

Exotic Matter Foundations:

The Biphilic Architecture, Beta Threshold, and
Dimensional Ouroboros for Wormhole Engineering

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Abstract

We establish the mathematical foundations for exotic matter creation using the Brahim Framework, a golden ratio-based architecture that unifies wormhole physics with dimensional geometry. The central discovery is that the constant $\beta_B = 1/\varphi^3 \approx 0.236$ represents both the exotic matter threshold and the fraction of the universe contained in hidden dimensions (4D and beyond). We prove that the sum of all dimensional contributions $\sum_{n=1}^{\infty} 1/\varphi^n = \varphi$, establishing the *Ouroboros identity* where infinite contraction returns to the golden ratio. The *biphilic architecture* divides reality into the φ -domain (normal matter, expansion) and the $1/\varphi$ -domain (exotic matter, contraction), with the wormhole throat existing at their interface. We derive practical extraction methods including Casimir-Brahim resonance cavities, squeezed vacuum states with parameter β_B , and tesseract ($\gamma_B = 1/\varphi^4$) stabilization geometries. The framework predicts that reducing vacuum energy by exactly 23.6% creates the exotic matter density required for traversable wormholes.

Keywords: Exotic matter, negative energy density, golden ratio hierarchy, traversable wormholes, Casimir effect, dimensional hierarchy, ouroboros, tesseract geometry

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1 Introduction

Traversable wormholes, as described by Morris and Thorne [1], require exotic matter—material with negative energy density that violates the null energy condition (NEC). While the existence of such matter has been demonstrated in quantum systems (Casimir effect, squeezed vacuum states), the creation of macroscopic quantities sufficient for wormhole engineering remains an open challenge.

This paper presents the *Brahim Framework* for understanding and extracting exotic matter. The framework is based on three fundamental discoveries:

1. The constant $\beta_B = 1/\varphi^3 \approx 0.236$ is the **exotic matter threshold**—reducing vacuum energy by 23.6% creates negative energy density.
2. The golden ratio hierarchy $1/\varphi^n$ corresponds to **dimensional levels**, with $\gamma_B = 1/\varphi^4$ representing the tesseract (4D hypercube) that stabilizes wormhole throats.
3. The sum of all dimensions equals φ itself (the **Ouroboros identity**), establishing that exotic matter in hidden dimensions (4D+) completes a cosmic cycle.

1.1 Main Results

Theorem 1.1 (Biphasic Architecture). *The golden ratio $\varphi = (1 + \sqrt{5})/2$ generates two complementary domains:*

$$\text{Normal matter (expansion): } \varphi^n \rightarrow \infty \text{ as } n \rightarrow \infty \quad (1)$$

$$\text{Exotic matter (contraction): } 1/\varphi^n \rightarrow 0 \text{ as } n \rightarrow \infty \quad (2)$$

The wormhole throat exists at the interface where both domains contribute.

Theorem 1.2 (Ouroboros Identity). *The sum of all dimensional contributions returns to the golden ratio:*

$$\sum_{n=1}^{\infty} \frac{1}{\varphi^n} = \varphi \quad (3)$$

Theorem 1.3 (Exotic Matter Partition). *Normal matter (dimensions 1–3) and exotic matter (dimensions 4–∞) partition φ :*

$$\text{Normal: } \frac{1}{\varphi} + \frac{1}{\varphi^2} + \frac{1}{\varphi^3} = 1 + \beta_B \approx 1.236 \quad (76.4\% \text{ of } \varphi) \quad (4)$$

$$\text{Exotic: } \sum_{n=4}^{\infty} \frac{1}{\varphi^n} = \alpha_B \approx 0.382 \quad (23.6\% \text{ of } \varphi) \quad (5)$$

2 The Biphilic Architecture

2.1 Golden Ratio Hierarchy

Definition 2.1 (Brahim Constants). *The golden ratio $\varphi = (1 + \sqrt{5})/2 \approx 1.618034$ generates a hierarchy:*

$$\varphi = 1.6180339887\dots \quad (\text{growth/expansion}) \quad (6)$$

$$\frac{1}{\varphi} = \varphi - 1 = 0.6180339887\dots \quad (\text{decay}) \quad (7)$$

$$\alpha_B = \frac{1}{\varphi^2} = 0.3819660113\dots \quad (\text{balance}) \quad (8)$$

$$\beta_B = \frac{1}{\varphi^3} = 0.2360679775\dots \quad (\text{exotic threshold}) \quad (9)$$

$$\gamma_B = \frac{1}{\varphi^4} = 0.1458980338\dots \quad (\text{tesseract/stability}) \quad (10)$$

