Exceptional points and Levels Coalesces in Dissipative Coupled Classical Oscillators

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Exceptional Point[1]

- At the exceptional points, two levels coalesces. But it is different with degeneracy, for there is only one eigenvector.

$$H = \begin{pmatrix} \omega_1 & \lambda_1 \\ \lambda_2 & \omega_2 \end{pmatrix} \qquad E = \frac{\omega_1 + \omega_2}{2} \pm \sqrt{\left(\frac{\omega_1 - \omega_2}{2}\right)^2 + \lambda_1 \lambda_2}$$
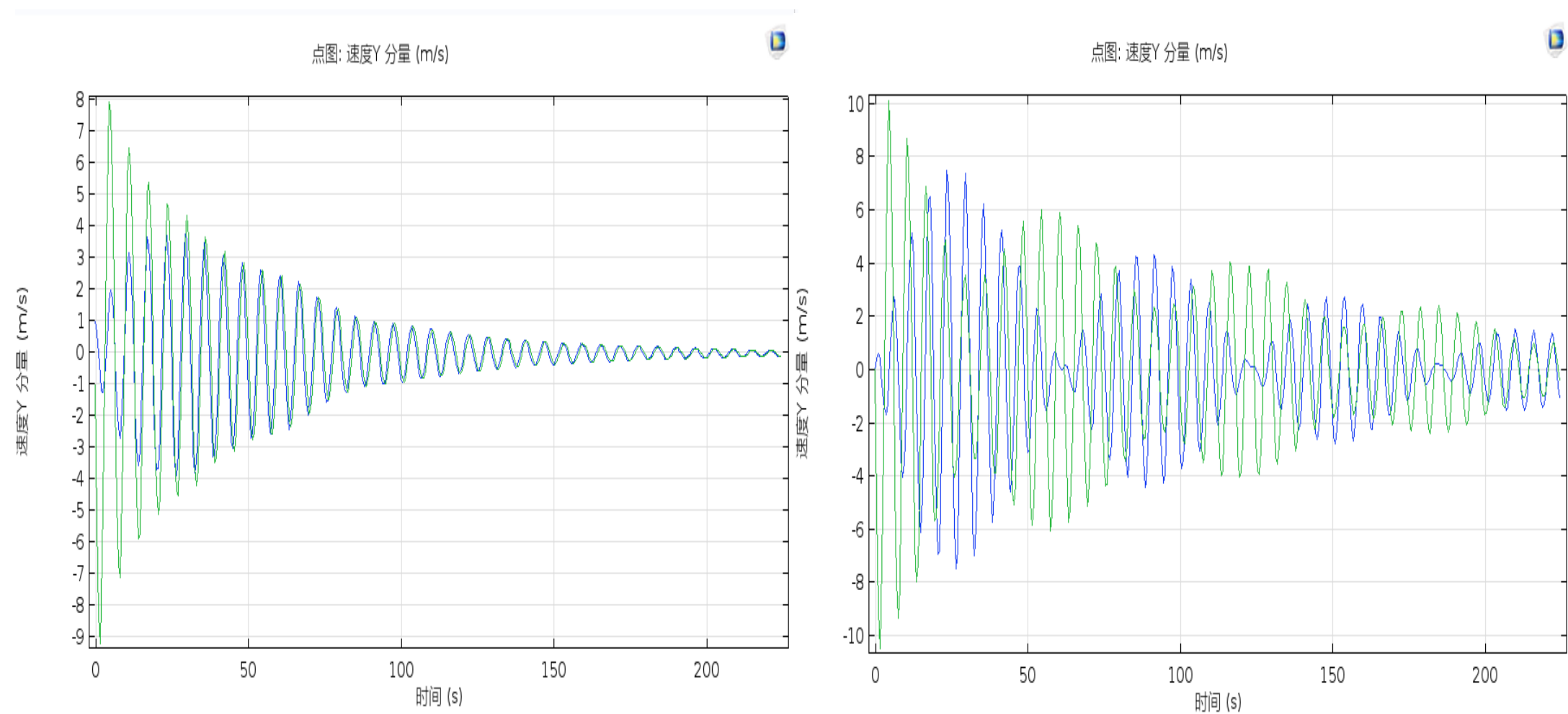
- So we have $\left(\frac{\omega_1 - \omega_2}{2}\right)^2 = -\lambda_1 \lambda_2$ at exceptional points.

