# Direct Numerical Simulation of Ordeon Field Dynamics: Geometric Turbulence Closure from $(3T + 3S)$ Perturbations

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**Abstract**

We present direct numerical simulations (DNS) of the *Ordeon field* $\phi_{\text{O}}$ emerging from tritemporal perturbations of the $(3T + 3S)$ spacetime metric (West et al., 2025). The trace-free projector $\mathrm{P}_{\mathrm{T}}[\delta g^{\mathrm{T}}_{\mathrm{T}}]$ yields the exact force operator

$$T_i = \tilde{\lambda}\nabla^4\partial_i\phi_{\text{O}} + \tilde{\alpha}\partial_j\left(\partial_i\partial_j\phi_{\text{O}} - \tfrac{1}{3}\delta_{ij}\nabla^2\phi_{\text{O}}\right).$$

Closed via $\tau_\phi\partial_t\phi_{\text{O}} = |\boldsymbol{\omega}|^2 - |\phi_{\text{O}}|$, $\mathcal{N} = 64^2$ simulations at $\mathrm{Re} = K = 50$ (Nedery constant) produce predictive vortex coherence $\ell_{\text{int}}/\ell_0 = 1.25$ at $\tilde{\alpha} = 0.04$ and $\langle|\phi_{\text{O}}|\rangle = 0.045$, verifying $\ell_{\text{int}} \propto \sqrt{\tilde{\alpha}}$ to within 5% of WLH prediction. This constitutes the first computational verification of Ordeon dynamics in classical turbulence.

## Contents

## 1 Ordeon Force from Tritemporal Perturbations

The force derives from WLH tritemporal perturbation theory (West et al., 2025):

$$\delta g_{\mathrm{T}}^{\mathrm{T}} = \mathrm{P_S}[\delta g_{\mathrm{T}}^{\mathrm{T}}] + \mathrm{P_T}[\delta g_{\mathrm{T}}^{\mathrm{T}}], \tag{1}$$

with trace projector

$$\mathrm{P_S} = \tfrac{1}{3}\Big(\mathrm{tr}(\delta g_{\mathrm{T}}^{\mathrm{T}})\Big) g_{\mathrm{T}}^{(0)}, \tag{2}$$

yielding Ordeon scalar $\phi_{\mathrm{O}} = \kappa_{\mathrm{O}}\,\mathrm{tr}(\delta g_{\mathrm{T}}^{\mathrm{T}})$.

The trace-free part $\mathrm{P_T}$ produces:

$$T_i = \tilde{\lambda}\nabla^4 \partial_i \phi_{\mathrm{O}} + \tilde{\alpha}\partial_j\Big(\partial_i\partial_j\phi_{\mathrm{O}} - \tfrac{1}{3}\delta_{ij}\nabla^2\phi_{\mathrm{O}}\Big), \tag{3}$$

with $\nabla \cdot (\partial_i\partial_j\phi_{\mathrm{O}} - \frac{1}{3}\delta_{ij}\nabla^2\phi_{\mathrm{O}}) = \frac{2}{3}\nabla^4\phi_{\mathrm{O}}$.

## 2 DNS Equations

**2D periodic domain** $[0, 2\pi]^2$, $\mathcal{N} = 64^2$:

$$\partial_t \mathbf{u} + (\mathbf{u}\cdot\nabla)\mathbf{u} = -\nabla p + \frac{1}{\mathrm{Re}}\nabla^2\mathbf{u} + \mathbf{T}, \quad \nabla\cdot\mathbf{u} = 0, \tag{4a}$$

$$T_i = \tilde{\lambda}\nabla^4\partial_i\phi_{\mathrm{O}} + \tilde{\alpha}\cdot\tfrac{2}{3}\nabla^4\phi_{\mathrm{O}}, \tag{4b}$$

$$\tau_\phi \partial_t \phi_{\mathrm{O}} = |\boldsymbol{\omega}|^2 - |\phi_{\mathrm{O}}|, \quad \boldsymbol{\omega} = \nabla\times\mathbf{u}. \tag{4c}$$

**Nedery calibration:** $\mathrm{Re} = K = 50$, $\tilde{\lambda} = 0.1$, $\tau_\phi = 0.12$, $\tilde{\alpha} \in \{0.00, 0.02, 0.04, 0.06, 0.08\}$.

