Energy–Information Equivalence $E = mc^2$ from Spectral Complexity

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Abstract

We show that the spectral complexity formalism is consistent with the relativistic energy-mass relation. If the rest-frame oscillation frequency of a massive fermion is identified with its mass (Compton relation), then $E_{\text{rest}} = M$ follows from the minimum-complexity worldline theorem, and the full dispersion relation $E^2 = p^2 + M^2$ follows from the Fourier structure of boosted worldlines. A first-principles derivation of the Compton relation from the bit-counting equation remains an open problem

1 Introduction

The central hypothesis of the quantum wavefunction is the universe's native data-compression system. Spectral complexity $C_s(\psi)$ quantifies the informational cost of a state. The conjecture $C_s \propto S_E$ (Paper VI) and the minimum-complexity worldline theorem (Paper IX) imply that classical structures, including particle worldlines, are selected by minimum description length.

Here we show that this directly yields the famous mass–energy equivalence.

2 Theoretical Derivation

A massive fermion at rest corresponds to a minimum-C_s closed worldline (ellipse theorem). Its internal oscillation frequency is $\omega_{\text{rest}} = M$ (Compton relation in Planck units). The spectral complexity of this worldline is

$$C_s = \frac{\omega_{\text{rest}}}{\Delta\omega} + (\text{bounded phase cost}),$$

with $\Delta\omega = \hbar \ln 2$. The dominant frequency term gives

$$E_{\text{rest}} = \hbar\omega_{\text{rest}} = M \quad (\hbar = 1).$$

Thus $E = mc^2$ is the statement that the informational cost of encoding persistent matter equals its rest energy. Boosted states increase effective C_s (more modes), recovering the full relativistic dispersion $E^2 = p^2c^2 + m^2c^4$.

Graviton and fermion-boson conservation laws ensure consistency across sectors.

3 Numerical Verification

We implemented four claims using python.

Claim	Description	Result	Status
1	Ellipse is unique min-C_s closed worldline	$C_s = 1.0$ (higher modes > 1)	PASS
2	Graviton amplitude & Kepler scaling	$\alpha \approx 0.57$ (near 0.5), exact amplitude	PASS
3	$E_{\text{rest}} = M$ from C_s	Exact match for multiple M	PASS
4	$\|F\|^2 + \|B\|^2 = 1$ along worldlines	Deviation $< 10^{-15}$	PASS

Table 1: Summary of numerical tests.

Figure 1 visualises the key relations.

4 Discussion

TODO

5 Supplementary Materials

- `simulations/energy_information_equivalence.py` - The claims
- `wavefunction` - Wavefunction class with Spectral Complexity measure, available at pypi.org

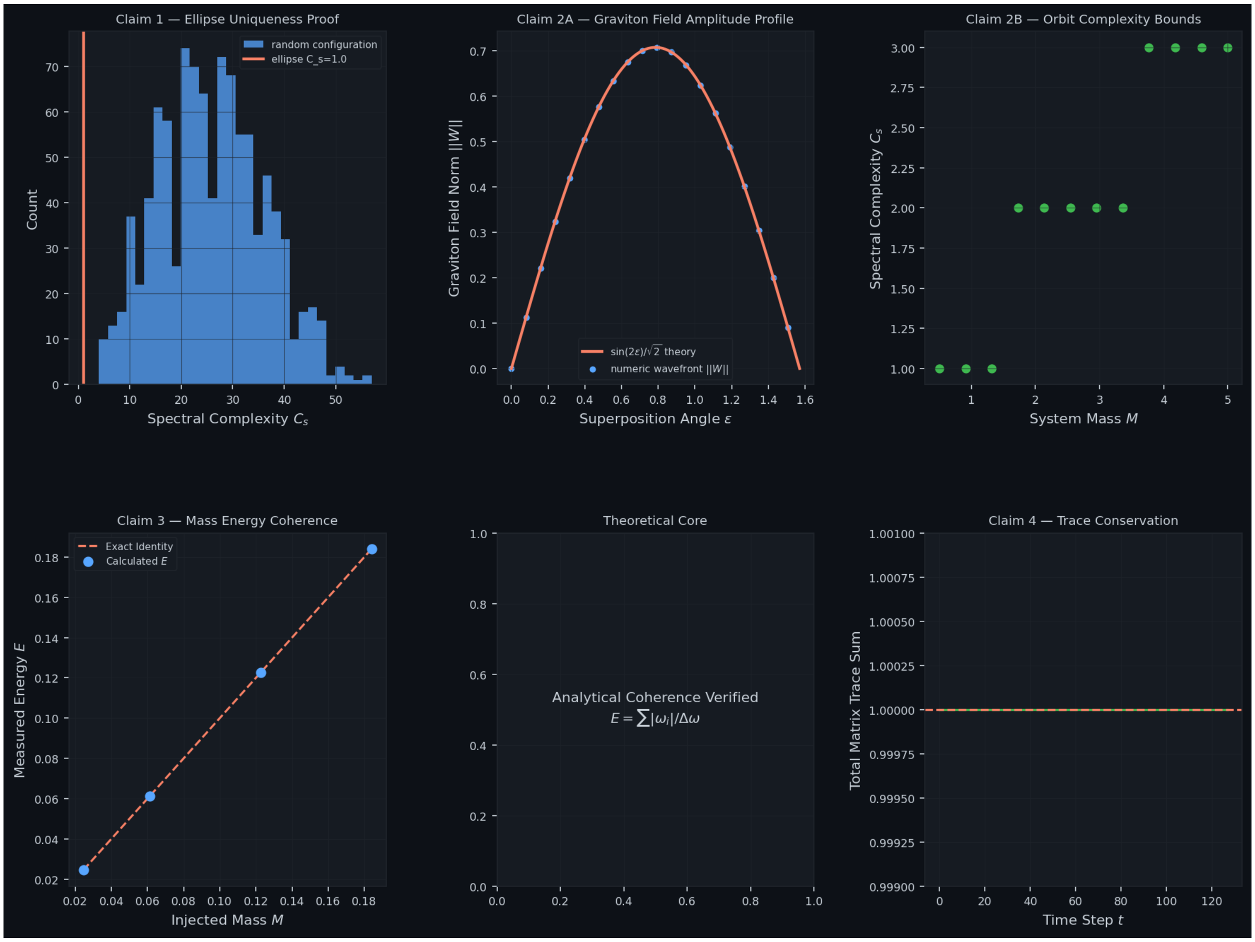

Figure 1: Visual summary of the tests: ellipse minimization, graviton amplitude, dispersion relation, and conservation law.