Quantum correlations of dissipative oscillators: Driving and synchronization effects

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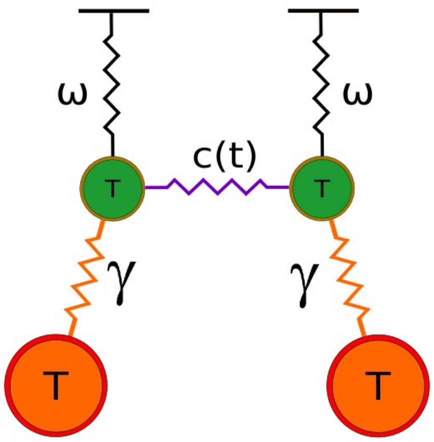
2 dissipative driven harmonic oscillators

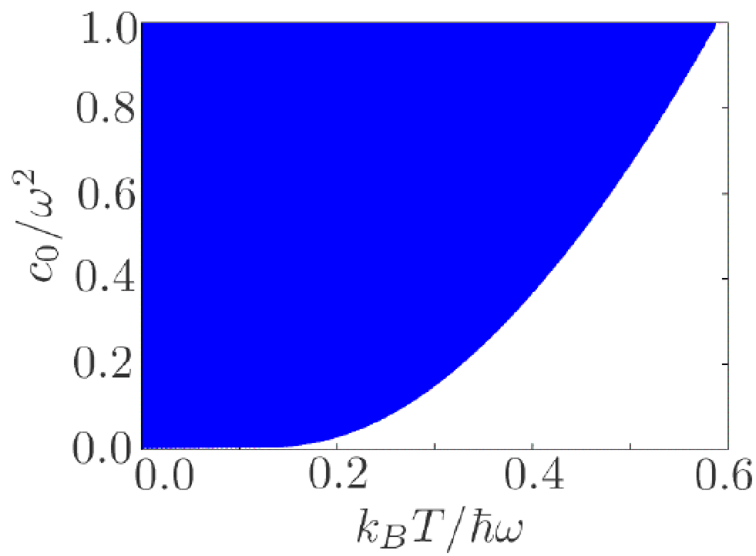
$$\mathcal{H}_s = \sum_{\alpha=1}^{2} \left(\frac{P_\alpha^2}{2m} + \frac{1}{2} m\omega^2 Q_\alpha^2 \right) + c(t)\, Q_1 Q_2 \qquad c(t) = mc_0 + mc_1 \cos(\omega_d t)$$

$$\mathcal{H} = \mathcal{H}_s + \sum_{\alpha,k=1}^{2,\infty} \frac{{p_{\alpha,k}}^2}{2m_k} + \frac{m_k \omega_k^2}{2} \left(x_{\alpha,k} - \frac{c_k Q_\alpha}{m_k \omega_k^2} \right)^2$$

