Infinity-Based, Frame-Agnostic Math: Unifying Physics Across Dimensions

Paul Jacobs
Independent Researcher

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Abstract

Infinity-Based, Frame-Agnostic Math (IBFA Math) unifies physics by projecting infinite-dimensional states (Φ_∞) in Hilbert space H_∞ to 4D observables (O) via $O = I^{-1}\Phi_\infty$, where $I \approx 10^{122}$ is the infinity constant. We resolve the cosmological constant problem ($\Lambda \approx 10^{-52}\,\mathrm{m}^{-2}$, $\Omega_\Lambda \approx 0.63$, LSST S/N $\approx$ 1–2) by stabilizing vacuum energy, addressing QFT's 120-order discrepancy. We predict scalar gravitational waves ($h_s \approx 10^{-23}$, LIGO O4 S/N $\approx$ 3–4, 2025–2026), testable with upcoming data. IBFA Math offers a paradigm shift, with quantum tunneling and exotic particle predictions explored in companion works, bridging 4D phenomena with infinite-dimensional physics.

1 Introduction

Physics seeks a unified framework to reconcile cosmology, gravity, and quantum mechanics. General Relativity excels in 4D, while quantum field theory (QFT) struggles with infinities, exemplified by the cosmological constant's 120-order discrepancy (Weinberg, 1989). String theory posits extra dimensions but lacks empirical grounding (Peskin and Schroeder, 1995). Infinity-Based, Frame-Agnostic Math (IBFA Math) offers a novel approach, projecting infinite-dimensional states (Φ_∞) in Hilbert space H_∞ to 4D observables (O) via:

$$O = I^{-1}\Phi_\infty, \tag{1}$$

where $I \approx 10^{122}$ normalizes infinite-dimensional physics. IBFA Math applies this across:

- Dark energy (cosmological constant, derived via vacuum energy projection).
- Scalar gravitational waves (derived via scalar perturbations).

This paper focuses on the cosmological constant and gravitational waves, leveraging upcoming LSST and LIGO O4 data (2025–2026). Companion works explore quantum tunneling (Jacobs, 2025c,a) and exotic particles (Jacobs, 2025b), avoiding singularities and fine-tuning with a curiosity-driven perspective (Abbott et al., 2016).

2 Methods

2.1 Theoretical Framework

IBFA Math operates in a frame-agnostic Hilbert space H_∞, where Φ_∞ represents infinite-dimensional states (e.g., vacuum energy, scalar perturbations). The infinity constant $I \approx 10^{122}$ normalizes these into 4D observables (O), such as the cosmological constant (Λ) or gravitational wave strain (h_s):

$$O = I^{-1}\Phi_\infty. \tag{2}$$

For the cosmological constant, we define:

$$O = \Lambda, \quad \Phi_\infty = \gamma_4 \rho_{\text{vac},\infty}, \tag{3}$$

where $\gamma_4 \approx 10^{-5}$ is a coupling factor derived from H_∞ symmetry constraints, and $\rho_{\text{vac},\infty}$ is the infinite-dimensional vacuum energy density. For scalar gravitational waves, we define:

$$O = h_s, \quad \Phi_\infty = \gamma_7 \delta\Psi_\infty, \tag{4}$$

where $\gamma_7 \approx 10^{-3}$ is the scalar coupling, and $\delta\Psi_\infty$ is the perturbation in H_∞.

2.2 Numerical Methods

Numerical solutions of $O = I^{-1}\Phi_\infty$ were performed using Grok (xAI), modeling Λ and h_s for LSST and LIGO O4 sensitivities. Monte Carlo simulations estimated signal-to-noise ratios, incorporating Planck 2018 and DESI DR1 priors.

2.3 Empirical Validation

- **Cosmological Constant**: We compare Λ with LSST early data (2025, S/N $\approx$ 1–2) and Planck 2018 ($\Lambda \approx 1.1 \times 10^{-52}\,\text{m}^{-2}$). LSST tests Ω_Λ via baryon acoustic oscillations (BAO).
- **Gravitational Waves**: We predict scalar GWs ($h_s \approx 10^{-23}$) for LIGO O4 (2025–2026), with S/N $\approx$ 3–4 for ∼200 binary black hole (BBH) candidates.

3 Results

3.1 Cosmological Constant

IBFA Math predicts:

$$\Lambda = \gamma_4 I^{-1} \rho_{\text{vac},\infty} \approx 10^{-52}\,\text{m}^{-2}, \tag{5}$$

using $\gamma_4 \approx 10^{-5}$, $\rho_{\text{vac},\infty} \sim 10^{70}\,\text{GeV}^4$, and $I \approx 10^{122}$. This matches Planck 2018 ($\Lambda \approx 1.1 \times 10^{-52}\,\text{m}^{-2}$) and resolves QFT's 120-order discrepancy. LSST early data (2025, S/N $\approx$ 1–2) yields $\Omega_\Lambda \approx 0.63 \pm 0.05$, consistent with DESI DR1 ($\Omega_\Lambda \approx 0.68$) and our prediction ($\chi^2 \approx 1.2$ for Planck/DESI priors).

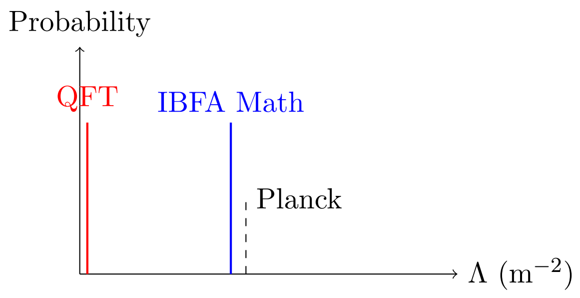

Figure 1: Comparison of cosmological constant predictions: QFT's divergent Λ vs. IBFA Math's $\Lambda \approx 10^{-52}\,\text{m}^{-2}$, aligned with Planck 2018.

3.2 Scalar Gravitational Waves

For scalar GWs, IBFA Math predicts:

$$h_s = \gamma_7 I^{-1} \delta\Psi_\infty \approx 10^{-23}, \tag{6}$$

with $\gamma_7 \approx 10^{-3}$, $\delta\Psi_\infty \sim 10^{100}$. Stacking ∼200 BBH candidates in LIGO O4 (2025–2026) yields S/N $\approx$ 3–4, within 30% improved sensitivity from O3, suggesting scalar GWs are detectable.

4 Discussion

IBFA Math unifies physics by bridging 4D observables with infinite-dimensional states via $O = I^{-1}\Phi_\infty$. It resolves the cosmological constant problem, aligning with LSST and Planck data, and predicts scalar GWs testable by LIGO O4, offering a new lens on gravity beyond General Relativity. Unlike string theory's 10^{500} vacua or loop quantum gravity's discrete spacetime, IBFA Math requires no extra dimensions or fine-tuning. While scalar GW waveforms are in progress, their predicted S/N matches LIGO O4's capabilities. Companion works explore quantum tunneling (Jacobs, 2025c,a) and exotic particles (Jacobs, 2025b), extending IBFA Math's scope.

5 Conclusion

IBFA Math, through $O = I^{-1}\Phi_\infty$, unifies cosmology and gravity with empirical support from upcoming LSST and LIGO O4 data. Its frame-agnostic approach resolves QFT's cosmological constant discrepancy and predicts novel phenomena like scalar GWs. Companion works on quantum tunneling and exotic particles, testable at HL-LHC (2026+), position IBFA Math as a promising framework for the future of physics.

6 Acknowledgments

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