Instabilities & boundary conditions: fractal mode patterns in kaleidoscope lasers

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The multi-scale - or *fractal* - nature of transverse modes in one-dimensional (1D) unstable cavity lasers has been known since the late 1990s [1]. Early collaborations with some members of our Group demonstrated that the origin of fractality (which demands both the *presence* and *comparable strength* of multiple spatial scales) lies in a subtle interplay between small-scale diffraction effects at the mirror edges and successive round-trip magnifications [2]. Kaleidoscope lasers are fully-2D generalizations of the more familiar 1D system, where the feedback mirror has a non-trivial transverse shape, such as a regular polygon [3]. The fundamental mechanism for fractal formation is the same as for 1D cavities, but until recently these highly geometric cavity designs have received relatively little attention. We will report on recent advances in our understanding of kaleidoscope lasers, facilitated by the development of new semi-analytical techniques. Key considerations include direct calculation of mode patterns (see figure 1), eigenvalue spectra, and convergence phenomena (e.g., as the feedback mirror tends towards the circular limit). We have also performed what appear to be the first computations of mode fractal dimension for arbitrary cavity parameters. Some surprising results have been uncovered.

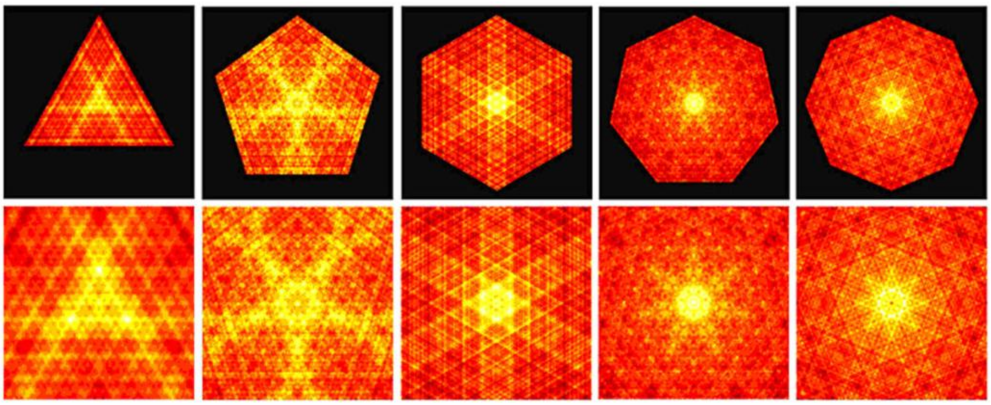

Figure 1. Top row: Computations of the lowest-loss modes for a range of kaleidoscope lasers. Bottom row: magnification of the central portion of each of the corresponding patterns in the top row.

References

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