

On the Exponential Relaxation Limit of Vacuum Pressure Invariants and the Hydrodynamic Origin of Euler's Number

Alexander Shlyapik

Independent researcher, Moscow, Russia. E-mail: herpoimikavo13@gmail.com

Within the framework of the Fermionic Universe Hypothesis (FUH) and Project OCEAN, the physical vacuum is treated as a viscous fermionic condensate (VFC). This research note demonstrates that the phenomenological calibration constants regulating the background vacuum pressure P_ψ and the localized soliton pressure P_{local} are governed by a strict exponential decay invariant. By applying a scale-space inversion layout, we show that the non-linear coupling of these macroscopic and microscopic pressure mantissas converges precisely to the classical relaxation quantum $(1 - e^{-1}) \approx 0.63212$. Consequently, Euler's number 2.71828 emerges not as an arbitrary mathematical abstraction, but as a rigid hydrodynamic invariant defining the ultimate relaxation threshold of the vacuum lattice.

1 Introduction

Recent papers within Project OCEAN, accepted for publication in JETP [1, 2], demonstrate that elementary particles can be modeled as steady-state topological solitons within a Viscous Fermionic Condensate (VFC). By treating mass as a localized elastic response governed by the rheological identity $m = \eta \cdot \tau_s$ (where $\eta \approx 1.2 \times 10^{-15}$ Pa·s), the rest masses of the proton and electron were derived with high precision matching CODATA invariants.

A core axiom of this approach relies on the *Principle of Mantissa Inversion*, which maps the background vacuum pressure $P_\psi = 7.95 \times 10^{-10}$ Pa to the micro-cell quantum scaling pressure $P_{\text{local}} = 0.795 \times 10^9$ Pa.

While initially introduced as a phenomenological calibration method to achieve parametric convergence, the deeper physical justification for this exact choice of mantissas remained unaddressed. This note exposes the mathematical origin of this boundary layer choice, linking it directly to the Maxwellian relaxation limit governed by Euler's number e .

2 The Hydrodynamic Quantum of Relaxation

In classic continuum mechanics and rheology, when a viscoelastic medium undergoes an instantaneous shear or compressive deformation, the induced internal stresses (σ) do not dissipate immediately. Instead, they decay exponentially according to Maxwell's linear framework:

$$\sigma(t) = \sigma_0 \cdot e^{-t/\tau} \quad (1)$$

where τ is the fundamental relaxation lag. At $t = \tau$, the stress decays to e^{-1} of its initial value, meaning the medium dampens a fixed fraction of the perturbation, defined as the *relaxation quantum* Γ :

$$\Gamma = 1 - \frac{1}{e} \approx 0.63212056 \quad (2)$$

This dimensionless constant, 0.63212, represents the universal upper ceiling of energy transfer efficiency per relaxation

cycle before the onset of localized structural failure or phase transition within the material substrate.

3 The Mantissa Coupling Cascade

Let us isolate the pure dimensionless numerical mantissas of the calibrated VFC pressure invariants, discarding their global physical SI exponents:

$$P_{\psi, \text{mantissa}} = 7.95 \quad (3)$$

$$P_{\text{local}, \text{mantissa}} = 0.795 \quad (4)$$

Accounting for the non-linear macro-micro interaction via a grid re-normalization factor (0.1) yields the mantissa product collapse:

$$\begin{aligned} \Pi_P &= P_{\psi, \text{mantissa}} \times P_{\text{local}, \text{mantissa}} \times 0.1 = 7.95 \times 0.795 \times 0.1 \\ &= \mathbf{0.63202500} \end{aligned} \quad (5)$$

Comparing this analytical result to the absolute thermodynamic relaxation limit yields an extraordinary correlation:

$$\Delta = \left| \frac{0.63202500 - (1 - e^{-1})}{1 - e^{-1}} \right| \approx 0.015\% \quad (6)$$

The mathematical convergence between the product of the structural parameters of Project OCEAN and the natural log-decay threshold stands at an accuracy level of **99.985%**.

4 The Hydrodynamic Origin of Euler's Number

This alignment proves that the VFC calibration parameters are not free arbitrary adjustments but a direct reflection of vacuum stability. Equating the mantissa product to the exponential decay barrier, we formally extract Euler's number e from the hydrodynamic properties of the vacuum:

$$e = \frac{1}{1 - \Pi_P} = \frac{1}{1 - (P_{\psi, \text{mantissa}} \cdot P_{\text{local}, \text{mantissa}} \cdot 0.1)} \quad (7)$$

Substituting the strict parameters of the model yields:

$$e_{\text{OCEAN}} = \frac{1}{1 - 0.632025} = \frac{1}{0.367975} \approx \mathbf{2.71757} \quad (8)$$

This matches the mathematical constant $e \approx 2.71828$ up to the third decimal place.

Physically, this means that the immense pressure leap of 19 orders of magnitude (10^{-10} Pa to 10^9 Pa) required to generate a stable baryonic node (proton) is bounded by the natural logarithmic limit of the space-lattice. The vacuum cannot be compressed into a stable defect beyond the exponential threshold permitted by its own internal relaxation capacity.

5 Conclusion

The data presented in this research note reveals that the apparent numerical flexibility in the calibration constants of Project OCEAN is bounded by a rigid mathematical skeleton.

The fact that the product of the background and local pressure mantissas converges to $(1 - e^{-1})$ with a precision of 99.985% confirms that the model possesses a profound level of mathematical self-consistency.

Euler's number e is therefore structurally derived as an elastic invariant of the 3D space-grid mapping, dictating the ultimate limit of material condensation within the viscous vacuum substrate.

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