

Erratum: Sixth-order time-convolutionless master equation and beyond: Late-time resummations, two types of divergences, and the limits of validity [Phys. Rev. A **111, 042214 (2025)]**

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(Received 1 September 2026; published 17 September 2026)

DOI: [10.1103/14sy-ybvn](https://doi.org/10.1103/14sy-ybvn)

UNDERLYING ERROR AND CORRECTION

In Appendix F of the published article [Phys. Rev. A **111**, 042214 (2025)], the ordered fivefold integration domain in Eqs. (F1)–(F30) is rearranged according to Appendix C and then reduced to the double-integral form beginning with Eq. (F31). In one positive rearrangement branch used for the following four correlation products,

$$\langle 02 \rangle \langle 14 \rangle \langle 35 \rangle, \quad \langle 02 \rangle \langle 14 \rangle \langle 53 \rangle, \quad \langle 02 \rangle \langle 41 \rangle \langle 35 \rangle, \quad \langle 02 \rangle \langle 41 \rangle \langle 53 \rangle, \quad (1)$$

the lower end point of one eliminated time was set to zero. Denoting that eliminated time by s , the interval used in this step was $0 \leq s \leq t$. The ordering constraints of this branch instead require $t_a \leq s \leq t$, where the two times retained in Eq. (F31) obey $0 \leq t_b \leq t_a \leq t$.

For $t_a > 0$, the intervals $[0, t]$ and $[t_a, t]$ differ by $[0, t_a]$, a set of nonzero measure, and therefore define different integration domains. The operator-valued integrand and its factor ordering are unchanged.

The intermediate bound is not shown in the published article; Appendix F gives only the reduced result. The error appears there in the lower-end-point arguments of Eqs. (F34), (F36), (F46), and (F49).

For the notation

$$\Delta\Gamma(x, y) \equiv \Gamma(x) - \Gamma(y), \quad \Delta\Gamma^T(x, y) \equiv \Gamma^T(x) - \Gamma^T(y), \quad (2)$$

Eq. (68), written with s for the eliminated time, gives the two oriented identities

$$\begin{aligned} \int_{t_i}^{t_f} ds \mathcal{B}(\hat{s}) \langle sb \rangle &= \mathcal{B}\{\hat{b} \circ \Delta\Gamma(t_f - t_b, t_i - t_b)\}, \\ \int_{t_i}^{t_f} ds \mathcal{B}(\hat{s}) \langle bs \rangle &= \mathcal{B}\{\hat{b} \circ \Delta\Gamma^T(t_b - t_i, t_b - t_f)\}. \end{aligned} \quad (3)$$

Using the incorrect end points $(t_i, t_f) = (0, t)$ produces the lower-end-point arguments printed in the four affected terms. Using the required end points $(t_i, t_f) = (t_a, t)$ gives

$$\hat{b} \circ \Delta\Gamma(t - t_b, -t_b) \longrightarrow \hat{b} \circ \Delta\Gamma(t - t_b, t_a - t_b), \quad (4)$$

$$\hat{b} \circ \Delta\Gamma^T(t_b, t_b - t) \longrightarrow \hat{b} \circ \Delta\Gamma^T(t_b - t_a, t_b - t). \quad (5)$$

No symmetry of Γ or Γ^T is used in these replacements. The other kernel factors, operator products, commutators, density-operator positions, and the common outer domain $\int_0^t dt_a \int_0^{t_a} dt_b$ are unchanged.

CORRECTED AFFECTED TERMS

The labels below refer to the four affected lines in the published Appendix F. The correction changes only the indicated kernel arguments; the operator ordering and the position of $\hat{q}$ in each term are unchanged.

For $\langle 02 \rangle \langle 14 \rangle \langle 35 \rangle$, Eq. (F34) is replaced by

$$\mathcal{T}_{34}^{\text{corr}} = +[(\hat{b} \circ \Delta\Gamma(t - t_b, t_a - t_b)), (\hat{0} \circ \Delta\Gamma^T(t, t - t_a))][\hat{a}, \hat{b}](\hat{a} \circ \Gamma^T(t_a - t_b))\hat{q}. \quad (6)$$

For $\langle 02 \rangle \langle 14 \rangle \langle 53 \rangle$, Eq. (F36) is replaced by

$$\mathcal{T}_{36}^{\text{corr}} = -[(\hat{b} \circ \Delta\Gamma(t - t_b, t_a - t_b)), (\hat{0} \circ \Delta\Gamma^T(t, t - t_a))][\hat{a}, \hat{b}]\hat{q}(\hat{a} \circ [-\Gamma(t_b - t_a)]). \quad (7)$$

For $\langle 02 \rangle \langle 41 \rangle \langle 35 \rangle$, Eq. (F46) is replaced by

$$\mathcal{T}_{46}^{\text{corr}} = -[(\hat{b} \circ \Delta\Gamma^T(t_b - t_a, t_b - t)), (\hat{0} \circ \Delta\Gamma^T(t, t - t_a))](\hat{a} \circ \Gamma^T(t_a - t_b))\hat{q}[\hat{a}, \hat{b}]. \quad (8)$$

For $\langle 02 \rangle \langle 41 \rangle \langle 53 \rangle$, Eq. (F49) is replaced by

$$\mathcal{T}_{49}^{\text{corr}} = +[(\hat{b} \circ \Delta \Gamma^T(t_b - t_a, t_b - t)), (\hat{0} \circ \Delta \Gamma^T(t, t - t_a))] \hat{Q}(\hat{a} \circ [-\Gamma(t_b - t_a)])[\hat{a}, \hat{b}]. \quad (9)$$

Including the common outer commutator and double integral, the complete affected contribution is

$$\mathcal{L}_{\text{affected,corr}}^6(t) \hat{Q} = - \left[\hat{0}, \int_0^t dt_a \int_0^{t_a} dt_b (\mathcal{T}_{34}^{\text{corr}} + \mathcal{T}_{36}^{\text{corr}} + \mathcal{T}_{46}^{\text{corr}} + \mathcal{T}_{49}^{\text{corr}}) \right] + \text{H.c.} \quad (10)$$

In the complete corrected Appendix F below, the four published terms appear as

$$\begin{aligned} \text{published (F34)} &\longrightarrow \text{corrected (F96)}, & \text{published (F36)} &\longrightarrow \text{corrected (F98)}, \\ \text{published (F46)} &\longrightarrow \text{corrected (F107)}, & \text{published (F49)} &\longrightarrow \text{corrected (F111)}. \end{aligned}$$

The corrected contribution from published Eq. (F46) is identical to that from published Eq. (F77). Each has coefficient -1 , and the two are collected in Eq. (F107) with coefficient -2 . The 125 separately listed published contributions therefore become 124 distinct terms. The 40 cumulative-correlation expressions and the Hadamard identity are unchanged; the correction is to one integration-domain assignment in the Appendix C reduction.

NUMERICAL CONSISTENCY CHECK

For a d -level dynamical map $\Phi_t^{(n)}$ propagated with the cumulative TCL truncation through order n , define the normalized Choi matrix and its negativity by

$$J^{(n)}(t) = \frac{1}{d} \sum_{i,j=1}^d |i\rangle\langle j| \otimes \Phi_t^{(n)}(|i\rangle\langle j|), \quad \mathcal{N}_C^{(n)}(t) = - \sum_{\lambda_k[J^{(n)}(t)] < 0} \lambda_k[J^{(n)}(t)]. \quad (11)$$

An exactly completely positive map has $\mathcal{N}_C = 0$. Choi negativity therefore measures deviations from complete positivity.

We use a fixed four-level realization with energies $(-0.6490, -0.2045, 0.1274, 0.6317)$ and a Hermitian Gaussian-unitary-ensemble coupling normalized to unit Frobenius norm. The zero-temperature Ohmic bath correlation is

$$C(t) = \frac{\alpha \omega_c^2}{2(1 + i\omega_c t)^2}, \quad \omega_c = 10. \quad (12)$$

The map is propagated without eigenvalue clipping or positivity repair over $0 \leq t \leq 200$, using map spacing 0.0125. The cumulative generators are $K^{[2]} = K_2$, $K^{[4]} = K_2 + K_4$, and $K_{\text{corr}}^{[6]} = K_2 + K_4 + K_{6,\text{corr}}$. To test cancellation within the sixth-order sum, 11 separate calculations propagate

$$K_{(-q)}^{[6]} = K_2 + K_4 + K_{6,\text{corr}} - K_{6,q}, \quad q \in \mathcal{S}_F, \quad (13)$$

where $\mathcal{S}_F$ contains Eqs. (F32)–(F37), (F43), (F98), (F106), (F115), and (F144) of the corrected replacement below. Each calculation deletes the entire contribution shown in the indicated equation—including its coefficient, common outer commutator, and Hermitian conjugate—while leaving all other terms and model parameters unchanged.

At $\alpha = 0.03$, the corrected TCL_6 maximum Choi negativity is more than five orders of magnitude below TCL_4 and more than nine orders below TCL_2 . Figure 2(d) shows how the 11 one-term deletion results change across the coupling sweep. Away from the numerical floor, removing a term generally increases the maximum Choi negativity. This behavior is consistent with cancellations among the sixth-order contributions: omitting one contribution changes their balance and increases the propagated map's departure from complete positivity. Together with the order-by-order reduction in Fig. 1, the deletion tests provide a numerical consistency check on the corrected expression for this model. A separate manuscript describing an accelerated method for evaluating TCL_6 is in preparation.

