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# Time-Modulated Gain and Loss Parity-Time Symmetric Resonators

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Loss has, without a doubt, been one of the key issues in optical communication. On the other hand, the applications of gain have been primarily studied in laser technologies. It has recently been shown that, under a judicious combination of both gain and loss, a new novel system, namely the Parity-Time (PT) symmetric structures, is constructed. In our recent works [1,2], we have developed a semi-analytical method based on the Boundary Integral Equation (BIE) method to study the spectral characteristics of resonator structures with balanced and unbalanced gain/loss in a system which takes the form of coupled resonators and finite chain structures. In particular, we show the impact of dispersion on the spectral behaviour such that PT-symmetry can only be achieved at a single frequency and is sensitive to mismatching conditions.

In this contribution, we explore the time-dynamics of coupled resonators structures, see Fig. 1. For this purpose, a two-dimensional time-domain Transmission-Line Modelling (2DTLM) method equipped with a dispersive gain/loss model is developed. The 2DTLM method is well-suited to model the temporal dynamic of a PT-symmetric coupled structure under time-modulated gain and loss conditions. Figure 1 further shows that, by switching on/off the gain/loss alternatively at a rate described by a switching time parameter, flexible optical spatial switching can be achieved.

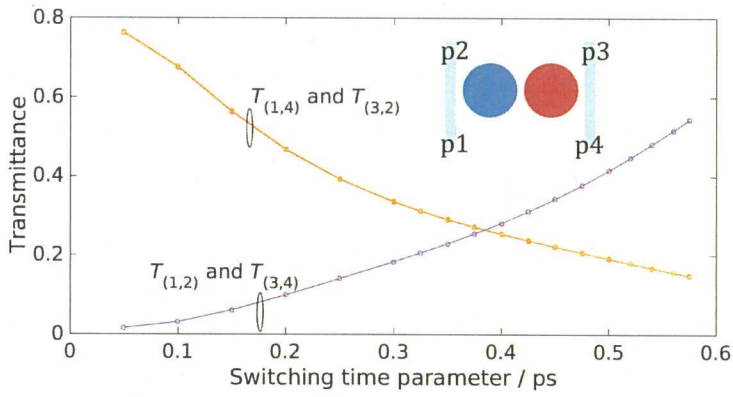


**Fig. 6. Transmittance between ports as a function of switching-time parameter.**

References

[1] S. Phang, A. Vukovic, S. C. Creagh, T. M. Benson, P. D. Sewell, G. Gradoni, *Parity-time symmetric coupled microresonators with a dispersive gain/loss*, Optics Express, vol. 23, no. 9, 2015

[2] S. Phang, A. Vukovic, S. C. Creagh, G. Gradoni, P. D. Sewell, T. M. Benson, *Localized Single Frequency Lasing States in a Finite Parity-Time Symmetric Resonator Chain*, Scientific Reports, vol. 6, 2016