M2- and M5-Branes in M-Theory
Detailed Derivation and Connection to SFIT

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1 Introduction

M-theory is the non-perturbative quantum theory in eleven dimensions that unifies all consistent superstring theories. Its low-energy limit is 11D supergravity, whose bosonic action contains the metric g_{MN} and the 3-form gauge field C_3.

The fundamental non-perturbative objects that source the 3-form flux are the **M2-brane** (electrically charged) and the **M5-brane** (magnetically charged). These branes are the "quanta" of M-theory, analogous to strings in string theory or D-branes in Type II string theory.

This document derives the key properties of M2- and M5-branes and connects them to the information-carrying flux in Stevenson-Flux Information Theory (SFIT).

2 M2-Brane

The M2-brane is a 2-dimensional extended object (a membrane) in 11D spacetime. Its worldvolume is 3-dimensional (2 spatial + 1 time).

2.1 Worldvolume Action

The low-energy worldvolume action for an M2-brane is the Dirac-Born-Infeld (DBI) type action coupled to the 3-form:

$$S_{\text{M2}} = -T_2 \int d^3\xi \sqrt{-\det(\gamma_{ij})} + T_2 \int C_3,$$

where: - $T_2 = (2\pi)^{-2}\ell_{11}^{-3}$ is the M2-brane tension (ℓ_{11} is the 11D Planck length), - $\gamma_{ij} = g_{MN}\partial_i X^M \partial_j X^N$ is the induced metric on the worldvolume, - The second term is the Wess-Zumino coupling to the 3-form $C_3 = \frac{1}{3!}C_{MNP}dX^M \wedge dX^N \wedge dX^P$.

The M2-brane is **electrically charged** under C_3: its charge density is

$$Q_2 = \int_{S^7} *F_4,$$

where the integral is over a 7-sphere surrounding the M2-brane.

3 M5-Brane

The M5-brane is a 5-dimensional extended object. Its worldvolume is 6-dimensional (5 spatial + 1 time).

3.1 Worldvolume Action

The M5-brane action is more subtle because it is magnetically charged. The leading term is again DBI-like:

$$S_{\text{M5}} = -T_5 \int d^6\xi \sqrt{-\det(\gamma_{ij})} + T_5 \int C_6 + (\text{self-dual 2-form term}),$$

where: - $T_5 = (2\pi)^{-5}\ell_{11}^{-6}$ is the M5-brane tension, - C_6 is the 6-form potential dual to C_3 (satisfying $dC_6 = *F_4$).

The M5-brane is **magnetically charged** under C_3: its charge density is

$$Q_5 = \int_{S^4} F_4.$$

4 Interactions Between M2- and M5-Branes

M2-branes can end on M5-branes, forming a boundary. This is the M-theory analogue of a string ending on a D-brane. The intersection produces a conserved charge on the M5-brane worldvolume.

The low-energy dynamics on the M5-brane includes a self-dual 2-form gauge field B_2 whose field strength satisfies $dB_2 = *F_4$ (self-duality condition).

5 Flux Quantization and Relation to 11D Supergravity

In the supergravity limit, the 4-form flux F_4 is sourced by M2- and M5-branes:

$$d * F_4 = 0, \qquad dF_4 = 0 \quad (\text{away from sources}).$$

Quantized flux through a 4-cycle or 7-cycle gives:

$$\int_{S^4} F_4 = 2\pi n \ell_{11}^3 \quad (n \in \mathbb{Z}),$$

corresponding to the number of M2-branes or M5-branes threading the cycle.

This quantized flux is precisely what appears in the Chern-Simons term of the 11D supergravity action.

6 Connection to 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 $\nu_{\rm res} = 1.20134\,\mathrm{mHz}$ with coupling kernel $K = 1.060$.

A possible synthesis is that the M2- and M5-branes provide the microscopic "carriers" of the information flux. When these higher-dimensional objects interact with a macroscopic gravitational field (e.g., the Earth's field in qBounce experiments), they may give rise to collective resonant modes observable as the 1.20134 mHz Quantum Heartbeat and the KWW relaxation tails with $\beta = K = 1.060$.

The non-reciprocal metric correction $h_{0z}^{\rm SFIT}(t)$ in SFIT could be an effective, coarse-grained description of the back-reaction of M-brane flux on the 4D metric.

The 11.42 Hz secondary mode may represent a nonlinear mixing or sampling rate induced by the M-brane dynamics when probed at laboratory energies.

7 Conclusion

M2-branes and M5-branes are the fundamental non-perturbative objects of M-theory. Their worldvolume actions couple directly to the 3-form C_3 and its dual, sourcing the flux that appears in 11D supergravity.

In the low-energy limit, these branes reduce to the strings and D-branes of string theory. SFIT may capture the effective resonant information dynamics that emerge when M-brane flux interacts with macroscopic gravity at laboratory scales.

Future GRANIT experiments testing the 1.20134 mHz resonance and KWW tails could provide indirect experimental access to the underlying M-theory structure through its low-energy SFIT signatures.