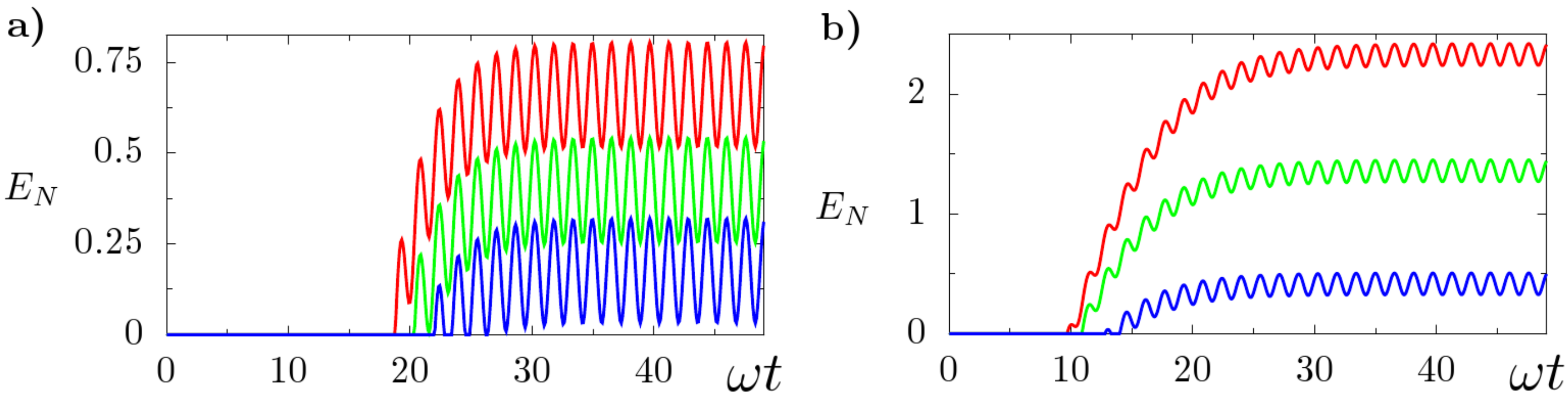
– We choose separate baths –



– Thermal entanglement –



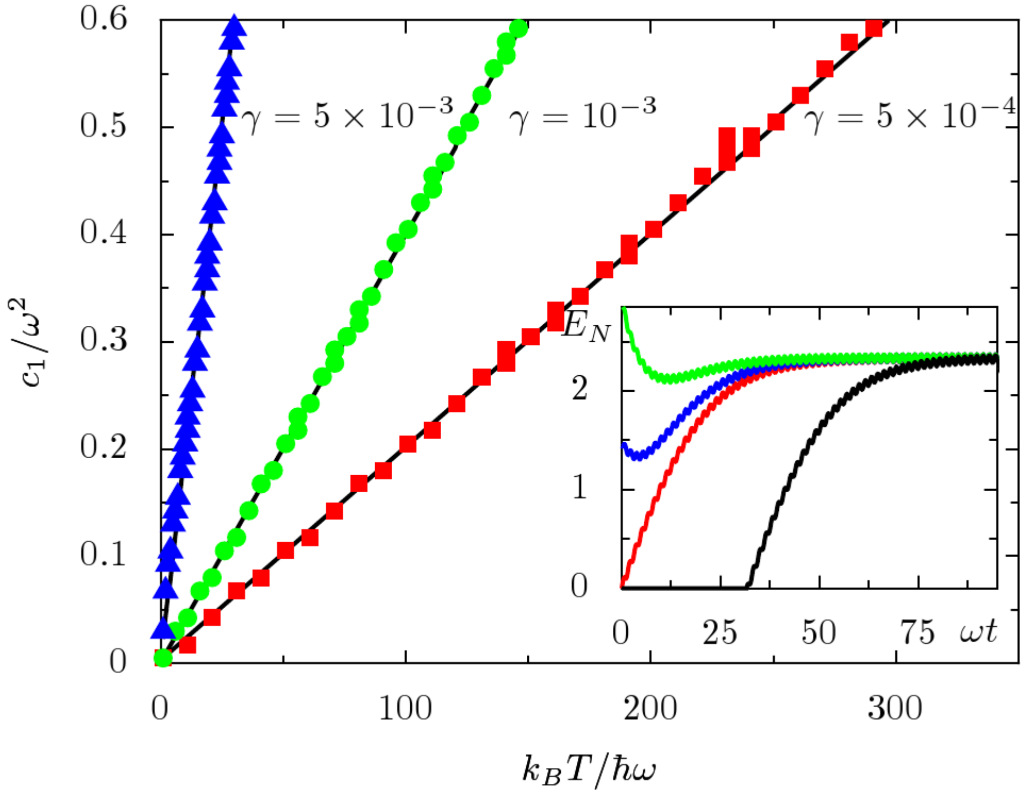
Driving produces nonequilibrium stationary entanglement



a) $\gamma = 0.005\omega$, $c_1 = 0.5m\omega^2$,
$k_B T/\hbar\omega = 250$(red), 300(green), 350(blue)

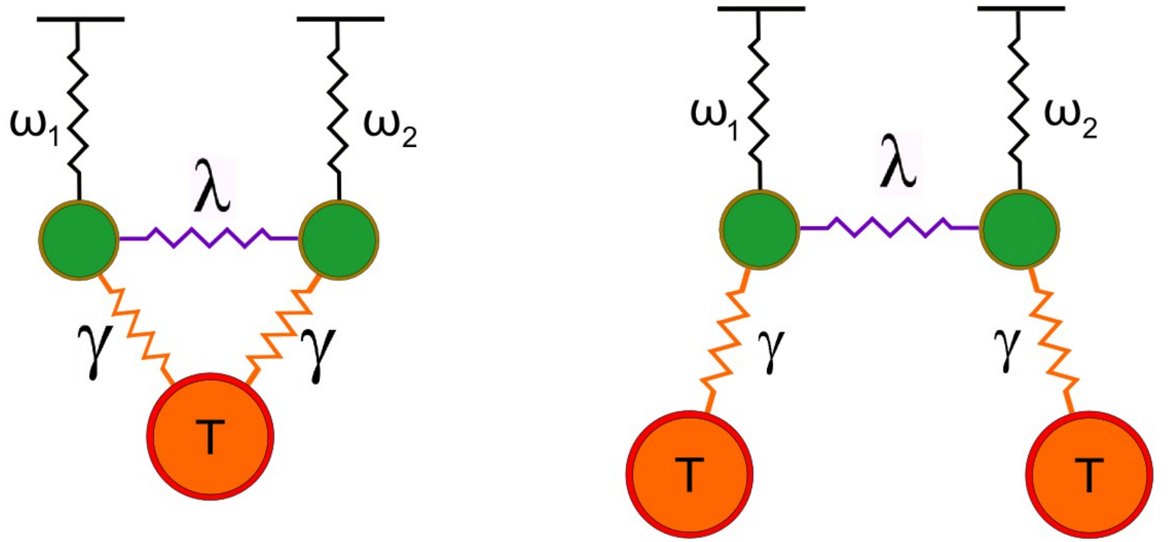
b) $c_1 = 0.5m\omega^2$, $k_B T/\hbar\omega = 5$,
$\gamma = 0.005\omega$(red), 0.01ω(green), 0.02ω(blue)