COMPLETE CORRECTED APPENDIX F

Equations (F1)–(F30) reproduce the unchanged cumulative-correlation form. Equation (F31) introduces the reduced double-integral form, Eqs. (F32)–(F155) give the 124 corrected collected terms, and Eq. (F156) supplies the Hermitian-conjugate completion. The corrected reduced terms are numbered consecutively, so their labels differ from those in the published reduced list:

$$\mathcal{L}^6 \hat{Q} = - \left[\hat{0}, \int_0^t dt_1 \int_0^{t_1} dt_2 \int_0^{t_2} dt_3 \int_0^{t_3} dt_4 \int_0^{t_4} dt_5 (\right. \quad (F1)$$

$$+ \langle 02 \rangle \langle 14 \rangle \langle 35 \rangle ([\hat{1}, \hat{2}] [\hat{3}, \hat{4}] \hat{S} \hat{Q}) + \langle 02 \rangle \langle 14 \rangle \langle 53 \rangle (-[\hat{1}, \hat{2}] [\hat{3}, \hat{4}] \hat{Q} \hat{S}) + \langle 02 \rangle \langle 41 \rangle \langle 35 \rangle (-[\hat{1}, \hat{2}] \hat{S} \hat{Q} [\hat{3}, \hat{4}]) \quad (F2)$$

$$+ \langle 02 \rangle \langle 41 \rangle \langle 53 \rangle ([\hat{1}, \hat{2}] \hat{Q} \hat{S} [\hat{3}, \hat{4}]) + \langle 02 \rangle \langle 15 \rangle \langle 34 \rangle ([\hat{1}, \hat{2}] ([\hat{3}, \hat{4}] \hat{S} \hat{Q}) - \hat{S} [\hat{3}, \hat{4}] \hat{Q}) \quad (F3)$$

$$+ \langle 02 \rangle \langle 15 \rangle \langle 43 \rangle (-[\hat{1}, \hat{2}] [\hat{3}, \hat{5}] \hat{Q} \hat{4}) + \langle 02 \rangle \langle 51 \rangle \langle 34 \rangle (-[\hat{1}, \hat{2}] \hat{4} \hat{Q} [\hat{3}, \hat{5}]) + \langle 02 \rangle \langle 51 \rangle \langle 43 \rangle ([\hat{1}, \hat{2}] ([\hat{3}, \hat{Q} \hat{S} \hat{4}] - [\hat{3}, \hat{Q} \hat{4}] \hat{S})) \quad (F4)$$

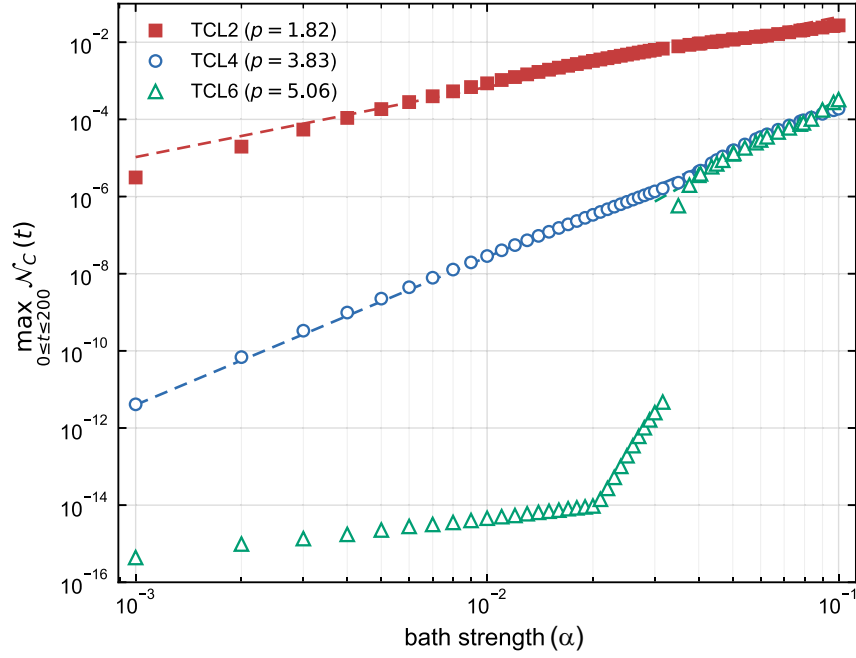


FIG. 1. Order-by-order Choi-negativity comparison for cumulative TCL_2 , TCL_4 , and corrected TCL_6 . Symbols show $\max_{0 \leq t \leq 200} \mathcal{N}_C(t)$ vs bath strength α . Dashed lines are least-squares fits to $A\alpha^p$, with p reported in the legend. The TCL_2 and TCL_4 fits use $10^{-3} \leq \alpha \leq 10^{-1}$, while the TCL_6 fit uses $0.035 \leq \alpha \leq 0.1$. At lower coupling, the smallest TCL_6 maxima lie at the numerical Choi-eigenvalue floor; a resolved early-time maximum appears near $\alpha = 0.027$, and the dominant maximum switches to a late-time branch near $\alpha = 0.0333$.

$$+ \langle 03 \rangle \langle 14 \rangle \langle 25 \rangle (-\hat{3} [\hat{1}, [\hat{2}, \hat{4}] \hat{5} \hat{\rho}] - [\hat{1}, [\hat{3} \hat{4}, \hat{2}] \hat{5} \hat{\rho}] - [\hat{2}, \hat{3}] \hat{5} [\hat{1}, \hat{4} \hat{\rho}]) \quad (\text{F5})$$

$$+ \langle 03 \rangle \langle 14 \rangle \langle 52 \rangle (\hat{3} [\hat{1}, [\hat{2}, \hat{4}] \hat{\rho} \hat{5}] - [\hat{1}, [\hat{2}, \hat{3} \hat{4}] \hat{\rho} \hat{5}] + [\hat{2}, \hat{3}] [\hat{1}, \hat{4} \hat{\rho}] \hat{5}) \quad (\text{F6})$$

$$+ \langle 03 \rangle \langle 41 \rangle \langle 25 \rangle (-[\hat{1}, [\hat{2}, \hat{3}] \hat{5}] \hat{\rho} \hat{4} - [\hat{1}, \hat{3}] \hat{5} \hat{\rho} [\hat{2}, \hat{4}]) + \langle 03 \rangle \langle 41 \rangle \langle 52 \rangle ([\hat{1}, \hat{3}] \hat{\rho} \hat{5} [\hat{2}, \hat{4}] + [\hat{1}, [\hat{2}, \hat{3}] \hat{\rho} \hat{5} \hat{4}] - [\hat{2}, \hat{3}] [\hat{1}, \hat{4} \hat{\rho}] \hat{5}) \quad (\text{F7})$$

$$+ \langle 03 \rangle \langle 15 \rangle \langle 24 \rangle ([\hat{1}, [\hat{2}, \hat{3}] \hat{4}] \hat{5} \hat{\rho} + [\hat{1}, \hat{3}] [\hat{2}, \hat{4} \hat{5} \hat{\rho}] - [\hat{1}, \hat{3}] \hat{5} [\hat{2}, \hat{4} \hat{\rho}]) \quad (\text{F8})$$

$$+ \langle 03 \rangle \langle 15 \rangle \langle 42 \rangle (\hat{3} [\hat{1}, [\hat{2}, \hat{5}] \hat{\rho} \hat{4}] - [\hat{1}, [\hat{2}, \hat{3} \hat{5}] \hat{\rho} \hat{4}] + [\hat{2}, \hat{3}] [\hat{1}, \hat{5} \hat{\rho}] \hat{4}) + \langle 03 \rangle \langle 51 \rangle \langle 24 \rangle (-[\hat{1}, \hat{3}] \hat{4} \hat{\rho} [\hat{2}, \hat{5}] - [\hat{1}, [\hat{2}, \hat{3}] \hat{4}] \hat{\rho} \hat{5}) \quad (\text{F9})$$

$$+ \langle 03 \rangle \langle 51 \rangle \langle 42 \rangle (-\hat{3} [\hat{1}, [\hat{2}, \hat{\rho} \hat{5} \hat{4}]] - [\hat{1}, \hat{3}] [\hat{2}, \hat{\rho} \hat{4}] \hat{5} - [\hat{2}, \hat{3}] [\hat{1}, \hat{\rho} \hat{5}] \hat{4} + [\hat{1}, [\hat{2}, \hat{3} \hat{\rho} \hat{5} \hat{4}]]) \quad (\text{F10})$$

$$+ \langle 04 \rangle \langle 12 \rangle \langle 35 \rangle (-[\hat{3}, \hat{4}] \hat{5} [\hat{1}, \hat{2} \hat{\rho}] + [\hat{1}, \hat{2}] [\hat{3}, \hat{4}] \hat{5} \hat{\rho}) + \langle 04 \rangle \langle 12 \rangle \langle 53 \rangle ([\hat{3}, \hat{4}] [\hat{1}, \hat{2} \hat{\rho}] \hat{5} - [\hat{1}, \hat{2}] [\hat{3}, \hat{4}] \hat{\rho} \hat{5}) \quad (\text{F11})$$

