = \left(1 + \Lambda_- r^2\right) dt^2 - \left(1 + \Lambda_- r^2\right)^{-1} dr^2 - r^2 d\Omega^2, \quad (2.5)$$

separated by a time-like 4-dimensional spherical shell (brane, bubble) with FLRW metric:

$$ds^2 = d\tau^2 - a^2(\tau) d\Omega^2, \quad (2.6)$$

where τ is the intrinsic time of this spherical universe ([2], Equation (13) and Equation (14)). Here the cosmological scale factor $r = a(\tau)$ of the shell is the same as its 4-dimensional radial coordinate.

3. Nested Gogberashvili Models

It is natural to consider the nested variant of considered solution as a simplified model of *multiverses* restricted to their $(3 + 1)$ -dimensional strata. So, we consider a sequence of n nested spherical shells-universes S_k around the same

center with masses m_k , $1 \leq k \leq n$. Denote by $M_k = \sum_{i=1}^k m_k$ the total mass of first k shells. Local outer and inner metrics are defined by the following formulas:

$$ds_{+,k}^2 = \left(1 - 2M_k G/r^2 + \Lambda_{+,k} r^2\right) dt^2 \tag{3.1}$$

$$-\left(1 - 2M_k G/r^2 + \Lambda_{+,k} r^2\right)^{-1} dr^2 - r^2 d\Omega^2, \tag{3.2}$$

$$ds_{-,k}^2 = \left(1 - 2M_{k-1} G/r^2 + \Lambda_{+,k-1} r^2\right) dt^2 \tag{3.3}$$

$$-\left(1 - 2M_{k-1} G/r^2 + \Lambda_{+,k-1} r^2\right)^{-1} dr^2 - r^2 d\Omega^2. \tag{3.4}$$

Thus, $ds_{-,k}^2 = ds_{+,k-1}^2$ for $2 \leq k \leq n$. We put here $M_0 = 0$, so the innermost Gogberashvili metric has the form:

$$ds_{-,1}^2 = \left(1 + \Lambda_- r^2\right) dt^2 - \left(1 + \Lambda_- r^2\right)^{-1} dr^2 - r^2 d\Omega^2, \tag{3.5}$$

where, by definition, $\Lambda_- = \Lambda_{+,0}$.

4. Harmony of Transcosmic Spheres

Let g_k denote the gravitational constant on the k th shell of thickness ε_k then $G \sim \varepsilon_k g_k$. It is natural to suppose the following relations:

$$\Lambda_{+,k-1} - \Lambda_{+,k} = \sigma_k g_k / G, \tag{4.1}$$

$1 \leq k \leq n$, where σ_k is the energy density of the k th shell ([2], Equation (21)). Consequently,

$$\Lambda_{+,n} = \Lambda_{+,0} - \sum_{k=1}^n \sigma_k g_k / G. \tag{4.2}$$

In this picture, a large 5-dimensional gravitational constant $\Lambda_{+,0}$ could generate a sequence of potential wells (cf. [1], Figure 1), trapping matter on a sequence of expanding branes-universes. The expansion rate of the bubble S_k depends on its energy density as well as on $\Lambda_{+,k-1}$ and $\Lambda_{+,k}$. Meanwhile, the 4-dimensional cosmological constant on S_k vanishes.

5. Sequence of Event Horizons

The metric $ds_{+,k}^2$ becomes singular when

$$1 - 2M_k G/r^2 + \Lambda_{+,k} r^2 = 0 \tag{5.1}$$

So, we have the following growing sequence of event horizons:

$$r_k = \sqrt{\left(\sqrt{1 + 8GM_k \Lambda_{+,k}} - 1\right) / 2\Lambda_{+,k}} \tag{5.2}$$

for $1 \leq k \leq n$.

The most meaningful is the *external event horizon* with radial coordinate r_n , located outside of S_n .

6. Time-Amalgamated Multiverses

Four-dimensional Gogberashvili shells S_k with FLRW metric

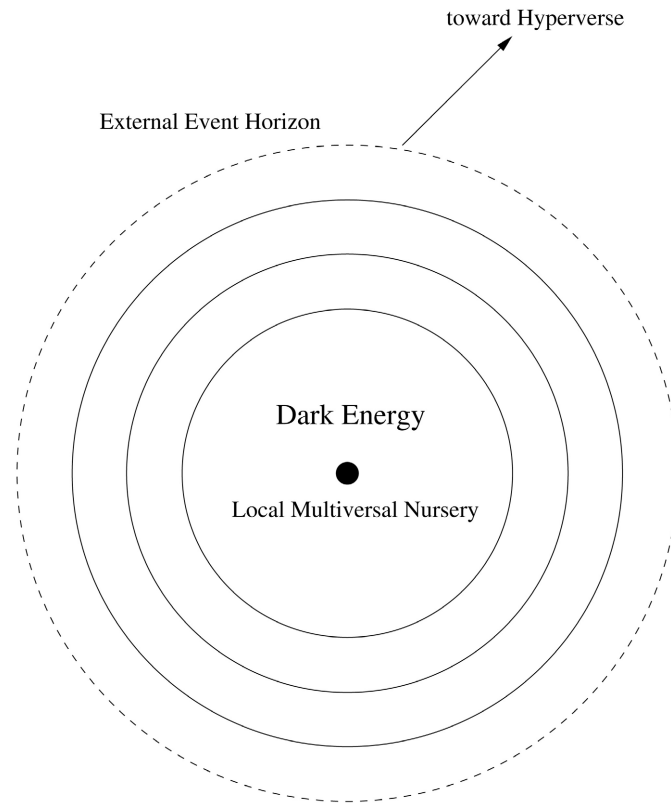


Figure 1. Multiverse with 3 Gogberashvili shells.

