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)

$$oldsymbol{\lambda} = egin{pmatrix} \lambda_C \ \lambda_S \ \lambda_E \end{pmatrix}$$

$$F(P) = \sum_{i=1}^N \left(\mathbf{w}_i^ op oldsymbol{\lambda} - oldsymbol{eta}^ op \mathbf{S}_i
ight) A_i$$

3. FFT-Based Spectral Feedback

$$S_{ ext{dynamic}}(t+1) = (1-\tau)S_{ ext{dynamic}}(t) + \tau \operatorname{FFT}(\lambda(t))$$

4. Recursive Lambda Update (Original)

$$\lambda_i(t+1) = \lambda_i(t) - lpha \cdot rac{\partial L}{\partial \lambda_i} - eta \cdot \mathcal{F}(\lambda_i)$$

5. Recursive Lambda Update (Improved)

$$\lambda_i(t+1) = \lambda_i(t) - lpha \,
abla_{\lambda_i} L(\lambda(t)) - eta \, \mathcal{F}ig(\mathrm{FFT}(\lambda_i(t)) ig)$$

6. Adaptive Update Rule with FFT Correction

$$egin{aligned} \lambda^{(t+1)} &= \lambda^{(t)} - \eta \,
abla_{\lambda} L(\lambda^{(t)}) - \gamma \, \mathcal{E}_{FFT}(\lambda^{(t)}) \ & \mathcal{E}_{FFT}(\lambda) = \left\| ext{FFT}(\lambda) - \mathcal{S}_{ ext{target}}
ight\| \end{aligned}$$

7. FFT-Enhanced Balance Function (Improved)

$$F(P) = \sum_{i=1}^{N} \left[\left(\lambda_C + \lambda_S + \lambda_E
ight) - oldsymbol{eta}^ op \mathbf{S}_i
ight] w_i A_i$$

8. Generalized Update Mapping

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

9. Contraction Condition

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

10. Sufficient Condition

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

11. Lyapunov Stability Function

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

1 of 2 4/2/25, 2:41 PM

$$E(\lambda) = \left\| ext{FFT}(\lambda) - \mathcal{S}_{ ext{target}}
ight\|^2 \ V(\lambda(t+1)) - V(\lambda(t)) \le -\epsilon \left\| \lambda(t+1) - \lambda(t)
ight\|^2, \quad \epsilon > 0$$

12. QFT-Based Quantum Spectral Feedback

$$| ilde{\psi}
angle = ext{QFT}(|\psi
angle)$$

13. Recursive Lambda Update with QFT Correction

$$egin{aligned} \lambda^{(t+1)} &= \lambda^{(t)} - \eta
abla_{\lambda} L(\lambda^{(t)}) - \gamma \mathcal{E}_{QFT}(\lambda^{(t)}) \ & \mathcal{E}_{QFT}(\lambda) = \left\| ext{QFT}(\lambda) - \mathcal{S}_{ ext{target}}
ight\| \end{aligned}$$

2 of 2