$$+ \langle 04 \rangle \langle 21 \rangle \langle 35 \rangle (-[\hat{1}, [\hat{3}, \hat{4}] \hat{5}] \hat{\rho} \hat{2}) + \langle 04 \rangle \langle 21 \rangle \langle 53 \rangle (-[\hat{3}, \hat{4}] [\hat{1}, \hat{2} \hat{\rho}] \hat{5} + [\hat{1}, [\hat{3}, \hat{4}] \hat{\rho} \hat{5} \hat{2}]) \quad (\text{F12})$$

$$+ \langle 04 \rangle \langle 13 \rangle \langle 25 \rangle (-\hat{4} [\hat{1}, [\hat{2}, \hat{3}] \hat{5}] \hat{\rho}] + [\hat{1}, [\hat{2}, \hat{3} \hat{4}] \hat{5} \hat{\rho}] - [\hat{2}, \hat{4}] \hat{5} [\hat{1}, \hat{3} \hat{\rho}]) \quad (\text{F13})$$

$$+ \langle 04 \rangle \langle 13 \rangle \langle 52 \rangle (\hat{4} [\hat{1}, [\hat{2}, \hat{3}] \hat{\rho} \hat{5}] - [\hat{1}, [\hat{2}, \hat{3} \hat{4}] \hat{\rho} \hat{5}] + [\hat{2}, \hat{4}] [\hat{1}, \hat{3} \hat{\rho}] \hat{5}) \quad (\text{F14})$$

$$+ \langle 04 \rangle \langle 31 \rangle \langle 25 \rangle (-[\hat{1}, [\hat{2}, \hat{4}] \hat{5}] \hat{\rho} \hat{3} - [\hat{1}, \hat{4}] \hat{5} \hat{\rho} [\hat{2}, \hat{3}]) + \langle 04 \rangle \langle 31 \rangle \langle 52 \rangle ([\hat{1}, \hat{4}] \hat{\rho} \hat{5} [\hat{2}, \hat{3}] + [\hat{1}, [\hat{2}, \hat{4}] \hat{\rho} \hat{5} \hat{3}] - [\hat{2}, \hat{4}] [\hat{1}, \hat{\rho} \hat{3}] \hat{5}) \quad (\text{F15})$$

$$+ \langle 04 \rangle \langle 15 \rangle \langle 23 \rangle (-[\hat{1}, \hat{4}] \hat{5} [\hat{2}, \hat{3} \hat{\rho}] + \hat{4} [\hat{2}, \hat{3}] [\hat{1}, \hat{5} \hat{\rho}]] - \hat{4} [\hat{1}, [\hat{2}, \hat{3} \hat{5} \hat{\rho}]] - [\hat{2}, \hat{3} \hat{4}] [\hat{1}, \hat{5} \hat{\rho}]] + [\hat{1}, [\hat{2}, \hat{3} \hat{4} \hat{5} \hat{\rho}]] \quad (\text{F16})$$

$$+ \langle 04 \rangle \langle 15 \rangle \langle 32 \rangle (\hat{4} [\hat{1}, [\hat{2}, \hat{5}] \hat{\rho} \hat{3}] + [\hat{2}, \hat{4}] [\hat{1}, \hat{5} \hat{\rho}] \hat{3} - [\hat{1}, [\hat{2}, \hat{4} \hat{5}] \hat{\rho} \hat{3}]) \quad (\text{F17})$$

$$+ \langle 04 \rangle \langle 51 \rangle \langle 23 \rangle (\hat{4} [\hat{2}, \hat{3} \hat{\rho}] \hat{5}] - \hat{4} [\hat{2}, \hat{3}] [\hat{1}, \hat{\rho} \hat{5}]] + [\hat{1}, \hat{4}] [\hat{2}, \hat{3} \hat{\rho}] \hat{5}] + [\hat{2}, \hat{3} \hat{4}] [\hat{1}, \hat{\rho} \hat{5}]] - [\hat{1}, [\hat{2}, \hat{3} \hat{4} \hat{\rho} \hat{5}]] \quad (\text{F18})$$

$$+ \langle 04 \rangle \langle 51 \rangle \langle 32 \rangle (-[\hat{1}, \hat{4}] [\hat{2}, \hat{\rho} \hat{3}] \hat{5} - [\hat{2}, \hat{4}] [\hat{1}, \hat{\rho} \hat{5}] \hat{3} - \hat{4} [\hat{1}, [\hat{2}, \hat{\rho} \hat{5} \hat{3}]] + [\hat{1}, [\hat{2}, \hat{4} \hat{\rho} \hat{5} \hat{3}]]) \quad (\text{F19})$$

$$+ \langle 05 \rangle \langle 12 \rangle \langle 34 \rangle (\hat{5} [\hat{3}, \hat{4}] \hat{5} [\hat{1}, \hat{2} \hat{\rho}]] - [\hat{1}, \hat{2}] \hat{5} [\hat{3}, \hat{4} \hat{\rho}]] + [\hat{1}, \hat{2}] [\hat{3}, \hat{4} \hat{5} \hat{\rho}]] - [\hat{3}, \hat{4} \hat{5} [\hat{1}, \hat{2} \hat{\rho}]] \quad (\text{F20})$$

$$+ \langle 05 \rangle \langle 12 \rangle \langle 43 \rangle ([\hat{3}, \hat{5}] [\hat{1}, \hat{2} \hat{\rho}] \hat{4} - [\hat{1}, \hat{2}] [\hat{3}, \hat{5}] \hat{\rho} \hat{4}) + \langle 05 \rangle \langle 21 \rangle \langle 34 \rangle (-[\hat{1}, [\hat{3} \hat{4}, \hat{5}]] \hat{\rho} \hat{2} + [\hat{1}, [\hat{4}, \hat{5}] \hat{\rho} \hat{3} \hat{2}] - [\hat{4}, \hat{5}] [\hat{1}, \hat{\rho} \hat{2}] \hat{3}) \quad (\text{F21})$$

$$+ \langle 05 \rangle \langle 21 \rangle \langle 43 \rangle (-[\hat{3}, \hat{5}] [\hat{1}, \hat{\rho} \hat{2}] \hat{4} + [\hat{1}, [\hat{3}, \hat{5}] \hat{\rho} \hat{4} \hat{2}]) \quad (\text{F22})$$

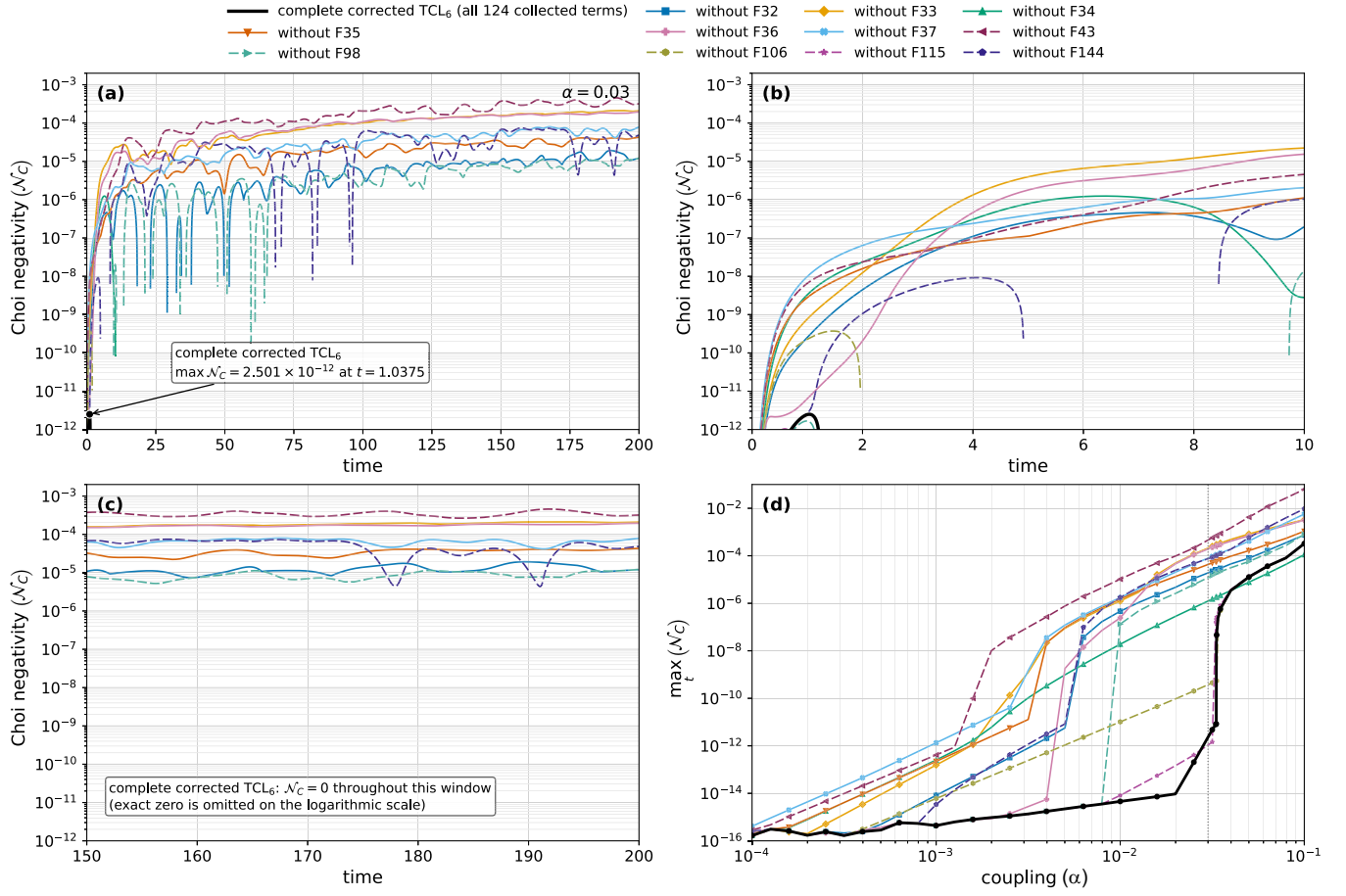


FIG. 2. Choi negativity for the complete corrected TCL_6 generator and 11 one-term deletions. The black curve uses all 124 collected terms; each colored curve omits the contribution named in the legend, including its coefficient, common outer commutator, and Hermitian conjugate. (a)–(c) $0 \leq t \leq 200$, $0 \leq t \leq 10$, and $150 \leq t \leq 200$, respectively, at $\alpha = 0.03$. (d) Maximum Choi negativity vs bath strength. The complete result has maximum 2.501×10^{-12} at $t = 1.0375$ and is zero at every sampled time in panel (c).