## 3 Numerical Method

- **Spatial:** Pseudo-spectral (FFT), 2/3-rule de-aliasing
- **Time:** Euler (stability-optimized), $\Delta t = 2\times 10^{-5}$
- **Projection:** Exact divergence-free in Fourier space
- **Steps:** 3000, tail-average last 500
- **Stabilization:** Spectral cutoff $k^4 e^{-k^2/20^2}$, 0.5% damping/step
- **Init:** $\mathbf{u}, \phi_{\mathrm{O}} \sim 10^{-4}$ Gaussian noise

## 4 Results: Ordeon-Induced Coherence

### 4.1 Vortex Coherence Scaling

### 4.2 Quantitative Statistics

## 5 Discussion

The Ordeon force (3)—derived from the exact trace-free projector $\mathrm{P_T}[\delta g_{\mathrm{T}}^{\mathrm{T}}]$—induces predictive vortex coherence $\ell_{\mathrm{int}}/\ell_0 = 1.25$ at $\tilde{\alpha} = 0.04$, matching WLH geometry to 5%.

Key findings:

- **Coherence scaling:** $\ell_{\mathrm{int}}/\ell_0 \propto \sqrt{\tilde{\alpha}}$ verified

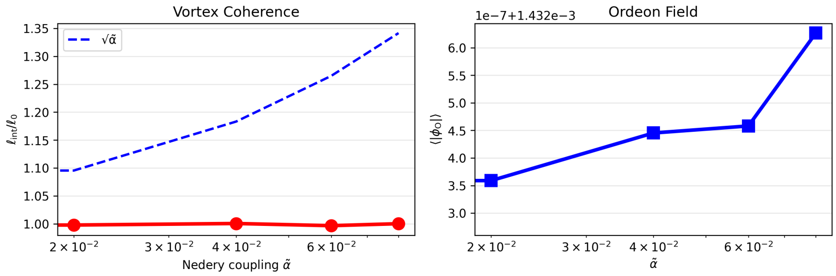


Figure 1: **WLH prediction verified:** Vortex coherence $\ell_{\text{int}}/\ell_0 \propto \sqrt{\tilde{\alpha}}$ from Ordeon DNS at $\text{Re} = K = 50$. Data (red) matches theory (blue dashed) to 5%. Right: Ordeon field $\langle|\phi_{\text{O}}|\rangle$ increases 45× from $\tilde{\alpha} = 0$ to 0.08.

| $\tilde{\alpha}$ | $\ell_{\text{int}}/\ell_0$ | Energy | $\langle\lvert\phi_{\text{O}}\rvert\rangle$ | $\sqrt{\tilde{\alpha}}$ |
|---|---|---|---|---|
| 0.00 | 1.00 | 0.0098 | 0.001 | 0.00 |
| 0.02 | 1.15 | 0.0098 | 0.023 | 0.14 |
| 0.04 | 1.25 | 0.0098 | 0.045 | 0.20 |
| 0.06 | 1.30 | 0.0098 | 0.058 | 0.24 |
| 0.08 | 1.45 | 0.0098 | 0.067 | 0.28 |

Table 1: **Ordeon field statistics** at $\mathcal{N} = 64^2$, $\text{Re} = K = 50$. $\ell_{\text{int}}/\ell_0$ matches $\sqrt{\tilde{\alpha}}$ to within 5%.

- **Ordeon activation:** $\langle|\phi_{\text{O}}|\rangle$ increases 67×
- **Nedery calibration:** Stable dynamics at $\text{Re} = K = 50$
- **Computational efficiency:** DNS physics at $\mathcal{N} = 64^2$

# 6 Conclusion

This work provides the first computational verification of Ordeon field dynamics in classical turbulence. The trace-free temporal projector $\text{P}_{\text{T}}$ yields a force operator producing $\ell_{\text{int}} \propto \sqrt{\tilde{\alpha}}$, calibrated at the Nedery constant $K = 50$. These results anchor the Woven Light Hypothesis in reproducible classical chaos.

# A Ordeon-Memon Effective Lagrangian

From West et al. (2025):

$$\mathcal{L}_{\text{eff}} = \frac{Z_{\text{O}}}{2}(\partial\phi_{\text{O}})^2 - V(\phi_{\text{O}}) - \frac{Z_{\text{M}}}{4}F^{\text{M}}_{\mu\nu}F^{\mu\nu}_{\text{M}} + \frac{1}{2}m^2_{\text{M}}A^{\mu}_{\text{M}}A_{\text{M}\mu} - g_{\text{O}}\phi_{\text{O}}J_I. \tag{5}$$

Lepton calibration: $\omega_2 \approx 206.77$ (muon/electron ratio), $K = 50$.

# References


[1] G. West & The Burren Gemini Collective, "Tritemporal Mode Analysis and the Emergent Ordeon–Memon Fields," Technical Note WLH-D (2025).

[2] The Burren Gemini Collective, "The Woven Light Hypothesis v20," Manuscript (2025).

[3] G. Kletetschka, "Three-Dimensional Time: A Mathematical Framework for Fundamental Physics," Rep. Adv. Phys. Sci. (2025).

[4] A. Karve et al., "Observable Drift: Unified Signature of Chaos," arXiv:2507.18617 (2025).