- Exceptional points exits in gain-lose systems[2] and dissipative coupled system.
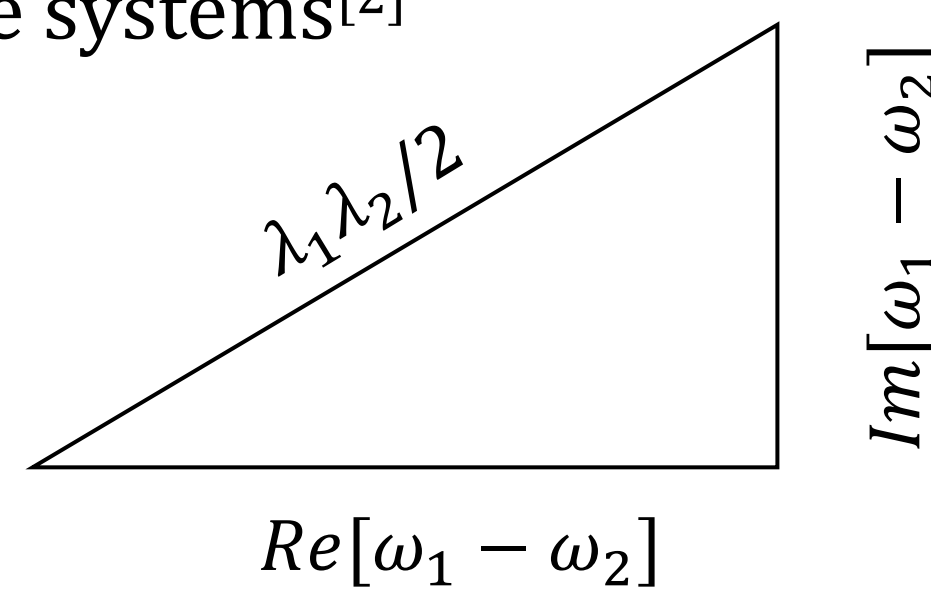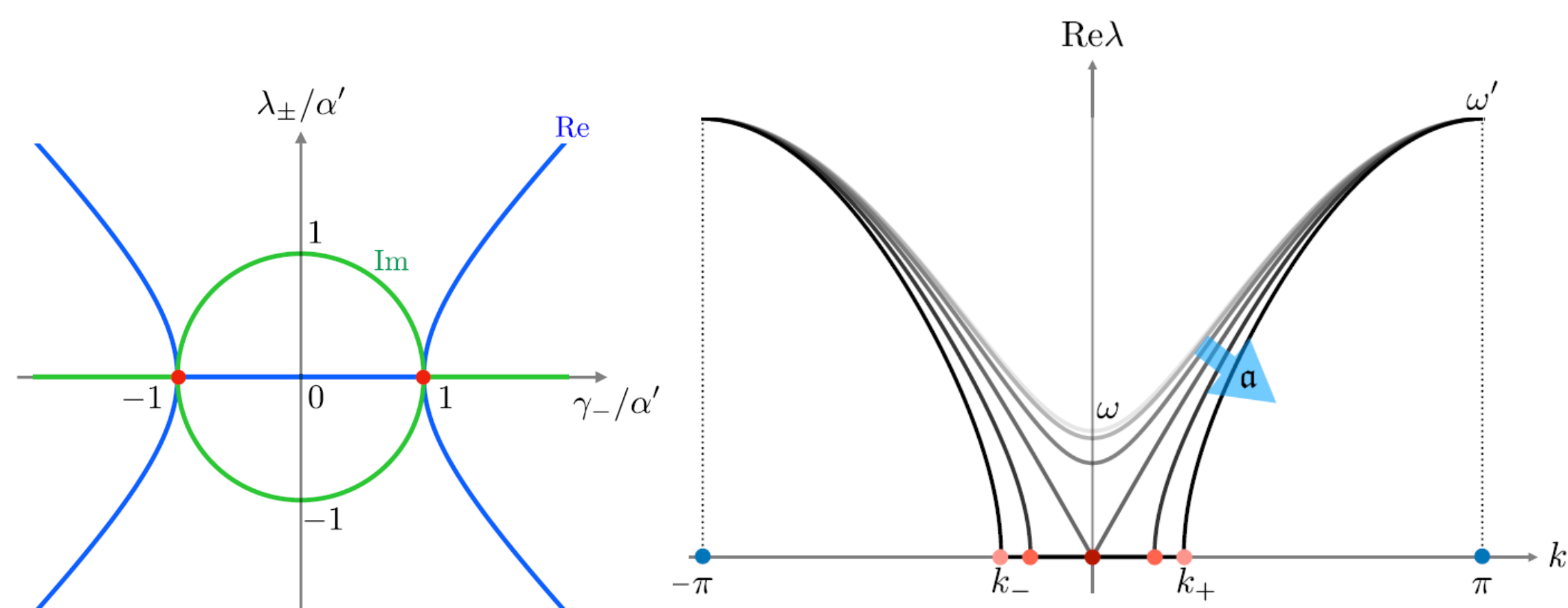