$$+ \langle 05 \rangle \langle 13 \rangle \langle 24 \rangle (-\hat{S} [\hat{1}, [\hat{2}, \hat{3}] \hat{4} \hat{\rho}] + \hat{S} [\hat{2}, \hat{4} [\hat{1}, \hat{3} \hat{\rho}]] - [\hat{1}, \hat{3} \hat{S} [\hat{2}, \hat{4} \hat{\rho}]] - [\hat{2}, \hat{4} \hat{S} [\hat{1}, \hat{3} \hat{\rho}]] + [\hat{1}, [\hat{2}, \hat{3} \hat{4} \hat{S} \hat{\rho}]]) \quad (\text{F23})$$

$$+ \langle 05 \rangle \langle 13 \rangle \langle 42 \rangle (\hat{S} [\hat{1}, [\hat{2}, \hat{3}] \hat{\rho} \hat{4}] + [\hat{2}, \hat{S}] [\hat{1}, \hat{3} \hat{\rho}] \hat{4} - [\hat{1}, [\hat{2}, \hat{3} \hat{S}] \hat{\rho} \hat{4}]) \quad (\text{F24})$$

$$+ \langle 05 \rangle \langle 31 \rangle \langle 24 \rangle (\hat{S} [\hat{1}, \hat{4} \hat{\rho} [\hat{2}, \hat{3}]] - \hat{S} [\hat{2}, \hat{4} [\hat{1}, \hat{\rho} \hat{3}]] + [\hat{1}, \hat{S} [\hat{2}, \hat{4} \hat{\rho}] \hat{3}] + [\hat{2}, \hat{4} \hat{S} [\hat{1}, \hat{\rho} \hat{3}]] - [\hat{1}, [\hat{2}, \hat{4} \hat{S} \hat{\rho} \hat{3}]]) \quad (\text{F25})$$

$$+ \langle 05 \rangle \langle 31 \rangle \langle 42 \rangle ([\hat{1}, \hat{S}] \hat{\rho} \hat{4} [\hat{2}, \hat{3}] + [\hat{1}, [\hat{2}, \hat{S}] \hat{\rho} \hat{4} \hat{3}] - [\hat{2}, \hat{S}] [\hat{1}, \hat{\rho} \hat{3}] \hat{4}) \quad (\text{F26})$$

$$+ \langle 05 \rangle \langle 14 \rangle \langle 23 \rangle (\hat{S} [\hat{1}, \hat{4} [\hat{2}, \hat{3} \hat{\rho}]] + \hat{S} [\hat{2}, \hat{3} [\hat{1}, \hat{4} \hat{\rho}]] - \hat{S} [\hat{1}, [\hat{2}, \hat{3} \hat{4} \hat{\rho}]] - [\hat{1}, \hat{4} \hat{S} [\hat{2}, \hat{3} \hat{\rho}]] - [\hat{2}, \hat{3} \hat{S} [\hat{1}, \hat{4} \hat{\rho}]] + [\hat{1}, [\hat{2}, \hat{3} \hat{4} \hat{S} \hat{\rho}]]) \quad (\text{F27})$$

$$+ \langle 05 \rangle \langle 14 \rangle \langle 32 \rangle (\hat{S} [\hat{1}, [\hat{2}, \hat{4}] \hat{\rho} \hat{3}] + [\hat{2}, \hat{S}] [\hat{1}, \hat{4} \hat{\rho}] \hat{3} - [\hat{1}, [\hat{2}, \hat{4} \hat{S}] \hat{\rho} \hat{3}]) \quad (\text{F28})$$

$$+ \langle 05 \rangle \langle 41 \rangle \langle 23 \rangle (\hat{S} [\hat{1}, \hat{3} \hat{\rho} [\hat{2}, \hat{4}]] - \hat{S} [\hat{2}, \hat{3} [\hat{1}, \hat{\rho} \hat{4}]] + [\hat{1}, \hat{S} [\hat{2}, \hat{3} \hat{\rho}] \hat{4}] + [\hat{2}, \hat{3} \hat{S} [\hat{1}, \hat{\rho} \hat{4}]] - [\hat{1}, [\hat{2}, \hat{3} \hat{S} \hat{\rho} \hat{4}]]) \quad (\text{F29})$$

$$+ \langle 05 \rangle \langle 41 \rangle \langle 32 \rangle (-[\hat{1}, \hat{S}] [\hat{2}, \hat{\rho} \hat{3}] \hat{4} + [\hat{S}, \hat{2}] [\hat{1}, \hat{\rho} \hat{4}] \hat{3} - \hat{S} [\hat{1}, [\hat{2}, \hat{\rho} \hat{4} \hat{3}]] + [\hat{1}, [\hat{2}, \hat{S} \hat{\rho} \hat{4} \hat{3}]]) \Big] + \text{H.c.}, \quad (\text{F30})$$

$$\mathcal{L}^6(t) \hat{\rho} = - \left[\hat{0}, \int_0^t dt_a \int_0^{t_a} dt_b (\right. \quad (\text{F31})$$

$$- (\hat{0} \circ \Delta \Gamma^T(t, t - t_a)) [(\hat{b} \circ \Delta \Gamma(t - t_b, t_a - t_b)), [\hat{a}, \hat{b}] \hat{\rho} (\hat{a} \circ \Gamma(t_b - t_a))] \quad (\text{F32})$$

$$+ (\hat{0} \circ \Delta \Gamma^T(t, t - t_a)) [(\hat{b} \circ \Delta \Gamma(t_b - t_a, t_b - t)), [\hat{a}, \hat{\rho} \hat{b} (\hat{a} \circ \Gamma(t_b - t_a))] \quad (\text{F33})$$

$$- (\hat{0} \circ \Delta \Gamma^T(t, t - t_b)) [\hat{a}, \hat{b} \hat{\rho} [(\hat{b} \circ \Delta \Gamma(t_a - t_b, -t_b)), (\hat{a} \circ \Gamma(t_b - t_a))] \quad (\text{F34})$$

$$+ (\hat{0} \circ \Delta \Gamma^T(t, t - t_b)) [\hat{a}, \hat{b} \hat{\rho} [(\hat{b} \circ \Gamma(t_a - t_b)), (\hat{a} \circ \Delta \Gamma(t_b - t_a, -t_a))] \quad (\text{F35})$$

$$- (\hat{0} \circ \Delta \Gamma^T(t, t - t_b)) [\hat{a}, [(\hat{b} \circ \Gamma(t_a - t_b)), \hat{b} (\hat{a} \circ \Delta \Gamma^T(t_a, t_a - t_b)) \hat{\rho}]] \quad (\text{F36})$$

$$+(\hat{0} \circ \Delta \Gamma^T(t, t - t_b)) [(\hat{a} \circ \Gamma^T(t_a - t)), \hat{b} \hat{q} [(\hat{b} \circ \Delta \Gamma(t_a - t_b, -t_b)), \hat{a}]] \quad (\text{F37})$$

$$+ (\hat{0} \circ \Delta \Gamma^T(t, t - t_b)) [(\hat{b} \circ \Delta \Gamma(t - t_b, t_a - t_b)), \hat{b}[\hat{a}, (\hat{a} \circ \Gamma^T(t_a - t_b)) \hat{q}]] \quad (\text{F38})$$

$$-(\hat{\theta} \circ \Delta \Gamma^T(t, t - t_b)) [(\hat{b} \circ \Delta \Gamma(t - t_b, t_a - t_b)), [\hat{a}, \hat{b}] (\hat{a} \circ \Delta \Gamma^T(t_a, t_a - t_b)) \hat{e}] \quad (\text{F39})$$

$$+ (\hat{\mathcal{O}} \circ \Delta \Gamma^T(t, t - t_b)) [(\hat{b} \circ \Delta \Gamma(t - t_b, t_a - t_b)), [\hat{a}, \hat{b}] \hat{\mathcal{Q}} (\hat{a} \circ \Delta \Gamma(t_b - t_a, -t_a))] \quad (\text{F40})$$

$$+(\hat{\mathcal{O}} \circ \Delta \Gamma^T(t, t - t_b))[(\hat{b} \circ \Delta \Gamma(t_a - t_b, -t_b)), \hat{b}[\hat{a}, (\hat{a} \circ \Gamma^T(t_a - t_b))\hat{q}]] \quad (\text{F41})$$

