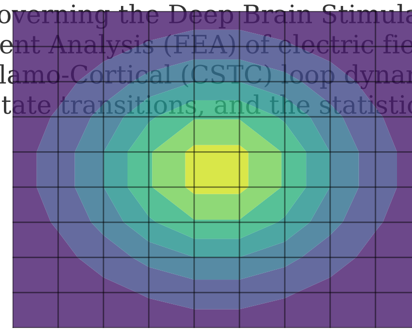
Finite Mathematical Framework for Deep Brain Stimulation & OCD Treatment

Scientific & Medical Advisory Board
Deep Brain Stimulation System

FEA Mesh & E-Field



This report details the underlying finite mathematical models governing the Deep Brain Stimulation (DBS) application. We present the Poisson formulation for Finite Element Analysis (FEA) of electric fields, the coupled differential equations modeling the Cortico-Striato-Thalamo-Cortical (CSTC) loop dynamics in OCD, the novel Quantum Surface Integral optimization for attractor state transitions, and the statistical mechanics underpinning clinical trial simulations.

1. Finite Element Analysis (FEA) of Electric Fields

The electric potential Phi within the brain tissue is governed by the quasi-static Poisson equation for volume conduction:

$$\nabla \cdot (\sigma(x) \nabla \Phi(x)) = -\nabla \cdot J_{source}$$

where sigma(x) is the conductivity tensor of the tissue (Gray Matter, White Matter, CSF). The Volume of Tissue Activated (VTA) is defined by the set of points where the second spatial difference of the potential exceeds the axonal activation threshold:

$$VTA = \left\{ x \in \Omega \mid \Delta^2 \Phi(x) > \theta_{activation} \right\}$$

2. CSTC Loop Dynamics & OCD Attractors

We model the OCD pathology as a hyperactive gain cycle in the CSTC loop. The firing rates of the Orbitofrontal Cortex (OFC), Caudate (C), and Thalamus (T) are governed by coupled nonlinear differential equations:

$$\tau \frac{dC}{dt} = -C + S(w_{OFC \to C} \cdot OFC + I_{DBS})$$

$$\tau \frac{dT}{dt} = -T + S(w_{C \to T} \cdot C - w_{GPi \to T} \cdot GPi)$$

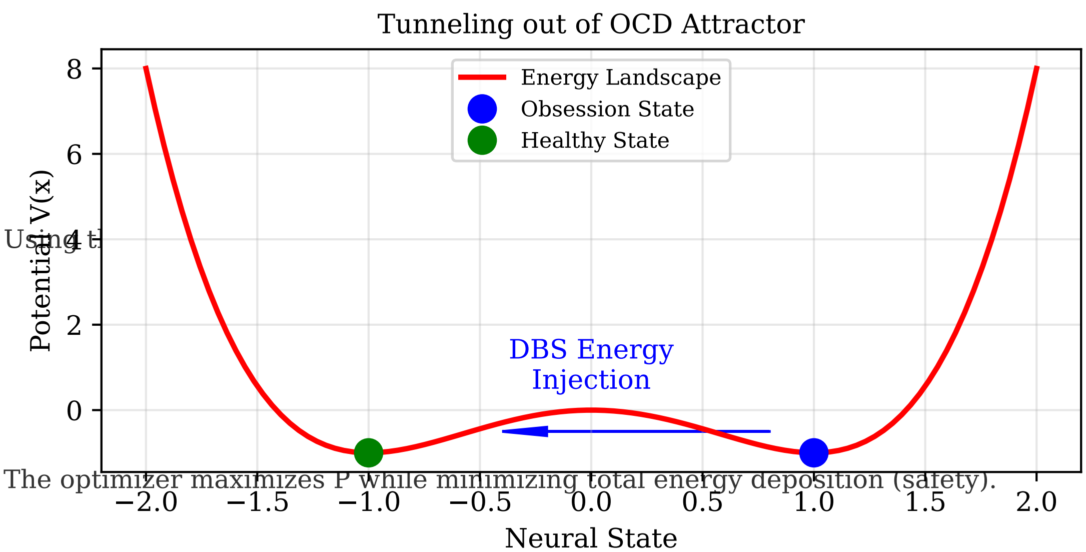
Finite Mathematical Framework for
Deep Brain Stimulation & OCD Treatment

Scientific & Medical Advisory Board
Deep Brain Stimulation System

3. Quantum Surface Integral Optimization

To optimize treatment, we calculate the probability of tunneling out of the pathological attractor. We define the 'Quantum Surface' S as the energy manifold of the obsession state. The transition probability P is derived from the E-field flux integrated over this surface:

Using t



The optimizer maximizes P while minimizing total energy deposition (safety).

4. Statistical Mechanics of Clinical Trials

We simulate clinical trials using a population distribution model. The pre- and post-treatment YBOCS scores are modeled as distributions shifted by the treatment efficacy E:

$$P_{post}(s) = \int P_{pre}(s') \cdot \mathcal{N}(s' - E(s'), \sigma_{var})\, ds'$$

Significance is determined via a paired t-test on the finite sample N:

$$t = \frac{\bar{X}_{diff}}{s_{diff}/\sqrt{N}}, \quad p = 2(1 - F_{t_{N-1}}(|t|))$$