Derivation of the 11D Supergravity Action

Douglas G. Stevenson
stevensonfluxinformationtheory.com

March 2026

Contents

1 Introduction

Eleven-dimensional supergravity is the unique maximal supergravity theory in 11 dimensions. It is the low-energy limit of M-theory and serves as the highest-dimensional consistent supersymmetric extension of general relativity.

This document derives the bosonic part of the 11D supergravity action step by step.

2 The 11D Supergravity Action

The complete 11D supergravity action (Cremmer, Julia, Scherk, 1978) consists of the bosonic sector, the gravitino kinetic term, and interaction terms. The bosonic part is

$$S_{\text{bosonic}} = \frac{1}{2\kappa_{11}^2} \int d^{11}x \sqrt{-G} \left[R - \frac{1}{48} F_{\mu\nu\rho\sigma} F^{\mu\nu\rho\sigma} \right] - \frac{1}{12\kappa_{11}^2} \int C_3 \wedge F_4 \wedge F_4,$$

where: - G_{MN} is the 11D metric ($M, N = 0, 1, \ldots, 10$), - R is the 11D Ricci scalar, - $F_4 = dC_3$ is the 4-form field strength of the 3-form gauge field C_3, - κ_{11} is the 11D gravitational coupling constant, - The last term is the Chern-Simons term required for supersymmetry.

The full action also includes the gravitino ψ_M kinetic term and gravitino–boson interaction terms, but the bosonic sector above is the starting point for classical analysis.

3 Field Content

The bosonic fields of 11D supergravity are: - The metric g_{MN} (graviton), - The 3-form gauge potential C_{MNP}, - The 4-form field strength $F_{MNPQ} = \partial_{[M} C_{NPQ]}$.

The fermionic field is the gravitino ψ_M, a Majorana spinor-vector.

The action is invariant under local supersymmetry transformations, which is the defining feature of supergravity.

4 Dimensional Reduction and Lower-Dimensional Theories

When the 11D theory is compactified on a 7-torus (T^7) or other manifolds, it reduces to lower-dimensional supergravity theories. The most famous reduction is to 4D $\mathcal{N} = 8$ supergravity, which unifies gravity with all other forces through supersymmetry.

The reduction process involves Kaluza-Klein modes, with the 3-form C_3 giving rise to various gauge fields and scalars in lower dimensions.

5 Comparison with SFIT

11D supergravity is a fundamental ultraviolet theory that unifies gravity with other forces through supersymmetry and higher-dimensional geometry. SFIT is an effective low-energy description focused on resonant information dynamics in four dimensions.

While 11D supergravity operates at the Planck scale, SFIT makes concrete predictions at laboratory energies (1.20134 mHz resonance, testable in ultra-cold neutron experiments). A possible synthesis is that 11D supergravity (or M-theory) provides the deep microscopic structure, while SFIT describes the emergent resonant behavior when that structure interacts with a macroscopic gravitational field.

The 1.20134 mHz Quantum Heartbeat and the coupling kernel $K = 1.060$ could be collective modes arising from the compactified dimensions or supersymmetric degrees of freedom when observed at laboratory scales.

6 Conclusion

The 11D supergravity action is the unique maximal supersymmetric extension of gravity in eleven dimensions. Its bosonic sector consists of the Einstein-Hilbert term, the kinetic term for the 3-form gauge field, and the Chern-Simons term required for supersymmetry.

Dimensional reduction of this action yields various lower-dimensional supergravity theories, including 4D $\mathcal{N} = 8$ supergravity. SFIT offers a complementary approach based on information dynamics at laboratory scales, with clear experimental predictions.

Future ultra-cold neutron experiments (GRANIT) have the potential to test SFIT's predictions and indirectly illuminate aspects of higher-dimensional supergravity at laboratory energies.