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# title: "EN_42: The universe as a regulated system. Bridges between the Riemann Hypothesis, black hole physics, and confinement geometry in the Einstein-VED framework" author: "Víctor Estrada Díaz" ORCID: 0000-0001-9942-1021 license: CC BY-SA 4.0 doi: 10.5281/zenodo.17172925

## Abstract


The Riemann Hypothesis (RH) is one of the most important open problems in mathematics. In this document we show that, within the deterministic **Einstein-VED** framework, the RH emerges as a **stability condition of spacetime** when described as a system regulated by confinement geometry.

We demonstrate that the universal geometric constant

$\tilde{n} = R_{\text{VED}} \cdot R_{\text{Sch}} = 4\ell_p^2$

connects:

- the zeros of the Riemann zeta function with Bekenstein's area quantization,
- the stability of atomic nuclei (rule $n \in \mathbb{N}^+$),
- the cosmic ionization cycle (Shaha-VED, EN_41),
- the critical pressure $P_{\text{crit}} = 1.85 \times 10^{18}$ Pa that triggers the Second Genesis of stable neutrons,

- the holographic topology of the 3S+T container with its 22 internal modes.

We present a path to approach the RH from physics, without adjustable parameters and without resorting to probabilistic quantum mechanics, opening a research line that connects number theory with spacetime geometry.

**Keywords:** Einstein-VED, Riemann Hypothesis, black holes, constant $\tilde{n}$, zeta function, area quantization, topological confinement, Shaha-VED, Two Genesis cycle.

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# 1. Introduction

The Riemann Hypothesis (RH) states that all non-trivial zeros of the zeta function $\zeta(s)$ have real part $\Re(s) = 1 / 2$. It is a central problem in number theory, with deep implications for the distribution of prime numbers.

In recent decades, several authors have suggested connections between RH and physics:

- **Berry and Keating** (1999) proposed that the Riemann zeros could be the energy levels of a non-relativistic quantum system.
- **Giri** (2020) showed that the normal modes of a scalar field near the Schwarzschild horizon coincide with the non-trivial zeros of $\zeta(s)$.
- **Latalia** (2024) argued that the thermodynamic stability of quantum spacetime requires all zeros to lie on the critical line.

In the **Einstein-VED** framework (EN_0, EN_19, EN_20), physics is reformulated as spacetime geometry. This document explores how the RH can be understood as a **geometric stability condition** of the 3S+T container, and how the constant $\tilde{n} = 4\ell_p^2$ serves as a bridge between number theory, black holes, and the confinement of matter.

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# 2. Fundamentals of the Einstein-VED framework

## 2.1. The container and the content (EN_0, EN_14)

Spacetime is a 3S+T continuum with a complex metric in $\mathbb{C}^4$:

$$ds^2 = dx^2 + dy^2 + dz^2 + dt^2 \quad (+ + + +).$$

The projection onto real space generates the Minkowski metric. This container imposes **22 internal degrees of freedom** (15 spatial, 3 temporal, 4 mixed) on any confined configuration. These modes are not properties of the particle, but of spacetime itself.

## 2.2. The geometric constant $\tilde{n}$ (EN_17)

Define:

$$\tilde{n} = R_{\mathrm{VED}} \cdot R_{\mathrm{Sch}} = 4\ell_p^2,$$

where:

- $R_{\mathrm{VED}} = n \cdot \frac{\hbar}{Mc}$ is the confinement radius of a wave of mass $M$ with $n$ cycles,
- $R_{\mathrm{Sch}} = \frac{2GM}{c^2}$ is the Schwarzschild radius,
- $\ell_p = \sqrt{\frac{\hbar G}{c^3}}$ is the Planck length.

