

Synchronization Enhancement by Dissipative Coupling

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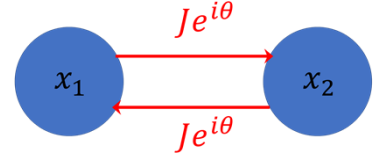
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Abstract

For a system of two weakly coupled Van der Pol oscillators:

- dissipative coupling yields a substantially wider synchronization window than coherent coupling
- hybrid coherent–dissipative coupling can extend this window even further in weak nonlinearity case, albeit with synchronized states of unequal amplitudes

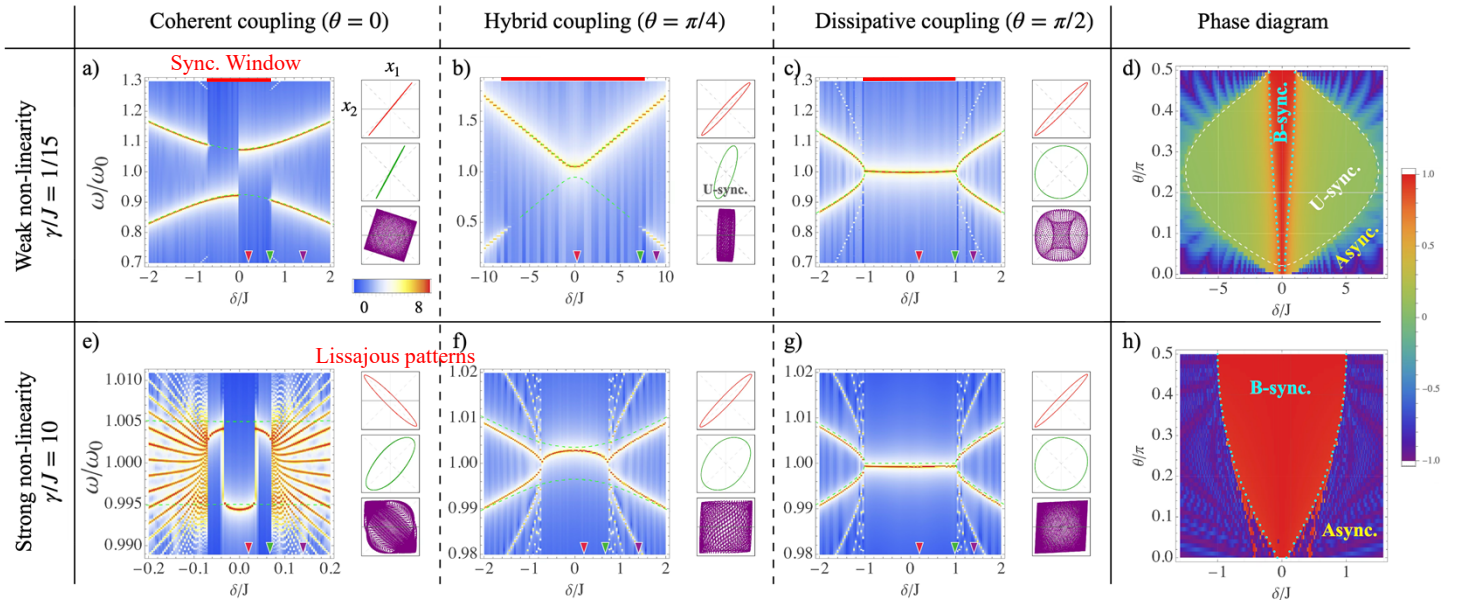
Model



Nonlinearity: γ_1 γ_2
Frequency: $\omega_1 \approx 1$ $\omega_2 \approx 1$

$$\frac{d^2 x_i(t)}{dt^2} + \omega_i^2 x_i = 2\gamma_i(1 - \beta_i x_i^2) \frac{dx_i(t)}{dt} + 2J \left(-\cos \theta \omega_0 + \sin \theta \frac{d}{dt} \right) x_i(t)$$

Simulation Results



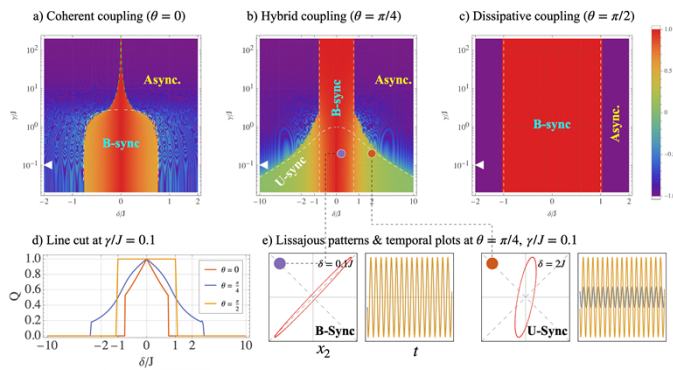
Sum spectra $S(\omega) = |\tilde{x}_1(\omega)| + |\tilde{x}_2(\omega)|$ for weak (a-c) and strong (e-f) nonlinearity.

The phase diagram of synchronization quality Q for weak (d) and strong (h) nonlinearity.

$$Q = \min \left(\left| \frac{\tilde{x}_1(\nu_1)}{\tilde{x}_2(\nu_2)} \right|, \left| \frac{\tilde{x}_2(\nu_2)}{\tilde{x}_1(\nu_1)} \right| \right) \times \begin{cases} +1 & \nu_1 = \nu_2 \\ -1 & \nu_1 \neq \nu_2 \end{cases}$$

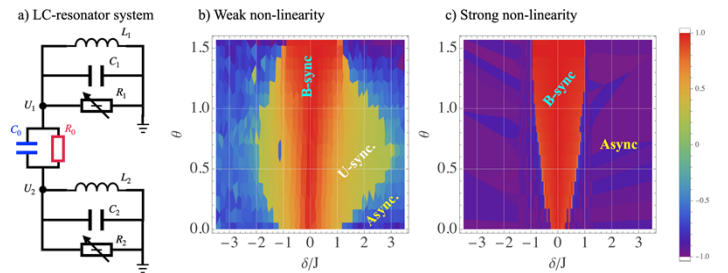
Nonlinearity Impart

Detect the synchronization quality Q as a function of δ and γ :



Experiment Verification

We employ two LC oscillators powered by negative resistance R_i to verify results above:



Reference

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- [4] A. P. Kuznetsov, N. V. Stankovitch, and L. V. Turukina, Physica D: Nonlinear Phenomena 238, 1203 (2009).