Which translates into a high-T entanglement diagram



$$\frac{k_B T}{\hbar\omega} \leq \frac{|\mathrm{Im}(\mu_{\mathrm{M}})|}{\gamma}$$

2 nonidentical dissipative harmonic oscillators (synchronization)



Common bath

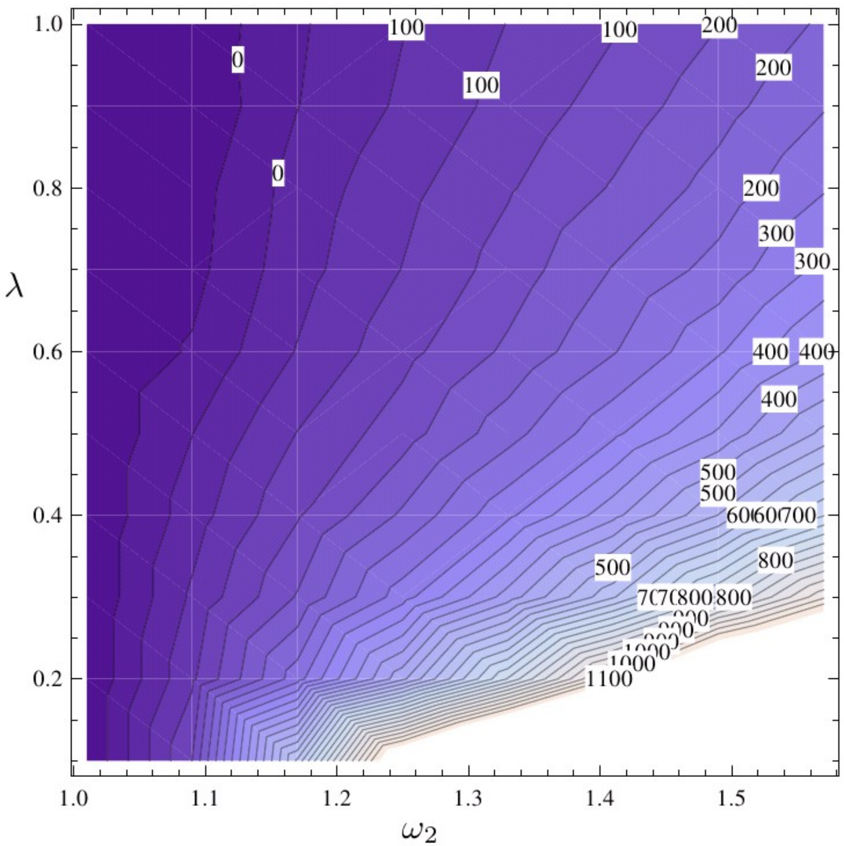
(oscs. variances synchronize)

