Technical Report: Equations, Models, and Dynamics

January 2026

This technical report formalizes the mathematical underpinnings of the Deep Brain Stimulation (DBS) application. It covers the Finite Element Analysis (FEA) of electric fields, the coupled differential equations for OCD CSTC loops, the neurotransmitter dynamics in Depression, the quantum surface integrals and continued fraction metrics for ASD neural repair, and the neural field equations for Dementia pathology. Each module is grounded in stochastic physics and statistical mechanics.

3. Depression Module: Neurotransmitter Dynamics

The Depression model simulates the restoration of bioamines (Serotonin 5-HT, Dopamine DA) and the regulation of Glutamate (Glu). The dynamics under formulation are:

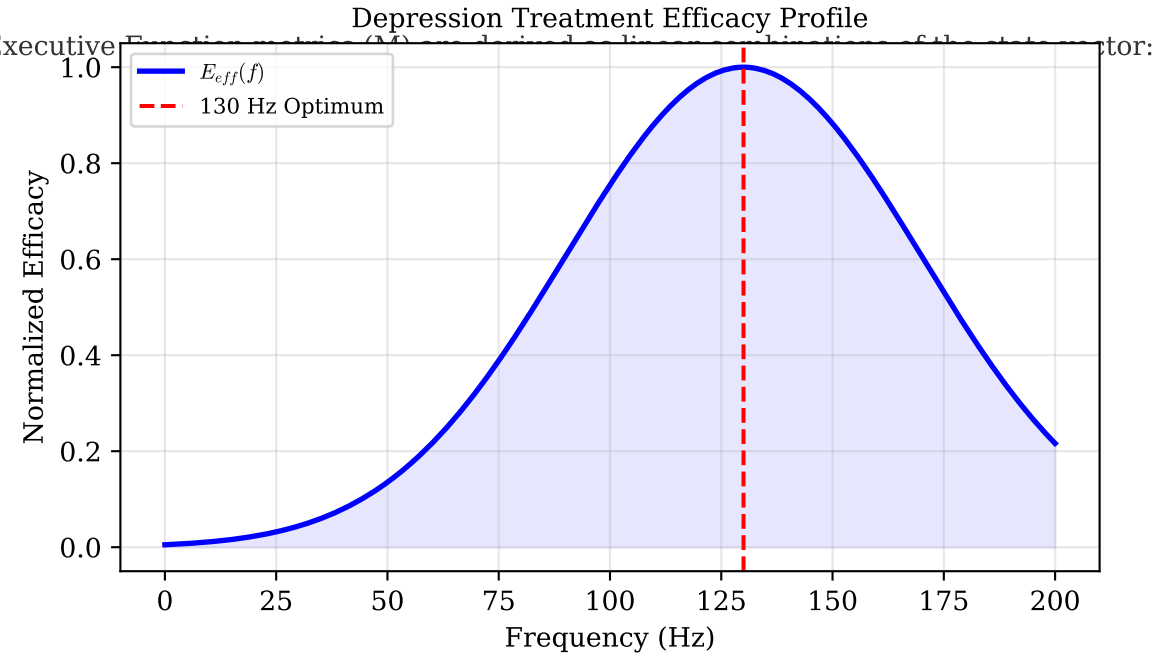
$$\frac{dS_{5HT}}{dt} = \alpha \cdot E_{eff}(f) \cdot (1 - S_{5HT}) - \gamma(S_{5HT} - S_{base})$$

$$\frac{dD_{DA}}{dt} = \beta \cdot E_{eff}(f) \cdot (1 - D_{DA}) - \gamma(D_{DA} - D_{base})$$

The stimulation efficacy E_eff is strictly frequency-dependent, modeled as a Gaussian resonance around 130 Hz:

$$E_{eff}(f) = A \cdot \exp\left(-\frac{(f-130)^2}{2\sigma^2}\right) \cdot \frac{V_{activation}}{V_{ref}}$$

Executive Function metrics (M) are derived as linear combinations of the state vector:



4. ASD Module: Quantum Neural Repair

ASD repair focuses on restoring connectivity. We utilize a Quantum Surface Integral formalism where the neural connectivity is treated as a wavefunction Psi:

$$\Phi_{repair} = \oint_S \Psi^* \nabla \Psi \cdot \hat{\mathbf{n}} \, dS$$

The repair trajectory is modeled using Continued Fraction sequences, representing the hierarchical restructuring of neural pathways:

$$C(t) = a_0 + \frac{1}{a_1 + \frac{1}{a_2 + \dots}}$$

Coherence of the repaired state is measured via Von Neumann Entropy:

$$S_{vonNeumann} = -\operatorname{Tr}(\rho \ln \rho)$$

5. Dementia Module: Neural Decay & Memory

Dementia pathology involves time-dependent atrophy and amyloid burden (Beta). The activity A of a memory region i is governed by:

$$\tau \frac{dA_i}{dt} = -A_i + \sigma\left(\sum_j w_{ij} A_j + C_{chol} - P_\beta\right)$$

Cognitive scores (MMSE) scale with the integral of hippocampal activity and inverse pathology load:

$$MMSE \propto \int_T A_{hippocampus}(t) \cdot (1 - P_\beta(t)) \, dt$$

DBS effectiveness at theta frequencies (4-8 Hz) enhances memory encoding via a logarithmic sensitivity function:

$$E_{stim} \propto Q_{charge} \cdot \frac{\ln(f+1)}{\ln(f_{cut})}$$