M-Theory and Its Connection to 11D Supergravity with Comparison to SFIT

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March 2026

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1 Introduction

M-theory is the leading candidate for a unified theory of quantum gravity and all fundamental forces. It is a non-perturbative quantum theory in eleven dimensions that encompasses all five consistent superstring theories as different limits or dual descriptions.

Eleven-dimensional supergravity is the unique maximal supergravity theory in 11 dimensions and serves as the **low-energy effective field theory** of M-theory.

2 What is M-Theory?

M-theory was conjectured by Edward Witten in 1995 during the second superstring revolution. It unifies the five consistent 10D superstring theories (Type I, Type IIA, Type IIB, Heterotic SO(32), Heterotic E8×E8) through a web of dualities (T-duality, S-duality, and U-duality).

Key features of M-theory: - It lives in **11 spacetime dimensions**. - It contains non-perturbative objects: **M2-branes** (membranes) and **M5-branes**. - It includes a 3-form gauge field C_3 whose 4-form field strength $F_4 = dC_3$ couples to the M2-branes. - At low energies (long wavelengths compared to the Planck length), M-theory is well-approximated by classical 11D supergravity.

3 Connection to 11D Supergravity

11D supergravity is the **low-energy limit** of M-theory. In the regime where energies are much lower than the Planck scale, quantum corrections and non-perturbative effects (branes, instantons) become negligible, and the theory reduces to the classical 11D supergravity action:

$$S = \frac{1}{2\kappa_{11}^2} \int d^{11}x \sqrt{-G} \left(R - \frac{1}{48} F_4^2 \right) - \frac{1}{12\kappa_{11}^2} \int C_3 \wedge F_4 \wedge F_4.$$

4 Comparison with SFIT

M-theory/11D supergravity is a **fundamental ultraviolet** theory whose non-perturbative objects (M2- and M5-branes) source the 3-form flux at the Planck scale.

SFIT is an **effective infrared** description in which gravity is a dynamic information-carrying flux vibrating at $\nu_{\text{res}} = 1.20134$ mHz with coupling kernel $K = 1.060$.

Key Differences and Connections: - M-theory operates at the Planck scale; SFIT describes emergent collective resonant behavior at laboratory energies. - The quantized flux of M2-branes in M-theory may provide the microscopic origin of the information-carrying flux in SFIT. - The KWW relaxation tails ($\beta = K = 1.060$) observed in SFIT could reflect slow relaxation processes of higher-dimensional or supersymmetric modes after perturbation by the gravitational flux. - SFIT offers a complementary, laboratory-testable framework based on dynamic information flux, while M-theory provides the deep ultraviolet completion.

Future GRANIT and precision gravitational experiments have the potential to test SFIT signatures and indirectly constrain or illuminate aspects of the underlying M-theory framework.

5 Conclusion

M-theory and 11D supergravity provide the fundamental high-energy framework, while SFIT offers a testable low-energy effective description of resonant gravitational information flux. Together they suggest a continuous bridge from Planck-scale topology to observable laboratory phenomena.

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