Separate baths

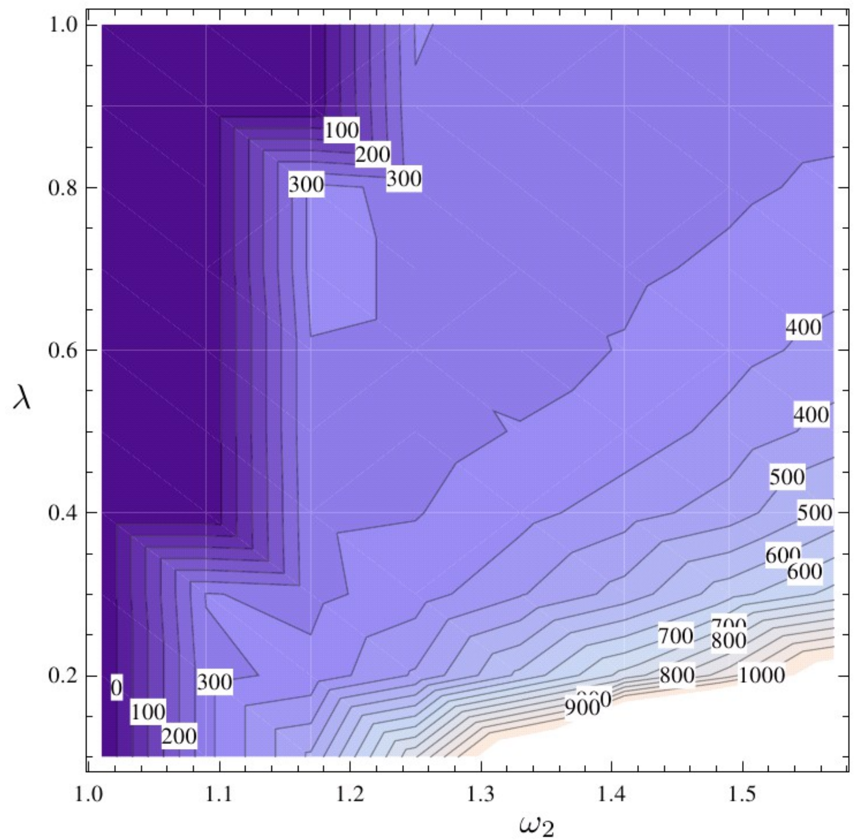
(oscs. var. do not synchronize)

Synchronization of first and second moments shows similar behaviour (common bath):

2nd moments sync. time



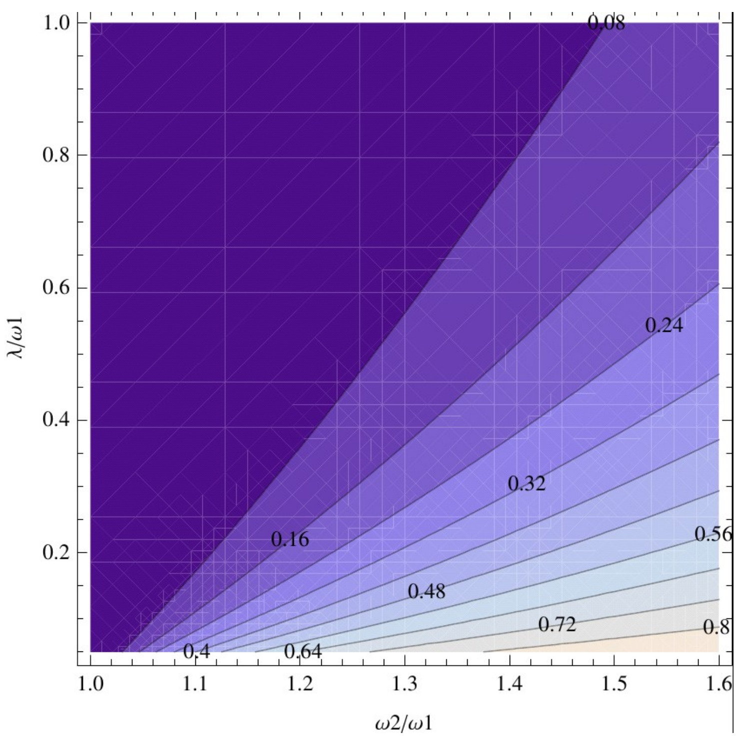
1st moments sync. Time



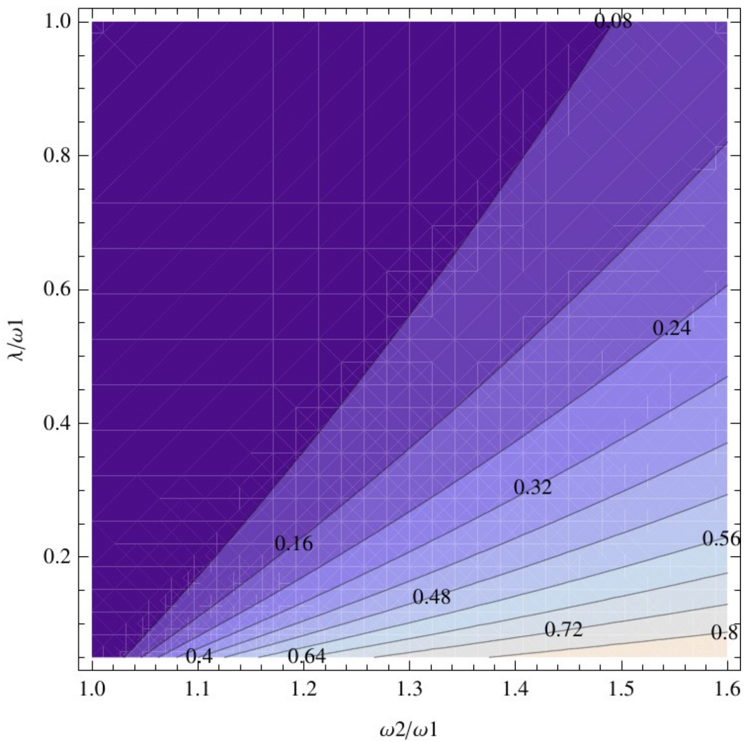
Synchronization times can be understood from the real parts of the eigenvalues of the dynamical equations (equations for all variances).