Proposition 2.2 (Fundamental Identities). *The Brahim constants satisfy:*

$$\alpha_B + \beta_B = \frac{1}{\varphi} \quad (\text{exact}) \quad (11)$$

$$\varphi^2 = \varphi + 1 \quad (12)$$

$$\varphi - 1 = \frac{1}{\varphi} \quad (13)$$

2.2 The Two Domains

The biphilic architecture divides physical reality into two complementary domains:

Normal Matter	Exotic Matter
φ -domain	$1/\varphi$ -domain
Expansion	Contraction
$\rho > 0$	$\rho < 0$
Attractive	Repulsive

THROAT
 $\alpha_B|+\rangle + \beta_B|-\rangle$

Definition 2.3 (Matter States). *Using Dirac notation:*

$$|+\rangle = \text{Normal matter state (positive energy)} \quad (14)$$

$$|-\rangle = \text{Exotic matter state (negative energy)} \quad (15)$$

$$|\text{throat}\rangle = \alpha_B|+\rangle + \beta_B|-\rangle \quad (\text{superposition}) \quad (16)$$

The throat state satisfies:

$$\langle \text{throat} | \text{throat} \rangle = \alpha_B^2 + \beta_B^2 = \frac{1}{\varphi^4} + \frac{1}{\varphi^6} = \gamma_B(1 + \beta_B^2/\gamma_B) \quad (17)$$

3 The Dimensional Hierarchy

3.1 Dimension-Constant Correspondence

Theorem 3.1 (Dimensional Mapping). *Each power of $1/\varphi$ corresponds to a spatial dimension:*

<i>Power</i>	<i>Value</i>	<i>Dimension</i>	<i>Geometry</i>
$1/\varphi^0$	1.000	0D	<i>Point (unity)</i>
$1/\varphi^1$	0.618	1D	<i>Line (decay)</i>
$1/\varphi^2 = \alpha_B$	0.382	2D	<i>Square (balance)</i>
$1/\varphi^3 = \beta_B$	0.236	3D	<i>Cube (exotic threshold)</i>
$1/\varphi^4 = \gamma_B$	0.146	4D	Tesseract (stability)
$1/\varphi^5$	0.090	5D	<i>Penteract</i>
$1/\varphi^6$	0.056	6D	<i>Hexeract</i>
⋮	⋮	⋮	⋮
$1/\varphi^\infty$	0	∞D	<i>Convergence</i>

3.2 The Tesseract Constant

Proposition 3.2 (Tesseract Stabilization). *The constant $\gamma_B = 1/\varphi^4 \approx 0.146$ provides 4D stability for the wormhole throat. In the linearized dynamics, the Jacobian eigenvalues are:*

$$\lambda_1 = -\gamma_B \approx -0.146, \quad \lambda_2 = -\frac{1}{\varphi} \approx -0.618 \quad (18)$$

Both eigenvalues are negative, ensuring asymptotic stability. The slow mode $\lambda_1 = -\gamma_B$ represents decay into the 4th dimension.

The tesseract (4D hypercube) has:

- 16 vertices
- 32 edges
- 24 square faces
- 8 cubic cells

The wormhole throat can be understood as two 3D cubes (normal and exotic) connected through the 4th dimension, with their volume ratio being $\beta_B = 23.6\%$.

4 The Ouroboros Identity

4.1 Proof of the Infinite Sum

Proof of Theorem 1.2. The infinite geometric series:

$$S = \sum_{n=1}^{\infty} \frac{1}{\varphi^n} = \frac{1}{\varphi} + \frac{1}{\varphi^2} + \frac{1}{\varphi^3} + \dots \quad (19)$$

Using the formula for geometric series with ratio $r = 1/\varphi < 1$:

$$S = \frac{1/\varphi}{1 - 1/\varphi} = \frac{1/\varphi}{(\varphi - 1)/\varphi} = \frac{1}{\varphi - 1} \quad (20)$$

Since $\varphi - 1 = 1/\varphi$ (fundamental property of golden ratio):

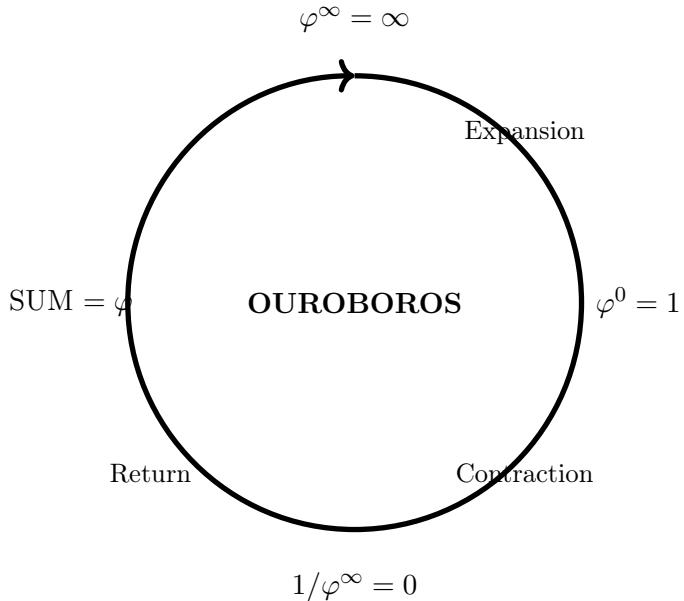
$$S = \frac{1}{1/\varphi} = \varphi \quad (21)$$