$$+ (\hat{0} \circ \Delta \Gamma^T(t, t - t_b)) [(\hat{b} \circ \Delta \Gamma(t_a - t_b, -t_b)), \hat{b}[\hat{a}, \hat{q}(\hat{a} \circ \Gamma(t_b - t_a))]] \quad (\text{F42})$$

$$-(\hat{O} \circ \Delta \Gamma^T(t, t - t_b))[(\hat{b} \circ \Delta \Gamma(t_a - t_b, -t_b)), \hat{b}[(\hat{a} \circ \Gamma(t - t_a)), \hat{a} \hat{q}]] \quad (\text{F43})$$

$$-(\hat{O} \circ \Delta \Gamma^T(t, t - t_b))[(\hat{b} \circ \Delta \Gamma(t_a - t_b, -t_b)), \hat{b}[(\hat{a} \circ \Gamma^T(t_a - t)), \hat{q} \hat{a}]] \quad (\text{F44})$$

$$+(\hat{0} \circ \Delta \Gamma^T(t, t - t_b))[(\hat{b} \circ \Gamma(t_a - t_b)), \hat{b}[\hat{a}, (\hat{a} \circ \Delta \Gamma^T(t_a, t_a - t_b))\hat{e}]] \quad (\text{F45})$$

$$-(\hat{\mathcal{O}} \circ \Delta \Gamma^T(t, t - t_b))[(\hat{b} \circ \Gamma(t_a - t_b)), \hat{b}[\hat{a}, \hat{q}(\hat{a} \circ \Delta \Gamma(t_b - t_a, -t_a))]] \quad (\text{F46})$$

$$+ (\hat{\mathcal{O}} \circ \Delta \Gamma^T(t, t - t_b)) [(\hat{b} \circ \Gamma(t_a - t_b)), \hat{b}[(\hat{a} \circ \Gamma(t - t_a)), \hat{a} \hat{c}]] \quad (\text{F47})$$

$$-(\hat{o} \circ \Delta \Gamma^T(t - t_b, t - t_a))[(\hat{b} \circ \Delta \Gamma(t - t_b, t_a - t_b)), [\hat{a}, \hat{b}](\hat{a} \circ \Delta \Gamma^T(t_a, t_a - t_b))\hat{c}] \quad (\text{F48})$$

$$+ (\hat{\mathcal{O}} \circ \Delta \Gamma^T(t - t_b, t - t_a)) [(\hat{b} \circ \Delta \Gamma(t - t_b, t_a - t_b)), [\hat{a}, \hat{b}] \hat{\mathcal{Q}} (\hat{a} \circ \Delta \Gamma(t_b - t_a, -t_a))] \quad (\text{F49})$$

$$- [\hat{a}, [(\hat{b} \circ \Delta\Gamma(t_a - t_b, -t_b)), (\hat{0} \circ \Delta\Gamma^T(t, t - t_b))] \hat{b}] \hat{e} (\hat{a} \circ \Gamma(t_b - t_a)) \quad (\text{F50})$$

$$- [\hat{a}, [(\hat{b} \circ \Gamma(t_a - t_b)), (\hat{0} \circ \Delta\Gamma^T(t, t - t_b))] \hat{b}] (\hat{a} \circ \Delta\Gamma^T(t_a, t_a - t_b)) \hat{e} \quad (\text{F51})$$

$$+ [\hat{a}, [(\hat{b} \circ \Gamma(t_a - t_b)), (\hat{0} \circ \Delta\Gamma^T(t, t - t_b))] \hat{b}] \hat{c} (\hat{a} \circ \Delta\Gamma(t_b - t_a, -t_a)) \quad (\text{F52})$$

$$- [\hat{a}, (\hat{\theta} \circ \Delta \Gamma^T(t, t - t_a))] (\hat{a} \circ \Delta \Gamma^T(t_a, t_a - t_b)) [(\hat{b} \circ \Gamma(t_a - t_b)), \hat{b} \hat{q}] \quad (\text{F53})$$

$$- [\hat{a}, (\hat{0} \circ \Delta \Gamma^T(t, t - t_a))] [(\hat{b} \circ \Delta \Gamma(t - t_b, t_a - t_b)), \hat{b} \hat{c}] (\hat{a} \circ \Gamma(t_b - t_a)) \quad (\text{F54})$$

$$+ [\hat{a}, (\hat{\theta} \circ \Delta\Gamma^T(t, t - t_a))] [(\hat{b} \circ \Gamma(t_a - t_b)), \hat{b}(\hat{a} \circ \Delta\Gamma^T(t_a, t_a - t_b)) \hat{c}] \quad (\text{F55})$$

$$- [\hat{a}, (\hat{0} \circ \Delta \Gamma^T(t, t - t_a))] [(\hat{b} \circ \Gamma(t_a - t_b)), (\hat{a} \circ \Delta \Gamma^T(t_a, t_a - t_b))] \hat{b} \hat{e} \quad (\text{F56})$$

$$+ [\hat{a}, (\hat{\sigma} \circ \Delta\Gamma^T(t, t - t_a))] [(\hat{b} \circ \Delta\Gamma^T(t_b - t_a, t_b - t)), \hat{q} \hat{b}] (\hat{a} \circ \Gamma(t_b - t_a)) \quad (\text{F57})$$

$$+ [\hat{a}, (\hat{\theta} \circ \Delta \Gamma^T(t, t - t_a))] [(\hat{b} \circ \Gamma^T(t_b - t_a)), \hat{q} \hat{b}] (\hat{a} \circ \Delta \Gamma(t_b - t_a, -t_a)) \quad (\text{F58})$$

$$- [\hat{a}, (\hat{\theta} \circ \Delta \Gamma^T(t, t - t_a))] [(\hat{b} \circ \Gamma^T(t_b - t_a)), \hat{g}(\hat{a} \circ \Delta \Gamma(t_b - t_a, -t_a)) \hat{b}] \quad (\text{F59})$$

$$+ [\hat{a}, (\hat{\theta} \circ \Delta \Gamma^T(t, t - t_a))] \hat{c} \hat{b} [(\hat{b} \circ \Gamma^T(t_b - t_a)), (\hat{a} \circ \Delta \Gamma(t_b - t_a, -t_a))] \quad (\text{F60})$$

$$- [\hat{a}, (\hat{\mathcal{O}} \circ \Delta \Gamma^T(t, t - t_b))] \hat{b} \hat{\rho} [(\hat{b} \circ \Delta \Gamma(t_a - t_b, -t_b)), (\hat{a} \circ \Gamma(t_b - t_a))] \quad (\text{F61})$$

$$+ [\hat{a}, (\hat{0} \circ \Delta\Gamma^T(t, t - t_b))] \hat{b} \hat{\rho} [(\hat{b} \circ \Gamma(t_a - t_b)), (\hat{a} \circ \Delta\Gamma(t_b - t_a, -t_a))] \quad (\text{F62})$$

$$+ [\hat{a}, (\hat{\Theta} \circ \Delta \Gamma^T(t, t - t_b))] (\hat{a} \circ \Delta \Gamma^T(t_a, t_a - t_b)) [\hat{b}, (\hat{b} \circ \Gamma^T(t_b)) \hat{c}] \quad (\text{F63})$$

$$- [\hat{a}, (\hat{\theta} \circ \Delta \Gamma^T(t, t - t_b))] (\hat{a} \circ \Delta \Gamma^T(t_a, t_a - t_b)) [(\hat{b} \circ \Delta \Gamma(t - t_b, t_a - t_b)), \hat{b} \hat{c}] \quad (\text{F64})$$

$$+ [\hat{a}, (\hat{\theta} \circ \Delta \Gamma^T(t, t - t_b))] (\hat{b} \circ \Gamma^T(t_b)) \hat{c} [\hat{b}, (\hat{a} \circ \Delta \Gamma(t_b - t_a, -t_a))] \quad (\text{F65})$$

$$- [\hat{a}, (\hat{\theta} \circ \Delta \Gamma^T(t, t - t_b))] [\hat{b}, (\hat{b} \circ \Gamma^T(t_b)) (\hat{a} \circ \Delta \Gamma^T(t_a, t_a - t_b)) \hat{c}] \quad (\text{F66})$$

$$+ [\hat{a}, (\hat{\mathcal{O}} \circ \Delta\Gamma^T(t, t - t_b))] [\hat{b}, \hat{\rho}(\hat{a} \circ \Delta\Gamma(t_b - t_a, -t_a)) (\hat{b} \circ \Gamma(-t_b))] \quad (\text{F67})$$

$$-[\hat{a}, (\hat{0} \circ \Delta\Gamma^T(t, t - t_b))] [\hat{b}, \hat{\rho}(\hat{b} \circ \Gamma(-t_b))] (\hat{a} \circ \Delta\Gamma(t_b - t_a, -t_a)) \quad (\text{F68})$$

$$-[\hat{a}, (\hat{0} \circ \Delta\Gamma^T(t, t - t_h))] [\hat{b}, (\hat{a} \circ \Delta\Gamma^T(t_a, t_a - t_h))] \hat{\phi} (\hat{b} \circ \Gamma(-t_h)) \quad (\text{F69})$$