This constant is universal and mass-independent: any probe mass (proton, black hole, universe) yields the same value. It is the **fundamental area unit** and coincides with Bekenstein's area quantization:

$$\Delta A = \tilde{n} = 4\ell_p^2 \, .$$

## 2.3. The closure rule and stability (EN_6, EN_22)

Stability of any confined configuration (neutron, nucleus, atom, black hole) requires the number of cycles $n$ to be a positive integer:

$$n \in \mathbb{N}^{+} \quad \Leftrightarrow \quad \text{stability}\,.$$

Any deviation $\delta = n - m \neq 0$ generates a phase shift that produces instability. In the free neutron, $\delta \approx 1.3 \times 10^{-12}$, giving a lifetime

$$\tau_n = \frac{4}{\nu_0\,\delta} \approx 877\ \text{s},$$

with no adjustable parameters (EN_4, EN_14).

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# 3. The Riemann zeta function and spacetime stability

## 3.1. RH as a stability condition

The Riemann zeta function is defined for $\Re(s) > 1$ as:

$$\zeta(s) = \sum_{n=1}^{\infty} \frac{1}{n^s},$$

and analytically continued to the whole complex plane except $s = 1$. Its non-trivial zeros are the subject of RH.

**Theorem (Latalia, 2024):** If any non-trivial zero had real part $\Re(s) \neq 1/2$, then the partition function of quantum spacetime would diverge, violating thermodynamic stability. Hence, RH is equivalent to **spacetime stability**.

In the Einstein-VED framework, stability is expressed by $n \in \mathbb{N}^{+}$. The sum over $n$ in $\zeta(s)$ is a sum over confinement modes. The critical line $\Re(s) = 1/2$ corresponds to the **boundary between stable and unstable configurations** in the 3S+T container.

## 3.2. The holographic analogy

The critical line $\Re(s) = 1 / 2$ acts as a **holographic boundary** encoding the distribution of prime numbers, analogous to the black hole horizon encoding its entropy.

| Physical concept | Mathematical concept |
|---|---|
| Event horizon | Critical line $\Re(s) = 1 / 2$ |
| Horizon area ($4\ell_p^2$) | Distance to the critical line boundary |
| Bekenstein-Hawking entropy | Prime information on the boundary |
| Area quantization ($\tilde{n}$) | Discretization of zeros |

The constant $\tilde{n} = 4\ell_p^2$ is the area quantum connecting both descriptions.

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# 4. Black holes and the constant $\tilde{n}$

## 4.1. Bekenstein's area quantization

Bekenstein (1973) proposed that the area of a black hole horizon is quantized in units of $\ell_p^2$. In our framework, that unit is exactly:

$$\Delta A = \tilde{n} = 4\ell_p^2 .$$

The Bekenstein-Hawking entropy is:

$$S_{\mathrm{BH}} = \frac{A}{4\ell_p^2} = \frac{A}{\tilde{n}} .$$

## 4.2. Physical realization of the Riemann zeros

Giri (2020) showed that the normal modes of a massive scalar field near the Schwarzschild horizon, with appropriate boundary conditions, **coincide with the non-trivial zeros of $\zeta(s)$**.

The area quantization ($\tilde{n}$) is responsible for breaking the continuous scale symmetry into a discrete one that gives rise to the zeros. In the VED framework, this discretization is $n \in \mathbb{N}^+$, and the regulating constant is $\tilde{n}$.

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# 5. Shaha-VED and the Two Genesis cycle (EN_41)

## 5.1. The geometric ionization function

In EN_41, the Shaha-VED function is derived, describing ionization as a **geometric confinement rupture** when the external pressure exceeds

$$P_{\text{crit}} = 1.85 \times 10^{18}\ \text{Pa}.$$

The electron exists only in $k \cdot 137$ configurations, where $k = 1$ is the hydrogen atom and $k = 2$ the Cooper pair. The ionization energy for state $k$ is:

$$\chi_k = \frac{m_e c^2}{2(k \cdot 137)^2}.$$

## 5.2. The Second Genesis

When $P \geq P_{\text{crit}}$, the electron orbital collapses geometrically and forced electron capture occurs:

$$p + e^- \rightarrow n + \nu_e.$$

These neutrons are born inside the stellar core, surrounded by other nucleons, and can form stable collective configurations (heavy isotopes). This cycle —from CMB recombination ($T_{\text{rec}} = 3750\ \text{K}$) to heavy element formation— is fully determined by the container geometry and $\tilde{n}$.

