Collected Equations from CSE + QFT research

1. Dynamic Balance Function (Original)

$$F(P) = \sum_{i=1}^{N} (\lambda_C + \lambda_S + \lambda_E) \cdot w_i \cdot A_i$$

2. Dynamic Balance Function (Improved)

$$\boldsymbol{\lambda} = \begin{pmatrix} \lambda_C \\ \lambda_S \\ \lambda_E \end{pmatrix}$$

$$F(P) = \sum_{i=1}^{N} \left(\mathbf{w}_i^\top \boldsymbol{\lambda} - \boldsymbol{\beta}^\top \mathbf{S}_i \right) A_i$$

3. FFT–Based Spectral Feedback

$$\mathcal{S}_{\text{dynamic}}(t+1) = (1-\tau)\mathcal{S}_{\text{dynamic}}(t) + \tau\, \text{FFT}(\lambda(t))$$

4. Recursive Lambda Update (Original)

$$\lambda_i(t+1) = \lambda_i(t) - \alpha \cdot \frac{\partial L}{\partial \lambda_i} - \beta \cdot \mathcal{F}(\lambda_i)$$

5. Recursive Lambda Update (Improved)

$$\lambda_i(t+1) = \lambda_i(t) - \alpha\, \nabla_{\lambda_i} L(\lambda(t)) - \beta\, \mathcal{F}\big(\text{FFT}(\lambda_i(t))\big)$$

6. Adaptive Update Rule with FFT Correction

$$\lambda^{(t+1)} = \lambda^{(t)} - \eta\, \nabla_\lambda L(\lambda^{(t)}) - \gamma\, \mathcal{E}_{FFT}(\lambda^{(t)})$$

$$\mathcal{E}_{FFT}(\lambda) = \left\| \text{FFT}(\lambda) - \mathcal{S}_{\text{target}} \right\|$$

7. FFT-Enhanced Balance Function (Improved)

$$F(P) = \sum_{i=1}^{N} \left[(\lambda_C + \lambda_S + \lambda_E) - \boldsymbol{\beta}^\top \mathbf{S}_i \right] w_i A_i$$

8. Generalized Update Mapping

$$\mathcal{T}(\lambda) = \lambda - \eta\, \nabla L(\lambda) - \gamma\, H_f(\lambda) + \delta\, D_f(\lambda)$$

9. Contraction Condition

$$\| \mathcal{T}(\lambda_1) - \mathcal{T}(\lambda_2) \| \leq q\, \|\lambda_1 - \lambda_2\|, \quad \text{with } 0 < q < 1$$

10. Sufficient Condition

$$\eta L_{\nabla L} + \gamma L_{H_f} + \delta L_{D_f} < 1$$

11. Lyapunov Stability Function

$$V(\lambda) = L(\lambda) + \kappa\, E(\lambda)$$

$$E(\lambda) = \left\| \text{FFT}(\lambda) - \mathcal{S}_{\text{target}} \right\|^2$$

$$V(\lambda(t+1)) - V(\lambda(t)) \leq -\epsilon \left\| \lambda(t+1) - \lambda(t) \right\|^2, \quad \epsilon > 0$$

12. QFT-Based Quantum Spectral Feedback

$$|\tilde{\psi}\rangle = \text{QFT}(|\psi\rangle)$$

13. Recursive Lambda Update with QFT Correction

$$\lambda^{(t+1)} = \lambda^{(t)} - \eta \nabla_\lambda L(\lambda^{(t)}) - \gamma \mathcal{E}_{QFT}(\lambda^{(t)})$$

$$\mathcal{E}_{QFT}(\lambda) = \left\| \text{QFT}(\lambda) - \mathcal{S}_{\text{target}} \right\|$$