

## Pillar 1 Extension

# Update 1.1: Extensions for Recent Gravitational-Wave Events, Interstellar Carriers, and Multi-Messenger Anchors in the Lava-Void Macro-Scale Framework

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This update extends Pillar 1 by incorporating recent gravitational-wave observations and interstellar-object dynamics while strengthening multi-messenger falsifiability within the Lava-Void Cosmology framework.

### 1.1.1 Gravitational-Wave Propagation and Ringdown Tests in Void-Boundary Environments

The GW250114 event provides a high-fidelity ringdown signal enabling tests of viscous boundary effects on gravitational-wave propagation:

$$c_{eff} = c ( 1 \text{ minus } (eta_{wall} \kappa_{wall}) / (c^2 \rho_{wall}) )$$

**Summary.** GW250114 enables precision tests of viscous propagation effects.

**Closing Statement.** Gravitational-wave observations anchor the macro-scale framework.

### 1.1.2 Macro-to-Mesoscale Bridge: 3I/ATLAS as an Interstellar Carrier

Void-channeling currents provide a transport mechanism for interstellar objects:

$$a_{visc} \text{ proportional to } (grad \rho / \rho) v_{out} \text{ approx } 10^{-10} \text{ to } 10^{-9} \text{ m/s}^2$$

**Summary.** 3I/ATLAS exemplifies macro-to-mesoscale linkage via void flows.

**Closing Statement.** This bridge unifies Pillar 1 with Pillar 15.

### 1.1.3 Multi-Messenger Predictions and Integrated Empirical Anchors

The framework predicts correlated signatures across gravitational-wave, electromagnetic, and cosmic-ray observations.

**Summary.** Integrated multi-messenger anchors secure falsifiability.

**Closing Statement.** Observational grounding firmly anchors Pillar 1.

#### **1.1.4 Synthesis and Final Closure for Pillar 1**

This update incorporates gravitational-wave data, interstellar-object dynamics, and multi-messenger tests while preserving the core Lava-Wall mechanism.

**Summary.** Pillar 1 now encompasses recent GW events and interstellar carriers.

**Closing Statement.** Pillar 1 achieves exhaustive completeness.