$$+ [\hat{a}, (\hat{0} \circ \Delta\Gamma^T(t, t - t_b))] [(\hat{b} \circ \Delta\Gamma(t - t_b, t_a - t_b)), \hat{b} \hat{\rho}] (\hat{a} \circ \Delta\Gamma(t_b - t_a, -t_a)) \quad (\text{F70})$$

$$- [\hat{a}, (\hat{\mathcal{O}} \circ \Delta \Gamma^T(t, t - t_b))] [(\hat{b} \circ \Gamma(t_a - t_b)), \hat{b} (\hat{a} \circ \Delta \Gamma^T(t_a, t_a - t_b)) \hat{\rho}] \quad (\text{F71})$$

$$- [\hat{a}, (\hat{\phi} \circ \Delta\Gamma^T(t, t - t_b))] [(\hat{b} \circ \Delta\Gamma^T(t_b - t_a, t_b - t)), \hat{\phi} \hat{b}] (\hat{a} \circ \Delta\Gamma(t_b - t_a, -t_a)) \quad (\text{F72})$$

$$- [\hat{a}, (\hat{0} \circ \Delta\Gamma^T(t, t - t_b))] [(\hat{b} \circ \Delta\Gamma^T(t_b - t_a, t_b - t)), \hat{\rho} \hat{b}] (\hat{a} \circ \Gamma(t_b - t_a)) \quad (\text{F73})$$

$$-[\hat{a}, (\hat{0} \circ \Delta\Gamma^T(t - t_b, t - t_a))] (\hat{a} \circ \Delta\Gamma^T(t_a, t_a - t_b)) [(\hat{b} \circ \Delta\Gamma(t - t_b, t_a - t_b)), \hat{b} \hat{\rho}] \quad (\text{F74})$$

$$- [\hat{a}, (\hat{0} \circ \Delta \Gamma^T(t - t_b, t - t_a))] (\hat{b} \circ \Gamma^T(t_b)) \hat{\rho} [\hat{b}, (\hat{a} \circ \Delta \Gamma(t_b - t_a, -t_a))] \quad (\text{F75})$$

$$+ [\hat{a}, (\hat{0} \circ \Delta \Gamma^T(t - t_b, t - t_a))] [\hat{b}, (\hat{a} \circ \Delta \Gamma^T(t_a, t_a - t_b))] (\hat{b} \circ \Gamma^T(t_b)) \hat{\rho} \quad (\text{F76})$$

$$+ [\hat{a}, (\hat{0} \circ \Delta\Gamma^T(t - t_b, t - t_a))] [\hat{b}, (\hat{a} \circ \Delta\Gamma^T(t_a, t_a - t_b))] \hat{\rho}(\hat{b} \circ \Gamma(-t_b)) \quad (\text{F77})$$

$$+ [\hat{a}, (\hat{0} \circ \Delta\Gamma^T(t - t_b, t - t_a))] [(\hat{b} \circ \Delta\Gamma(t - t_b, t_a - t_b)), \hat{b} \hat{\rho}] (\hat{a} \circ \Delta\Gamma(t_b - t_a, -t_a)) \quad (\text{F78})$$

$$- [\hat{a}, (\hat{0} \circ \Delta\Gamma^T(t - t_b, t - t_a))] [(\hat{b} \circ \Delta\Gamma^T(t_b - t_a, t_b - t)), \hat{q} \hat{b}] (\hat{a} \circ \Delta\Gamma(t_b - t_a, -t_a)) \quad (\text{F79})$$

$$-[\hat{a}, (\hat{0} \circ \Delta\Gamma^T(t - t_b, t - t_a))] \hat{q} (\hat{b} \circ \Gamma(-t_b)) [\hat{b}, (\hat{a} \circ \Delta\Gamma(t_b - t_a, -t_a))] \quad (\text{F80})$$

$$- [\hat{b}, (\hat{0} \circ \Delta \Gamma^T(t, t - t_b))] (\hat{b} \circ \Gamma^T(t_b)) [(\hat{a} \circ \Gamma(t - t_a)), \hat{a} \hat{q}] \quad (\text{F81})$$

$$-[\hat{b}, (\hat{\theta} \circ \Delta \Gamma^T(t, t - t_b))] [(\hat{a} \circ \Gamma(t - t_a)), \hat{a} \hat{q}] (\hat{b} \circ \Gamma(-t_b)) \quad (\text{F82})$$

$$- [\hat{b}, (\hat{\theta} \circ \Delta \Gamma^T(t, t - t_b))] [(\hat{a} \circ \Gamma^T(t_a - t)), \hat{q} \hat{a}] (\hat{b} \circ \Gamma(-t_b)) \quad (\text{F83})$$

$$+ [\hat{b}, (\hat{0} \circ \Delta \Gamma^T(t, t - t_b))] [(\hat{a} \circ \Gamma^T(t_a - t)), \hat{q} \hat{a}] (\hat{b} \circ \Gamma(t_a - t_b)) \quad (\text{F84})$$

$$-[(\hat{0} \circ \Delta\Gamma^T(t, t - t_b)), \hat{a}][(\hat{b} \circ \Delta\Gamma^T(t_b - t_a, t_b - t)), \hat{q} \hat{b}](\hat{a} \circ \Gamma(t_b - t_a)) \quad (\text{F85})$$

$$+ [(\hat{a} \circ \Gamma^T(t_a - t)), [\hat{b}, (\hat{0} \circ \Delta \Gamma^T(t, t - t_b))]] (\hat{b} \circ \Gamma^T(t_b))] \hat{q} \hat{a} \quad (\text{F86})$$

$$+[(\hat{a} \circ \Gamma^T(t_a - t)), [(\hat{b} \circ \Delta\Gamma(t_a - t_b, -t_b)), (\hat{0} \circ \Delta\Gamma^T(t, t - t_b))]] \hat{b} \hat{\varrho} \hat{a} \quad (\text{F87})$$

$$-[(\hat{a} \circ \Gamma^T(t_a - t)), (\hat{b} \circ \Gamma(t_a - t_b)), (\hat{0} \circ \Delta \Gamma^T(t, t - t_b))] \hat{b} \hat{q} \hat{a} \quad (\text{F88})$$

$$+ [(\hat{a} \circ \Gamma^T(t_a - t)), [(\hat{b} \circ \Gamma(t_a - t_b))\hat{b}, (\hat{0} \circ \Delta\Gamma^T(t, t - t_b))]]\hat{q}\hat{a} \quad (\text{F89})$$

$$+ [(\hat{a} \circ \Gamma^T(t_a - t)), (\hat{0} \circ \Delta \Gamma^T(t, t - t_b))] \hat{b} \hat{c} [(\hat{b} \circ \Delta \Gamma(t_a - t_b, -t_b)), \hat{a}] \quad (\text{F90})$$

$$+ [(\hat{b} \circ \Delta\Gamma(t - t_b, t_a - t_b)), [\hat{a}, (\hat{\theta} \circ \Delta\Gamma^T(t, t - t_a))]] (\hat{a} \circ \Gamma^T(t_a - t_b))] \hat{b} \hat{c} \quad (\text{F91})$$

$$-[(\hat{b} \circ \Delta\Gamma(t - t_b, t_a - t_b)), (\hat{0} \circ \Delta\Gamma^T(t, t - t_a))] \hat{b} [\hat{a}, (\hat{a} \circ \Delta\Gamma^T(t_a, t_a - t_b)) \hat{q}] \quad (\text{F92})$$

$$-[(\hat{b} \circ \Delta\Gamma(t - t_b, t_a - t_b)), (\hat{o} \circ \Delta\Gamma^T(t, t - t_a))] \hat{b} [\hat{a}, (\hat{a} \circ \Gamma^T(t_a - t_b)) \hat{q}] \quad (\text{F93})$$

$$+ [(\hat{b} \circ \Delta\Gamma(t - t_b, t_a - t_b)), (\hat{o} \circ \Delta\Gamma^T(t, t - t_a))] [\hat{a}, (\hat{a} \circ \Delta\Gamma^T(t_a, t_a - t_b)) \hat{b} \hat{c}] \quad (\text{F94})$$

$$+[(\hat{b} \circ \Delta\Gamma(t - t_b, t_a - t_b)), (\hat{0} \circ \Delta\Gamma^T(t, t - t_a))][\hat{a}, (\hat{a} \circ \Gamma^T(t_a - t_b))\hat{b}\hat{q}] \quad (\text{F95})$$

$$+[(\hat{b} \circ \Delta\Gamma(t - t_b, t_a - t_b)), (\hat{o} \circ \Delta\Gamma^T(t, t - t_a))][\hat{a}, \hat{b}](\hat{a} \circ \Gamma^T(t_a - t_b))\hat{c} \quad (\text{F96})$$

$$-[(\hat{b} \circ \Delta\Gamma(t - t_b, t_a - t_b)), (\hat{0} \circ \Delta\Gamma^T(t, t - t_a))] [\hat{a}, \hat{b}] \hat{e} (\hat{a} \circ \Delta\Gamma(t_b - t_a, -t_a)) \quad (\text{F97})$$

$$+[(\hat{b} \circ \Delta\Gamma(t - t_b, t_a - t_b)), (\hat{0} \circ \Delta\Gamma^T(t, t - t_a))] [\hat{a}, \hat{b}] \hat{\varrho} (\hat{a} \circ \Gamma(t_b - t_a)) \quad (\text{F98})$$

