Spontaneous spatial fractal light patterns in simple nonlinear cavities

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Nature furnishes us with a wide variety of patterns that, fundamentally, tend to fall into one of two categories: *simple* (characterized by a dominant scale-length or "size") or *fractal* (containing comparable levels of detail spanning decimal orders of scale). The physical mechanism that drives the emergence of simple patterns in reaction-diffusion models was originally identified by Alan Turing in his seminal work from over 60 years ago [Phil. Trans. R. Soc. Lond. B vol. 237, pp. 37 (1952)]. More recently, our Group proposed that a generalization of that mechanism – multi-Turing instability – could give rise to spontaneous fractal patterns in generic wave-based nonlinear systems [Huang & McDonald, Phys. Rev. Lett. vol. 95, art. no. 174101 (2005)].

In this presentation, we will provide an overview of our latest research into the fractal-generating properties of two simple nonlinear optical systems: the ring cavity and the Fabry-Pérot cavity. Laser light is fired into a cavity (constructed from a sequence of mirrors), whereupon it interacts with a thin slice of nonlinear material. After completing a transit, the light partially recombines with the pump light and is fed back into the cavity *ad infinitum* (an optical feedback loop). We have also taken the first steps toward understanding spontaneous fractal patterns in systems with a finite light-material interaction length, where the slice is replaced by a bulk medium. This conceptual leap, which requires one to take a more complete account of small-scale (nonparaxial) spatial structure in the circulating light, has not previously been addressed in the literature.