

THE KALEIDOSCOPE LASER

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Unstable cavities result in diverging light wavefronts, permit efficient gain extraction and are thus used in an important class of high power laser. Traditionally, these cavities are characterised only by their Fresnel number and magnification. However, an aperturing element is implicitly always present and its *shape* determines the actual transverse mode structure (see Figure 1). We have undertaken the first investigation of fully two-dimensional (regular polygon and variable-angle rhombus) intra-cavity aperturing. The resonator modes are found to be extremely complex but *fractal* in character [1]. Their aesthetic beauty and polygonal symmetries invite an analogy with Brewster's kaleidoscope and we have christened this device the Kaleidoscope Laser.

Experiments used a miniature He-Xe laser with an aperture assembly whose size and shape could be rapidly and precisely controlled. Theoretical modelling included computations based on a Kirchhoff-Huygens integral coupled to a nonorthogonal beam propagation method.

Fractal mode profiles, self-similar and kaleidoscopic features, eigenvalues and the dependence of the excess noise factor K will be reported. In experiments, K was determined from the level of spectral broadening while theoretical values were calculated from the mode profiles. Very good agreement was obtained using these quite independent approaches. Modelling enabled explorations of much wider ranges of cavity parameters and uncovered some rather complex resonant behaviours. We were able to explain these in terms of an interplay of resonant transverse lengths.

Techniques for computing higher-order mode profiles will also be discussed, along with future directions and applications. In particular, the formal correspondence with a conventional kaleidoscope suggests a range of other optical devices, such as novel laser designs and fractal kaleidoscopes.

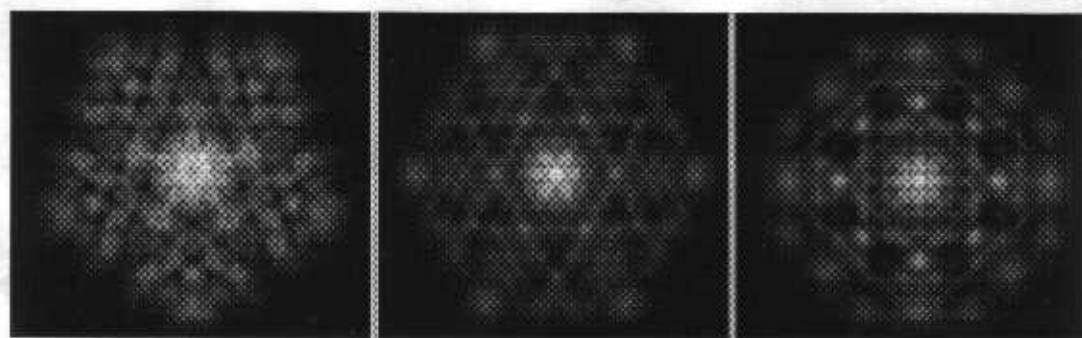


Figure 1 *Fractal transverse mode profiles of the Kaleidoscope Laser (the Fresnel number and magnification are the same in each case).*

Reference

[1] *Fractal Lasers*, GP Karman, GS McDonald, GHC New and JP Woerdman, submitted to Science.