$$+ [(\hat{b} \circ \Delta\Gamma(t - t_b, t_a - t_b)), (\hat{o} \circ \Delta\Gamma^T(t, t - t_b))] \hat{b} [\hat{a}, (\hat{a} \circ \Gamma^T(t_a - t_b)) \hat{g}] \quad (\text{F99})$$

$$+ [(\hat{b} \circ \Delta\Gamma(t_a - t_b, -t_b)), (\hat{o} \circ \Delta\Gamma^T(t, t - t_b))] \hat{b} [\hat{a}, (\hat{a} \circ \Gamma^T(t_a - t_b)) \hat{q}] \quad (\text{F100})$$

$$-[(\hat{b} \circ \Delta\Gamma(t_a - t_b, -t_b)), (\hat{o} \circ \Delta\Gamma^T(t, t - t_b))] \hat{b}[(\hat{a} \circ \Gamma(t - t_a)), \hat{a} \hat{g}] \quad (\text{F101})$$

$$+ [(\hat{b} \circ \Gamma(t_a - t_b)), (\hat{0} \circ \Delta \Gamma^T(t, t - t_b))] \hat{b}[(\hat{a} \circ \Gamma(t - t_a)), \hat{a} \hat{e}] \quad (\text{F102})$$

$$-[(\hat{b} \circ \Delta \Gamma^T(t_b - t_a, t_b - t)), [\hat{a}, (\hat{0} \circ \Delta \Gamma^T(t, t - t_a))](\hat{a} \circ \Gamma^T(t_a - t_b))] \hat{e} \hat{b} \quad (\text{F103})$$

$$-[(\hat{b} \circ \Delta\Gamma^T(t_b - t_a, t_b - t)), [\hat{a}, (\hat{\phi} \circ \Delta\Gamma^T(t, t - t_b))]](\hat{a} \circ \Delta\Gamma^T(t_a, t_a - t_b))\hat{\rho}\hat{b} \quad (\text{F104})$$

$$- [\hat{b} \circ \Delta\Gamma^T(t_b - t_a, t_b - t)), [\hat{a}, (\hat{o} \circ \Delta\Gamma^T(t - t_b, t - t_a))] (\hat{a} \circ \Delta\Gamma^T(t_a, t_a - t_b))] \hat{\rho} \hat{b} \quad (\text{F105})$$

$$-[(\hat{b} \circ \Delta\Gamma^T(t_b - t_a, t_b - t)), (\hat{o} \circ \Delta\Gamma^T(t, t - t_a))](\hat{a} \circ \Delta\Gamma^T(t_a, t_a - t_b))\hat{\rho}[\hat{a}, \hat{b}] \quad (\text{F106})$$

$$-2[(\hat{b} \circ \Delta \Gamma^T(t_b - t_a, t_b - t)), (\hat{0} \circ \Delta \Gamma^T(t, t - t_a))](\hat{a} \circ \Gamma^T(t_a - t_b)) \hat{\rho}[\hat{a}, \hat{b}] \quad (\text{F107})$$

$$+[(\hat{b} \circ \Delta\Gamma^T(t_b - t_a, t_b - t)), (\hat{0} \circ \Delta\Gamma^T(t, t - t_a))][\hat{a}, \hat{\rho} \hat{b}(\hat{a} \circ \Delta\Gamma(t_b - t_a, -t_a))] \quad (\text{F108})$$

$$-[(\hat{b} \circ \Delta\Gamma^T(t_b - t_a, t_b - t)), (\hat{0} \circ \Delta\Gamma^T(t, t - t_a))][\hat{a}, \hat{\rho}(\hat{a} \circ \Delta\Gamma(t_b - t_a, -t_a))]\hat{b} \quad (\text{F109})$$

$$+[(\hat{b} \circ \Delta\Gamma^T(t_b - t_a, t_b - t)), (\hat{0} \circ \Delta\Gamma^T(t, t - t_a))][\hat{a}, \hat{\rho}(\hat{a} \circ \Gamma(t_b - t_a))]\hat{b} \quad (\text{F110})$$

$$-[(\hat{b} \circ \Delta \Gamma^T(t_b - t_a, t_b - t)), (\hat{\theta} \circ \Delta \Gamma^T(t, t - t_a))] \hat{\rho}(\hat{a} \circ \Gamma(t_b - t_a)) [\hat{a}, \hat{b}] \quad (\text{E11})$$

$$-[(\hat{b} \circ \Delta \Gamma^T(t_b - t_a, t_b - t)), (\hat{0} \circ \Delta \Gamma^T(t, t - t_b))] (\hat{a} \circ \Delta \Gamma^T(t_a, t_a - t_b)) \hat{\rho} [\hat{a}, \hat{b}] \quad (\text{E112})$$

$$+ [(\hat{h} \circ \wedge \Gamma^T(t_b - t_a, t_b - t)) \cdot (\hat{0} \circ \wedge \Gamma^T(t, t - t_b))] \hat{\rho} (\hat{a} \circ \wedge \Gamma(t_b - t_a, -t_a)) [\hat{a}, \hat{b}] \quad (\text{E113})$$

$$-[(\hat{h} \circ \wedge \Gamma^T(t_k - t_-, t_k - t)) \cdot (\hat{\Omega} \circ \wedge \Gamma^T(t - t_k, t - t_-))](\hat{a} \circ \wedge \Gamma^T(t_-, t_- - t_k)) \hat{a} [\hat{a} \cdot \hat{b}] \quad (\text{E114})$$

$$+ [(\hat{h} \circ \wedge \Gamma^T(t_k - t_-, t_k - t)) \cdot (\hat{\theta} \circ \wedge \Gamma^T(t - t_k, t - t_-))] \hat{\theta} \cdot (\hat{a} \circ \wedge \Gamma(t_k - t_-, -t_-)) [\hat{a} \cdot \hat{b}] \quad (\text{E115})$$

$$-[\hat{a} \cdot (\hat{0} \circ \Delta \Gamma^T(t-t_k))][(\hat{b} \circ \Delta \Gamma(t_k-t_{k-})) \cdot \hat{b} \cdot \hat{a}](\hat{a} \circ \Gamma(t_k-t_{k-})) \quad (\text{E116})$$

$$+ [\hat{a} \cdot (\hat{\Omega} \circ \wedge \Gamma^T(t, t - t_1))][(\hat{b} \circ \Gamma(t, -t_1)) \cdot \hat{b} \hat{a}](\hat{a} \circ \wedge \Gamma(t_1 - t, -t_1)) \quad (\text{E117})$$

$$-[\hat{a} \cdot (\hat{a} \circ \Gamma^T(t_+ - t_-)) (\hat{\Omega} \circ \Lambda \Gamma^T(t_+ - t_-))][(\hat{b} \circ \Lambda \Gamma(t_+ - t_- - t_-)) \cdot \hat{b} \hat{a}] \quad (\text{E118})$$

$$-[\hat{a} \cdot [(\hat{h} \circ \wedge \Gamma(t_+ - t_-, -t_-)) \cdot (\hat{a} \circ \Gamma^T(t_+ - t_-)) \cdot (\hat{h} \circ \wedge \Gamma^T(t_+ - t_-))] \hat{h} \hat{a}] \quad (\text{E119})$$

$$+ [\hat{\alpha} \cdot (\hat{b} \circ \wedge \Gamma(t_1 - t_2, -t_2)) \cdot \hat{b} (\hat{\alpha} \circ \wedge \Gamma^T(t_1 - t_2, -t_2)) \hat{\alpha} (\hat{\alpha} \circ \Gamma(t_1 - t_2))]] \quad (\text{E120})$$

$$+ [\hat{a}, [(\hat{b} \circ \Delta\Gamma(t_a - t_b, -t_b)), (\hat{a} \circ \Gamma^T(t_a - t_b)) \hat{b} (\hat{0} \circ \Delta\Gamma^T(t, t - t_b)) \hat{q}]] \quad (\text{F121})$$

$$+ [\hat{a}, [(\hat{b} \circ \Gamma(t_a - t_b)), \hat{b} (\hat{0} \circ \Delta\Gamma^T(t, t - t_b)) (\hat{a} \circ \Delta\Gamma^T(t_a, t_a - t_b)) \hat{q}]] \quad (\text{F122})$$

$$- [\hat{a}, [(\hat{b} \circ \Gamma(t_a - t_b)), \hat{b} (\hat{0} \circ \Delta\Gamma^T(t, t - t_b)) \hat{q} (\hat{a} \circ \Delta\Gamma(t_b - t_a, -t_a))]] \quad (\text{F123})$$

$$+ [(\hat{a} \circ \Gamma(t - t_a)), \hat{a} (\hat{0} \circ \Delta\Gamma^T(t, t - t_b)) [(\hat{b} \circ \Delta\Gamma(t_a - t_b, -t_b)), \hat{b} \hat{q}]] \quad (\text{F124})$$

$$- [(\hat{a} \circ \Gamma(t - t_a)), \hat{a} (\hat{0} \circ \Delta\Gamma^T(t, t - t_b)) [(\hat{b} \circ \Gamma(t_a - t_b)), \hat{b} \hat{q}]] \quad (\text{F125})$$

$$+ [(\hat{a} \circ \Gamma(t - t_a)), \hat{a} [\hat{b}, (\hat{0} \circ \Delta\Gamma^T(t, t - t_b))]] (\hat{b} \circ \Gamma^T(t_b)) \hat{q}] \quad (\text{F126})$$