-- Smallest real part over largest one --

(2nd moments, common bath)

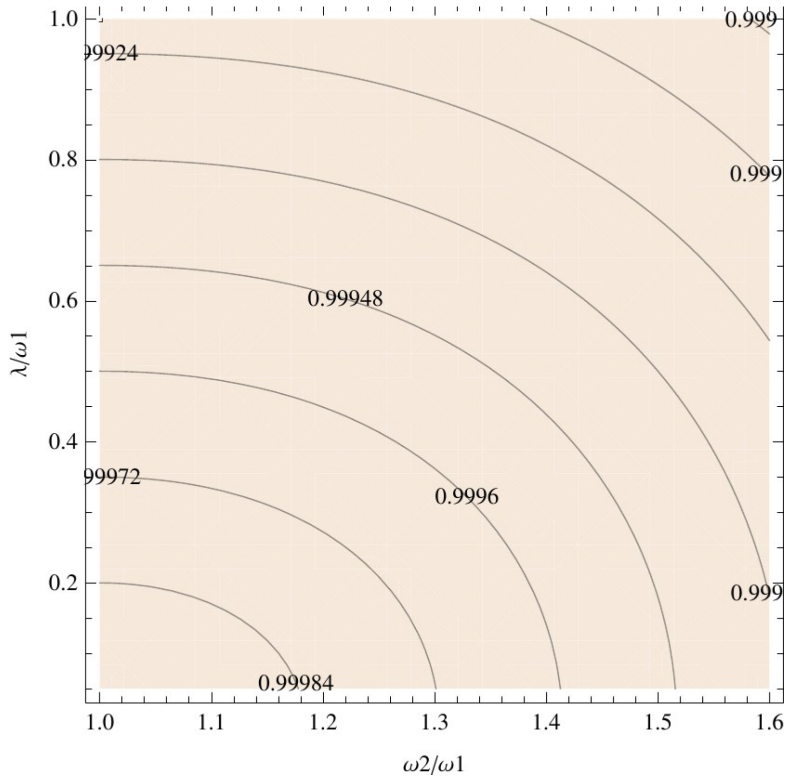


(1st moments, common bath)



-- Smallest real part over largest one --

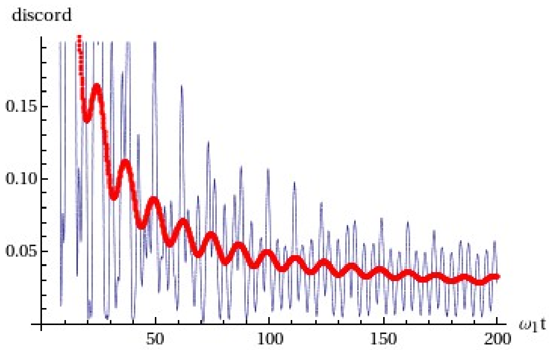
(2^{nd} moments, Separate baths)

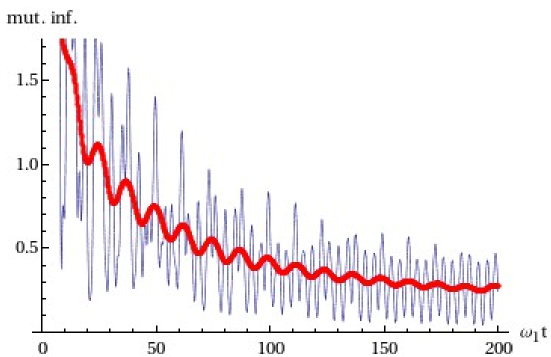


No “mode” relaxes faster than others, so NO synchronization

Synchronization of 2nd momenta leads to reduced information loss, both quantum correlations and total correlations (initial state: 2-mode squeezed):

<u>Common bath</u>





<u>Separate baths</u>