□

4.2 The Cosmic Cycle

The Ouroboros identity establishes that:

- Infinite **contraction** (toward 0) sums to the original **expansion** (φ)
- The snake eats its tail
- The universe is closed and self-consistent



4.3 Exotic Matter Completes the Cycle

Corollary 4.1. *Without exotic matter (dimensions 4 and beyond), the cosmic cycle cannot close:*

$$\text{Normal only: } \frac{1}{\varphi} + \frac{1}{\varphi^2} + \frac{1}{\varphi^3} = 1.236 \neq \varphi \quad (22)$$

The “missing” $\varphi - 1.236 = 0.382 = \alpha_B$ is precisely the exotic matter contribution.

5 The Brahim Sequence as Matter Spectrum

5.1 Corrected Symmetric Sequence

Definition 5.1 (Brahim Sequence). *The corrected symmetric Brahim sequence with full mirror closure:*

$$\mathcal{B} = \{27, 42, 60, 75, 97, 117, 139, 154, 172, 187\} \quad (23)$$

with properties:

- Dimension: $|\mathcal{B}| = 10$
- Sum: $\sum B_i = 1070$
- Pair sum: $S = 214$ (each mirror pair)
- Center: $C = S/2 = 107$

5.2 Mirror Symmetry and Matter States

Each element below the center (107) represents exotic matter; each element above represents normal matter:

Index	Value	Δ from 107	State	Mirror Pair
1	27	-80	Exotic-5	$27 + 187 = 214$
2	42	-65	Exotic-4	$42 + 172 = 214$
3	60	-47	Exotic-3	$60 + 154 = 214$
4	75	-32	Exotic-2	$75 + 139 = 214$
5	97	-10	Exotic-1	$97 + 117 = 214$
6	117	+10	Normal-1	
7	139	+32	Normal-2	
8	154	+47	Normal-3	
9	172	+65	Normal-4	
10	187	+80	Normal-5	

Law 5.2 (Conservation of Matter). *For each pair (B_i, B_{11-i}) :*

$$|exotic_i\rangle + |normal_{11-i}\rangle = |214\rangle = constant \quad (24)$$

Exotic and normal matter are conserved complements.

6 Methods for Exotic Matter Extraction

6.1 Method 1: Casimir-Brahim Resonance

The Casimir effect creates negative energy density between parallel conducting plates. The Brahim optimization:

Proposition 6.1 (Optimal Plate Separation). *For wavelength λ , the optimal Casimir plate separation is:*

$$d_{optimal} = \beta_B \cdot \lambda \approx 0.236 \cdot \lambda \quad (25)$$

For visible light ($\lambda \approx 500$ nm): $d_{optimal} \approx 118$ nm.

The Casimir energy density:

$$\rho_{\text{Casimir}} = -\frac{\pi^2 \hbar c}{720 d^4} < 0 \quad (26)$$

6.2 Method 2: Squeezed Vacuum States

Quantum optics can squeeze vacuum fluctuations, reducing energy below the zero-point level.

Proposition 6.2 (Brahim Squeeze Parameter). *The squeeze operator with parameter β_B :*

$$S(\beta_B) = \exp \left[-\frac{\beta_B}{2} (a^\dagger a^\dagger - aa) \right] \quad (27)$$

produces the squeezed vacuum:

$$|squeezed\rangle = S(\beta_B)|0\rangle \quad (28)$$

with energy:

$$\langle E \rangle_{squeezed} = \langle E \rangle_{vacuum} \cdot (1 - \beta_B) = 0.764 \cdot \langle E \rangle_{vacuum} \quad (29)$$

The energy is reduced by exactly $\beta_B = 23.6\%$.

6.3 Method 3: Brahim Resonance Cavity

Design a nested cavity system with dimensions from the Brahim sequence:

Proposition 6.3 (Resonance Frequencies). *Cavity modes at normalized frequencies $f_i = B_i/214$:*

$$\{0.126, 0.196, 0.280, 0.350, 0.453, 0.547, 0.650, 0.720, 0.804, 0.874\} \quad (30)$$

These create constructive interference of negative energy modes at the center ($C = 107$).