## 5.3. Connection with RH

The critical pressure $P_{\text{crit}}$ marks the validity limit of the Shaha-VED function. Beyond it, the system enters a regime where the internal modes (the 22 container modes) rearrange. This rearrangement is equivalent to **finding the zeta function zeros** on the critical line: only there can spacetime maintain the stability needed for complex nuclei formation.

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## 6. Synthesis: The bridge between RH, black holes, and confinement

The following table summarizes the correspondences:

| Concept | Riemann Hypothesis | Black hole physics | Einstein-VED (Shaha-VED) |
|---|---|---|---|
| **Boundary** | Critical line $\Re(s) = 1/2$ | Event horizon | 3S+T holographic plane |
| **Quantum** | Zeros of $\zeta(s)$ | Quantized area $\Delta A$ | $\tilde{n} = 4\ell_p^2$ |
| **Stability** | Zeros on $\Re(s) = 1/2$ | Maximum entropy | $n \in \mathbb{N}^+$ |
| **Discretization** | GUE spacing | Area modes | 22 internal modes |
| **Origin** | Prime distribution | Black hole microstates | Wave confinement |
| **Transition** | (N/A) | (N/A) | $P_{\text{crit}}$ (EN_41) |

**Partial conclusion:** RH, black hole entropy, and nuclear stability are manifestations of the same geometry. The constant $\tilde{n}$ is the unifying invariant.

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## 7. Implications for proving RH

1. **RH reduces to spacetime stability.** If we prove that the 3S+T container with 22 modes is only stable when $n \in \mathbb{N}^+$, and that this condition is equivalent to $\Re(s) = 1/2$ for all zeros, then RH is proven.

2. **The 22 nucleon modes are the physical realization of the zero discretization.** The distribution of these modes (see EN_14) may reflect the spacing of zeros (GUE distribution).

3. **The critical pressure $P_{\text{crit}}$ marks the boundary between the ionization regime (trivial zeros) and the nuclear confinement regime (non-trivial zeros).** Beyond $P_{\text{crit}}$, the system behaves like a mini black hole, whose normal modes are the Riemann zeros.

4. **The study of isotope decay periods (regulated by $\delta$) could provide information about the zero distribution.** The deviation $\delta$ for each nucleus might map to the position of a zero on the critical line.

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## 8. Open questions for dialogue and development

1. Can it be rigorously proven that spacetime stability (defined by $n \in \mathbb{N}^+$) is equivalent to the Riemann Hypothesis?

2. Are the 22 internal nucleon modes a physical realization of the discrete structure that generates the Riemann zeros?

3. Can the constant $\tilde{n} = 4\ell_p^2$ be used to derive the spacing of the Riemann zeros (GUE distribution) from first principles?

4. Is topological confinement on the holographic surface the key to understanding why the zeros lie on the critical line?

5. Can the study of isotope decay periods (regulated by $\delta$) provide information about the distribution of the zeros of the zeta function?

6. How does the critical pressure $P_{\text{crit}}$ fit into the spacetime phase diagram, and what relation does it have to the confinement-deconfinement phase transition in QCD?

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# 9. Conclusions

We have presented a **unified framework** connecting:

- the Riemann Hypothesis with spacetime stability,
- black holes and area quantization ($\tilde{n} = 4\ell_p^2$),
- topological confinement of matter (22 modes, $n \in \mathbb{N}^+$),
- the Shaha-VED ionization function and the Two Genesis cycle (EN_41).

All without adjustable parameters and without resorting to probabilistic quantum mechanics. This approach offers a deterministic, geometric path to address one of the millennium problems, opening a dialogue between number theory, gravity, and nuclear physics.

**The universe is a system regulated by geometry. RH is not an isolated mathematical conjecture, but a stability condition of spacetime that emerges from the constant $\tilde{n}$.**

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**End of EN_42**