Levels Coalesces (level attractive coupling)

- In the area between two exceptional points, two subsystem with different eigenfrequency will synchro.

- Compared with normal coupling, this synchro has completely different behavior.
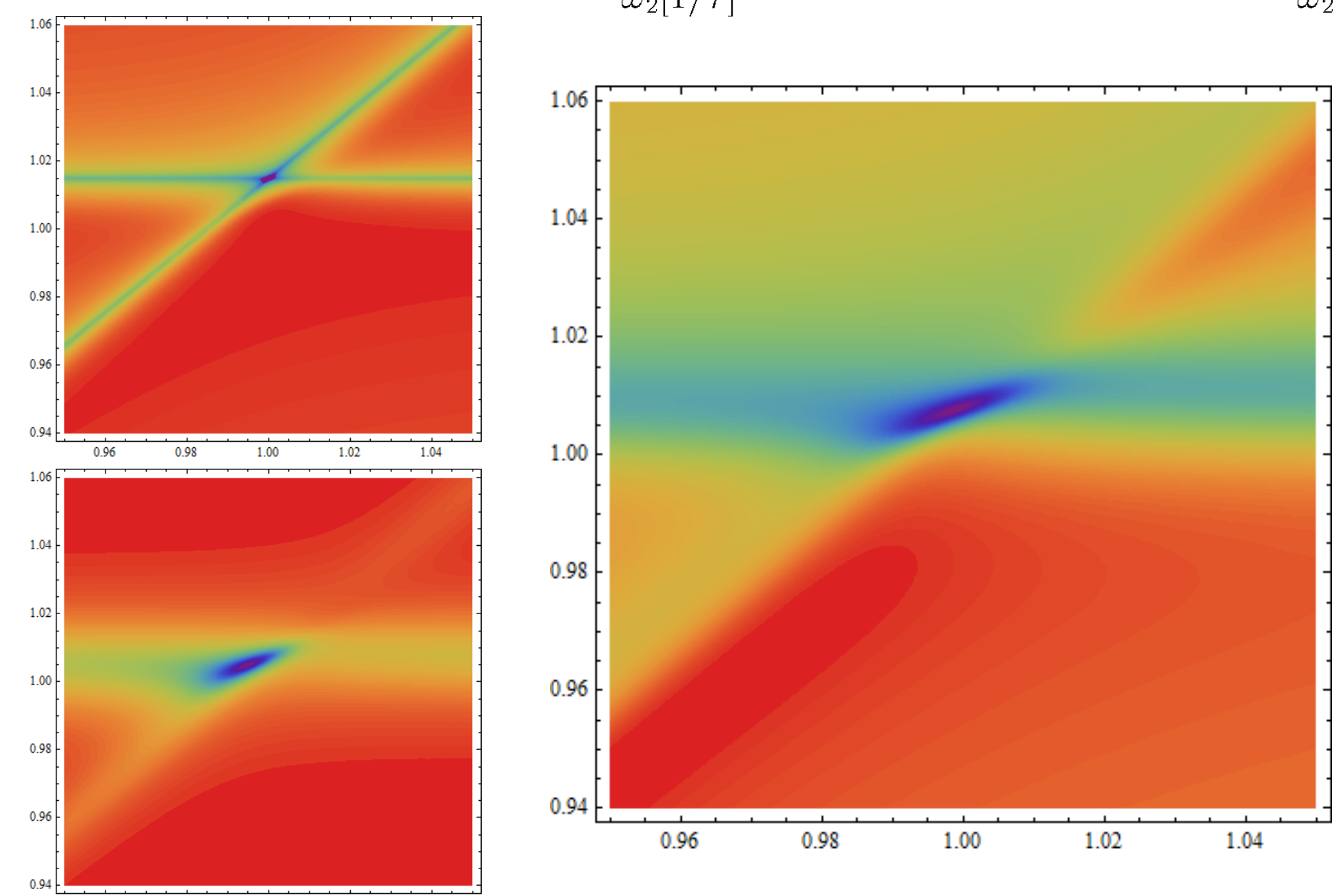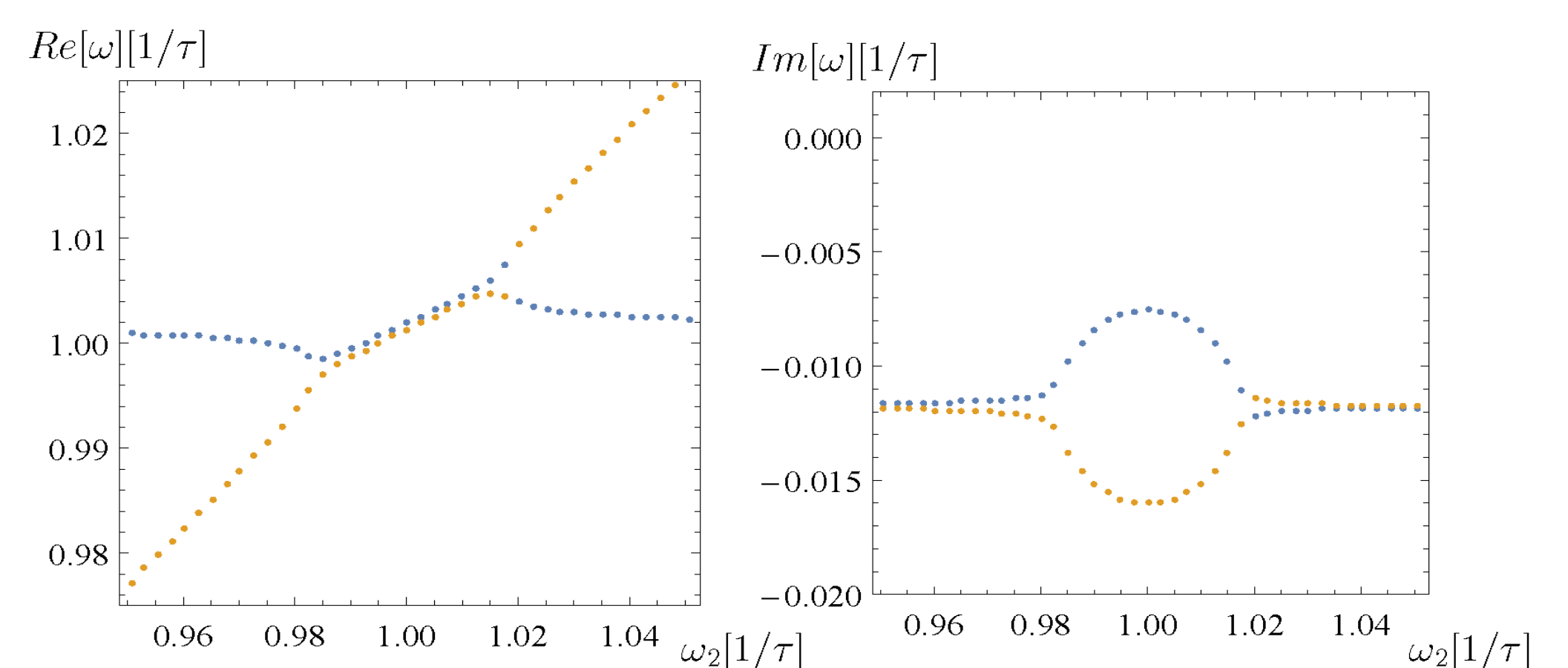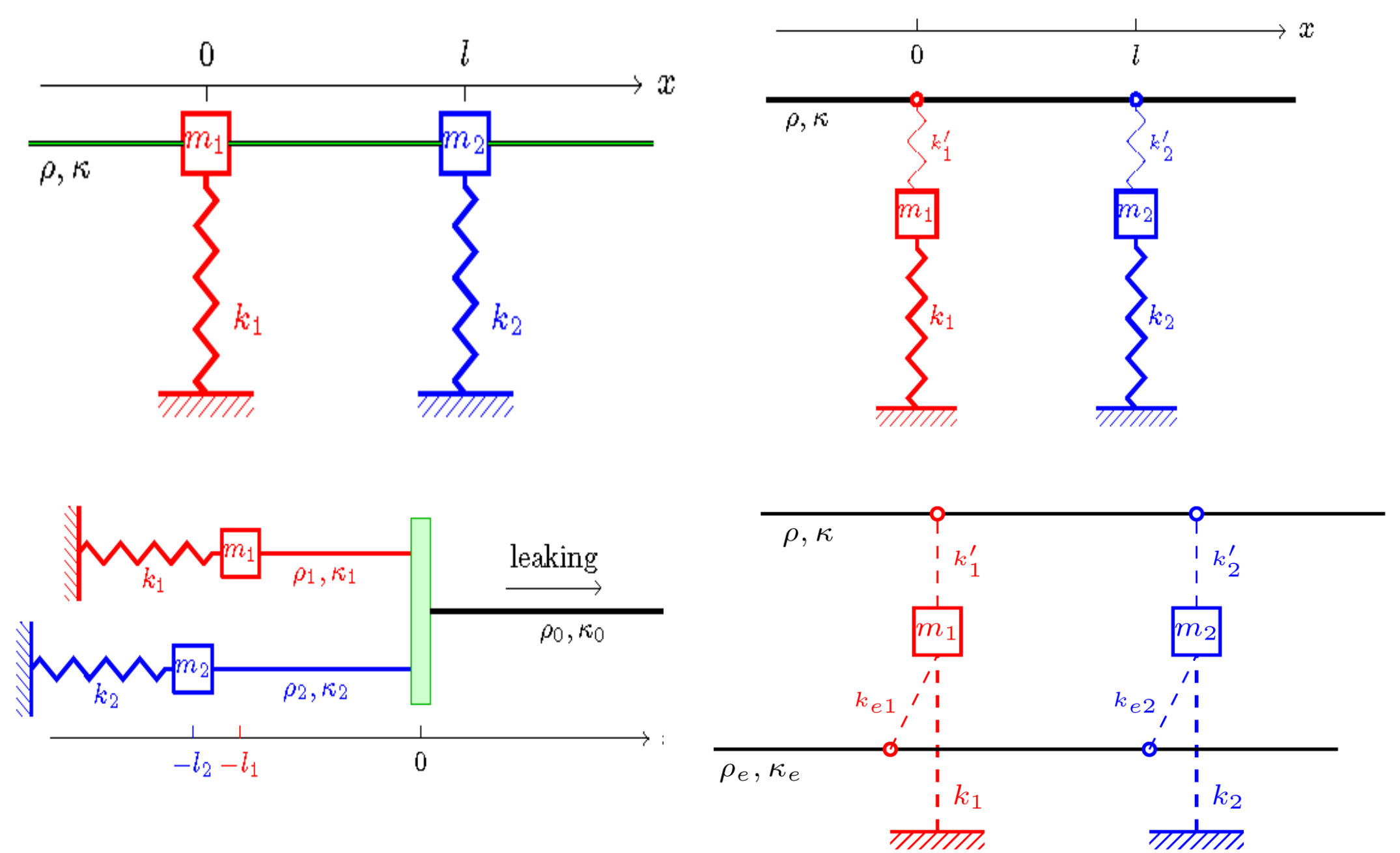

Normal coupling

Dissipative coupling

- When two expectational points meets, a Weyl point is obtained.[3]

Models and Results

$$\kappa_{12} \propto \sum_k e^{ik(l_1 - l_2)} \frac{1}{\omega_1 - \omega_k + o(k')} \frac{1}{\omega_2 - \omega_k + o(k')}$$

Conclusion and Outlook

- Dissipative coupling can induce a levels coalesces behavior, we have several models to get exceptional points.

- Synchronization of three or more oscillators is still not available.

Reference

[1] W. D. Heiss, J. Phys. A: Math. Theor. 45, 444016 (2012).

[2] A. Regensburger, C. Bersch, M.-A. Miri, G. Onishchukov, D. N. Christodoulides, and U. Peschel, Nature (London) 488, 167 (2012).

[3] Yaroslav Tserkovnyak, Phys. Rev. Research 2, 013031 (2020).