$$ds_k^2 = d\tau_k^2 - a_k^2(\tau_k) d\Omega^2, \tag{6.1}$$

$1 \leq k \leq n$, can be glued into a multiverse \mathcal{M} according to the procedure of time amalgamation, described in my paper [3]. It means that intrinsic times τ_k become mutually synchronized and there is a common timeline \mathbb{T} such that

$$\mathcal{M} = S_1 \times_{\mathbb{T}} \dots \times_{\mathbb{T}} S_n. \tag{6.2}$$

Here \mathcal{M} is considered as a fibered product.

In this way, all shells S_k can be studied simultaneously.

7. Dark Energy and Multiversal Nurseries

It is possible to endow the Hyperverses with a metric approximately describing several widely separated Gogberashvili multiverses. For example, one can use the work of Kashif Alvi on widely separated binary black holes [4].

In our picture, the Hyperverses has numerous powerful sources of dark energy with large local cosmological constants. Those sources play role of the *nurseries of multiverses*.

The situation is somewhat similar to the star formation and stellar nurseries in galaxies. In the latter case, it is related to the collapsing matter in giant molecular clouds.

Notice that, in our constructions, the dark energy is a higher-dimensional phenomenon of the Hyperverses.

8. Black Holes as Multiverses

For an external hyperversal observer, any $(3 + 1)$ -dimensional Gogberashvili multiverse would eventually appear as a supermassive black hole. It suggests the idea that astronomical black holes in our physical universe are, actually, nested and spherically embedded $(2 + 1)$ -dimensional branes-universes.

All solutions to $(2 + 1)$ -dimensional Einstein equations were actually classified [5]. Gogberashvili models correspond in this case to spherical Robinson-Trautman solutions [6]. In canonical coordinates the Robinson-Trautman metric is given by the formula:

$$ds^2 = \frac{r^2}{P^2} dx^2 + 2(er^2 + f) du dx - 2du dr + F(a, e, P, \Lambda; r) du^2, \quad (8.1)$$

where $a(x, u)$, $e(x, u)$, $f(x, u)$ and $P(x, u)$ are some metric functions while $F(a, e, P, \Lambda; r)$ is a polynomial of degree 2 with respect to r depending on a , e , P and the cosmological constant Λ ([5], Equation (37)).

Similar solutions in the form

$$ds^2 = g_{pq} dx^p dx^q + 2g_{up} du dx^p - 2du dr + g_{uu} du^2, \quad (8.2)$$

exist in all $(d + 1)$ -dimensional spacetimes with $d \geq 2$ (*cf.* [7], Equation (1)).

We should also mention innovative works of T.X. Zhang on black hole universes (*cf.* [8] and references therein).

9. Multi-Solitonic and Gyratonic Gravitational Waves

So, we are interested in Robinson-Trautman metrics describing expanding spacetimes with spherical gravitational waves. Multi-soliton solutions of this type, associated with matter trapping, correspond to our Gogberashvili multiverses.

If we admit that the null matter field has some internal spin/angular momentum, there are also more general (multi-)gyratonic solutions. They give rise to rotating Gogberashvili models/multiverses.

This intriguing topic, including a thorough comparison of two models, should be studied in more details. In particular, the harmony of transc cosmic spheres should acquire more complete meaning.

10. Elliptic and Spiral Galaxies

It seems that it partially explains the classification of galaxies, harboring supermassive black holes at their cores. Indeed, on the one hand, supermassive black holes of multi-solitonic type could generate elliptic galaxies.

On the other hand, multi-gyratonic black holes could generate spiral galaxies. The number of spirals and their configuration are related in this case to the number of multiversal layers and the harmony of the spheres (*cf.* Sections 4 and 9).

Relativistic jets, emitting by supermassive black holes at galaxy cores, also suggest their gyratonic nature.

11. Cosmological Coupling

Our constructions are consistent with the modern theory of *cosmological coupling* [9].

Recent astronomical observations show the abundance of black holes with unexpectedly high masses. Croker *et al.* proposed a mechanism, explaining the growth of black holes through anomalous coupling of matter with gravity [10].

It implies that the expansion of the universe and a large (but hidden) cosmological constant contribute to the growth of black hole masses.

12. Conclusions

It turns out that nested Gogberashvili shells represent good models for multiverses inside the Hyperverses.

In this paper, we have restrained the Hyperverses to its local $(4 + 1)$ -dimensional stratum. However, similar solutions exist in all dimensions $d + 1$ with $d \geq 2$. In fact, we can construct an infinite tower of embedded Gogberashvili multiverses of various dimensions.

An alternative approach is given by Robinson-Trautman metrics describing expanding spacetimes and spherical gravitational waves.

It provides us with an intriguing idea to consider supermassive astronomical black holes as expanding $(2 + 1)$ -dimensional multiverses (with possible higher strata too).

It might give new angles of view on the black hole growth, the cosmological coupling, relativistic jets and even on the classification of galaxies.

Conflicts of Interest

The author declares no conflicts of interest regarding the publication of this paper.

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