The absorptive ring cavity: Dynamics & patterns beyond the mean-field limit

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Keywords: thin-slice approximation, ring cavity, saturable absorber, *energy theme*

An optical ring cavity filled with an absorptive material is a fundamental spontaneous pattern-forming system [1]. Analyses of Turing bifurcations in these (uni-directional) cavity configurations [see Fig. 1(a)] can be simplified by deploying the thin-slice limit, wherein the host nonlinear medium (typically of the Maxwell-Bloch type) has a near-negligible thickness [2]. Our most recent research has investigated the emergence of spontaneous *simple* [see Fig. 1(b)] and *fractal* patterns (which are defined by the presence of a *single dominant scale length* and *multiple scale lengths of proportional amplitude*, respectively) in absorptive thin-slice cavities [3]. Extensive simulations have demonstrated that the plane-wave limit of our model (where transverse effects are neglected) tends to be stable and well behaved: the cavity dynamics lack the Ikeda-type instabilities that can dominate purely-dispersive systems [4]. We have also started to generalize earlier analyses [3] by accommodating a finite light-medium interaction length. Such considerations will, potentially, facilitate the description of fully-nonparaxial fractal light patterns in bulk-medium geometries [5].

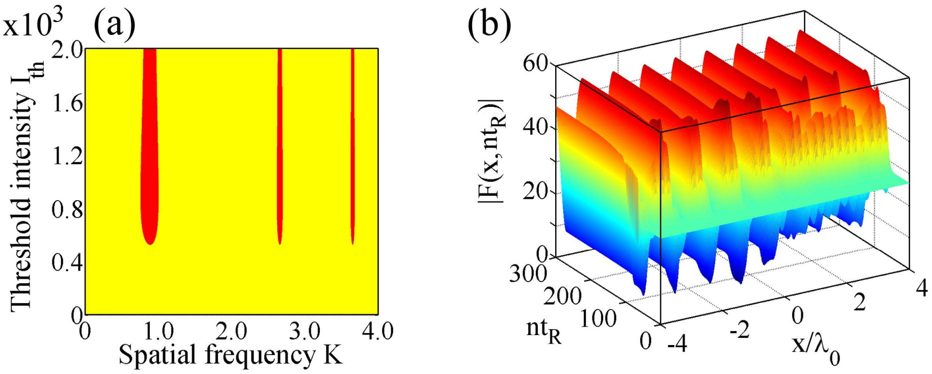

Figure 1. (a) A typical multi-Turing threshold spectrum for an absorptive ring cavity containing a thin slice of saturable absorber material [3]. (b) Simulation showing the spontaneous emergence of a spatial pattern whose most-unstable wavelength is $\lambda_0 = 2\pi/K_0$, where K_0 corresponds to the minimum of the first instability lobe [see part (a)].

References

[1] A. S. Patrascu, C. Nath, M. Le Berre, E. Ressayre, and A. Tallet, Opt. Commun. **91**, 433 (1992).
[2] M. Le Berre, A. S. Patrascu, E. Ressayre, and A. Tallet, Opt. Commun. **123**, 810 (1996).
[3] J. G. Huang, J. M. Christian, and G. S. McDonald, J. Nonlin. Opt. Mat. Phys. **21**, 1250018 (2012).
[4] K. Ikeda, H. Daido, and O. Akimoto, Phys. Rev. Lett. **45**, 709 (1980).
[5] M. Brambilla, L. Columbo, and T. Maggipinto, J. Phys. B: Quantum Semiclass. Opt. **6**, S197 (2004).