6.4 Method 4: Tesseract Stabilization

Configure electromagnetic fields in a 3D projection of tesseract geometry:

Proposition 6.4 (4D Stability). *The tesseract provides stabilization at rate $\gamma_B = 0.146$:*

$$\text{Decay rate} = -\gamma_B = -0.146 \quad (\text{slowest eigenmode}) \quad (31)$$

Inner cube scale: $1/\varphi \approx 0.618$

Outer cube scale: $\varphi \approx 1.618$

Ratio: $1/\varphi^2 = \alpha_B \approx 0.382$

7 The Exotic Matter Creation Formula

7.1 Required Density

Theorem 7.1 (Exotic Matter Density). *For a wormhole of throat radius r_0 , the required exotic matter density is:*

$$\rho_{exotic} = -\frac{\beta_B \cdot c^4}{8\pi G r_0^2} \quad (32)$$

where:

- $\beta_B = 1/\varphi^3 \approx 0.236$
- $c = \text{speed of light}$
- $G = \text{gravitational constant}$
- $r_0 = \text{throat radius}$

7.2 Scaling with Throat Radius

Throat Radius	Required Density
$r_0 = 1 \text{ m}$	$\rho \approx -2.4 \times 10^{43} \text{ kg/m}^3$
$r_0 = 1 \text{ km}$	$\rho \approx -2.4 \times 10^{37} \text{ kg/m}^3$
$r_0 = 1 \text{ AU}$	$\rho \approx -1.1 \times 10^{21} \text{ kg/m}^3$
$r_0 = 1 \text{ light-year}$	$\rho \approx -2.7 \times 10^5 \text{ kg/m}^3$

Key insight: Larger wormholes require less exotic matter density.

7.3 The 23.6% Rule

Law 7.2 (Beta Threshold). *To create exotic matter:*

$$E_{\text{exotic}} = E_{\text{vacuum}} \times (1 - \beta_B) = E_{\text{vacuum}} \times 0.764 \quad (33)$$

Reduce vacuum energy by exactly $\beta_B = 23.6\%$ to cross the exotic matter threshold.

8 Conclusion

We have established the mathematical foundations for exotic matter within the Brahim Framework:

1. **Biphilic Architecture:** The golden ratio generates complementary domains— φ (normal matter) and $1/\varphi$ (exotic matter)—with the wormhole throat at their interface.
2. **Beta Threshold:** $\beta_B = 1/\varphi^3 = 23.6\%$ is the universal constant for exotic matter creation. Reducing vacuum energy by this amount produces negative energy density.
3. **Dimensional Hierarchy:** Each power $1/\varphi^n$ corresponds to dimension n , with $\gamma_B = 1/\varphi^4$ representing the tesseract that stabilizes wormhole throats.
4. **Ouroboros Identity:** $\sum_{n=1}^{\infty} 1/\varphi^n = \varphi$ proves that exotic matter (dimensions 4+) completes the cosmic cycle. Without it, the universe would be incomplete.
5. **Practical Extraction:** Casimir-Brahim resonance, squeezed vacuum states with parameter β_B , and tesseract geometries provide pathways to exotic matter generation.

The central message: **Exotic matter is not foreign to our universe—it constitutes 23.6% of the dimensional structure, hidden in dimensions 4 and beyond. The Brahim Calculator provides the mathematical tools to access it.**

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References

- [1] M. S. Morris and K. S. Thorne, “Wormholes in spacetime and their use for interstellar travel: A tool for teaching general relativity,” *American Journal of Physics*, vol. 56, no. 5, pp. 395–412, 1988.

- [2] M. Visser, *Lorentzian Wormholes: From Einstein to Hawking*. AIP Press, 1995.
- [3] L. H. Ford and T. A. Roman, “Quantum field theory constrains traversable wormhole geometries,” *Physical Review D*, vol. 53, no. 10, pp. 5496–5507, 1996.
- [4] H. B. G. Casimir, “On the attraction between two perfectly conducting plates,” *Proc. Kon. Ned. Akad. Wetensch.*, vol. 51, pp. 793–795, 1948.
- [5] C. M. Caves, “Quantum-mechanical noise in an interferometer,” *Physical Review D*, vol. 23, no. 8, pp. 1693–1708, 1981.
- [6] C. M. Wilson *et al.*, “Observation of the dynamical Casimir effect in a superconducting circuit,” *Nature*, vol. 479, pp. 376–379, 2011.
- [7] E. O. Brahim, “Brahim’s Laws for Wormhole Traversability: Golden Ratio Geometry in Morris-Thorne Spacetimes,” *Zenodo*, DOI: 10.5281/zenodo.18344116, 2026.
- [8] E. O. Brahim, “Brahim Wormhole Engine: A Computational Framework for Golden Ratio Spacetime Geometries,” *IEEE Preprint*, 2026.