$$+ [(\hat{a} \circ \Gamma(t - t_a)), \hat{a} [\hat{b}, (\hat{0} \circ \Delta\Gamma^T(t, t - t_b))] \hat{q} (\hat{b} \circ \Gamma(-t_b))] \quad (\text{F127})$$

$$+ [(\hat{a} \circ \Gamma(t - t_a)), \hat{a} [(\hat{b} \circ \Gamma(t_a - t_b)), \hat{b} (\hat{0} \circ \Delta\Gamma^T(t, t - t_b)) \hat{q}]] \quad (\text{F128})$$

$$- [(\hat{a} \circ \Gamma(t - t_a)), \hat{a} [(\hat{b} \circ \Gamma(t_a - t_b)), (\hat{0} \circ \Delta\Gamma^T(t, t - t_b))] \hat{b} \hat{q}] \quad (\text{F129})$$

$$+ [(\hat{a} \circ \Gamma(t - t_a)), [(\hat{b} \circ \Delta\Gamma(t_a - t_b, -t_b)), \hat{a} (\hat{0} \circ \Delta\Gamma^T(t, t - t_b))] \hat{b} \hat{q}] \quad (\text{F130})$$

$$- [(\hat{a} \circ \Gamma(t - t_a)), [(\hat{b} \circ \Delta\Gamma(t_a - t_b, -t_b)), \hat{a} \hat{b} (\hat{0} \circ \Delta\Gamma^T(t, t - t_b)) \hat{q}]] \quad (\text{F131})$$

$$+ [(\hat{a} \circ \Gamma^T(t_a - t)), (\hat{0} \circ \Delta\Gamma^T(t, t - t_b)) [(\hat{b} \circ \Delta\Gamma(t_a - t_b, -t_b)), \hat{b} \hat{q}] \hat{a}] \quad (\text{F132})$$

$$+ [(\hat{a} \circ \Gamma^T(t_a - t)), [\hat{b}, (\hat{0} \circ \Delta\Gamma^T(t, t - t_b))] \hat{q} (\hat{b} \circ \Gamma(-t_b)) \hat{a}] \quad (\text{F133})$$

$$- [(\hat{a} \circ \Gamma^T(t_a - t)), [\hat{b}, (\hat{0} \circ \Delta\Gamma^T(t, t - t_b))] \hat{q} (\hat{b} \circ \Gamma(t_a - t_b)) \hat{a}] \quad (\text{F134})$$

$$- [(\hat{a} \circ \Gamma^T(t_a - t)), [(\hat{b} \circ \Delta\Gamma(t_a - t_b, -t_b)), \hat{b} (\hat{0} \circ \Delta\Gamma^T(t, t - t_b)) \hat{q} \hat{a}]] \quad (\text{F135})$$

$$- [(\hat{b} \circ \Delta\Gamma(t - t_b, t_a - t_b)), \hat{b} (\hat{0} \circ \Delta\Gamma^T(t, t - t_b)) [\hat{a}, (\hat{a} \circ \Gamma^T(t_a - t_b)) \hat{q}]] \quad (\text{F136})$$

$$- [(\hat{b} \circ \Delta\Gamma(t - t_b, t_a - t_b)), [(\hat{0} \circ \Delta\Gamma^T(t - t_b, t - t_a)) \hat{b}, \hat{a}] (\hat{a} \circ \Delta\Gamma^T(t_a, t_a - t_b)) \hat{q}] \quad (\text{F137})$$

$$+ [(\hat{b} \circ \Delta\Gamma(t - t_b, t_a - t_b)), [\hat{a}, \hat{b} (\hat{0} \circ \Delta\Gamma^T(t, t - t_b))] (\hat{a} \circ \Delta\Gamma^T(t_a, t_a - t_b)) \hat{q}] \quad (\text{F138})$$

$$- [(\hat{b} \circ \Delta\Gamma(t - t_b, t_a - t_b)), [\hat{a}, \hat{b} (\hat{0} \circ \Delta\Gamma^T(t, t - t_b))] \hat{q} (\hat{a} \circ \Delta\Gamma(t_b - t_a, -t_a))] \quad (\text{F139})$$

$$+ [(\hat{b} \circ \Delta\Gamma(t - t_b, t_a - t_b)), [\hat{a}, \hat{b} (\hat{0} \circ \Delta\Gamma^T(t, t - t_b))] \hat{q} (\hat{a} \circ \Gamma(t_b - t_a))] \quad (\text{F140})$$

$$+ [(\hat{b} \circ \Delta\Gamma(t - t_b, t_a - t_b)), [\hat{a}, (\hat{0} \circ \Delta\Gamma^T(t, t - t_a)) \hat{b}] \hat{q} (\hat{a} \circ \Gamma(t_b - t_a))] \quad (\text{F141})$$

$$- [(\hat{b} \circ \Delta\Gamma(t - t_b, t_a - t_b)), [\hat{a}, (\hat{0} \circ \Delta\Gamma^T(t, t - t_b)) \hat{b}] \hat{q} (\hat{a} \circ \Gamma(t_b - t_a))] \quad (\text{F142})$$

$$- [(\hat{b} \circ \Delta\Gamma(t - t_b, t_a - t_b)), [\hat{a}, (\hat{0} \circ \Delta\Gamma^T(t - t_b, t - t_a)) \hat{b}] \hat{q} (\hat{a} \circ \Delta\Gamma(t_b - t_a, -t_a))] \quad (\text{F143})$$

$$+ [(\hat{b} \circ \Delta\Gamma(t - t_b, t_a - t_b)), [\hat{a}, (\hat{a} \circ \Gamma^T(t_a - t_b)) \hat{b} (\hat{0} \circ \Delta\Gamma^T(t, t - t_b)) \hat{q}]] \quad (\text{F144})$$

$$- [(\hat{b} \circ \Delta\Gamma(t - t_b, t_a - t_b)), [\hat{a}, (\hat{a} \circ \Gamma^T(t_a - t_b)) (\hat{0} \circ \Delta\Gamma^T(t, t - t_b)) \hat{b} \hat{q}]] \quad (\text{F145})$$

$$- [(\hat{b} \circ \Delta\Gamma(t_a - t_b, -t_b)), \hat{b} (\hat{0} \circ \Delta\Gamma^T(t, t - t_b)) [\hat{a}, (\hat{a} \circ \Gamma^T(t_a - t_b)) \hat{q}]] \quad (\text{F146})$$

$$- [(\hat{b} \circ \Delta\Gamma(t_a - t_b, -t_b)), \hat{b} (\hat{0} \circ \Delta\Gamma^T(t, t - t_b)) [\hat{a}, \hat{q} (\hat{a} \circ \Gamma(t_b - t_a))]] \quad (\text{F147})$$

$$+ [(\hat{b} \circ \Delta\Gamma(t_a - t_b, -t_b)), \hat{b} (\hat{0} \circ \Delta\Gamma^T(t, t - t_b)) [(\hat{a} \circ \Gamma(t - t_a)), \hat{a} \hat{q}]] \quad (\text{F148})$$

$$+ [(\hat{b} \circ \Delta\Gamma(t_a - t_b, -t_b)), \hat{b} (\hat{0} \circ \Delta\Gamma^T(t, t - t_b)) [(\hat{a} \circ \Gamma^T(t_a - t)), \hat{q} \hat{a}]] \quad (\text{F149})$$

$$- [(\hat{b} \circ \Gamma(t_a - t_b)), \hat{b} (\hat{0} \circ \Delta\Gamma^T(t, t - t_b)) [\hat{a}, (\hat{a} \circ \Delta\Gamma^T(t_a, t_a - t_b)) \hat{q}]] \quad (\text{F150})$$

$$+ [(\hat{b} \circ \Gamma(t_a - t_b)), \hat{b} (\hat{0} \circ \Delta\Gamma^T(t, t - t_b)) [\hat{a}, \hat{q} (\hat{a} \circ \Delta\Gamma(t_b - t_a, -t_a))]] \quad (\text{F151})$$

$$- [(\hat{b} \circ \Gamma(t_a - t_b)), \hat{b} (\hat{0} \circ \Delta\Gamma^T(t, t - t_b)) [(\hat{a} \circ \Gamma(t - t_a)), \hat{a} \hat{q}]] \quad (\text{F152})$$

$$+ [(\hat{b} \circ \Delta\Gamma^T(t_b - t_a, t_b - t)), [\hat{a}, (\hat{0} \circ \Delta\Gamma^T(t, t - t_b))] \hat{q} (\hat{a} \circ \Delta\Gamma(t_b - t_a, -t_a)) \hat{b}] \quad (\text{F153})$$

$$+ [(\hat{b} \circ \Delta\Gamma^T(t_b - t_a, t_b - t)), [\hat{a}, (\hat{0} \circ \Delta\Gamma^T(t - t_b, t - t_a))] \hat{q} (\hat{a} \circ \Delta\Gamma(t_b - t_a, -t_a)) \hat{b}] \quad (\text{F154})$$

$$- [(\hat{b} \circ \Delta\Gamma^T(t_b - t_a, t_b - t)), [\hat{a}, (\hat{0} \circ \Delta\Gamma^T(t, t - t_a)) \hat{b} \hat{q} (\hat{a} \circ \Gamma(t_b - t_a))]] \quad (\text{F155})$$

$$)] + \text{H.c.} \quad (\text{F156})$$