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Fractal laser sources: new analyses, results and contexts

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A series of significant new extensions concerning fractal light generation are reported. *Firstly*, we summarise techniques and results from the first full analysis of the linear modes of 'fractal lasers' [1] – unstable-cavity geometries with arbitrary Fresnel number N_{eq} and arbitrary round-trip magnification M. *Secondly*, simulations and analyses for new contexts of laser-driven 'nonlinear fractal generators' [2] – where analogous nonlinear processes spontaneously generate fractals – are presented. *Finally*, we outline why such fractal laser sources may play a pivotal role in future Nature-inspired devices and system architectures.

Our discovery of fractal laser modes from unstable-cavity lasers [1] uncovered a general class of linear systems (with repeated magnification) that possess fractal eigenmodes. However, numerical or analytical analyses was limited to modes of either: very limited fractality, laser cavities with $N_{eq} \approx O(1)$; or unlimited fractality, when $N_{eq} >> O(1)$. General properties of fractal modes from these two extremes are, perhaps unsurprisingly, different. Building on Fresnel diffraction theory developments [3], we report fractal mode characteristics in the important intermediate regime – corresponding to real-world systems with significant and exploitable fractality (see Figure 1).

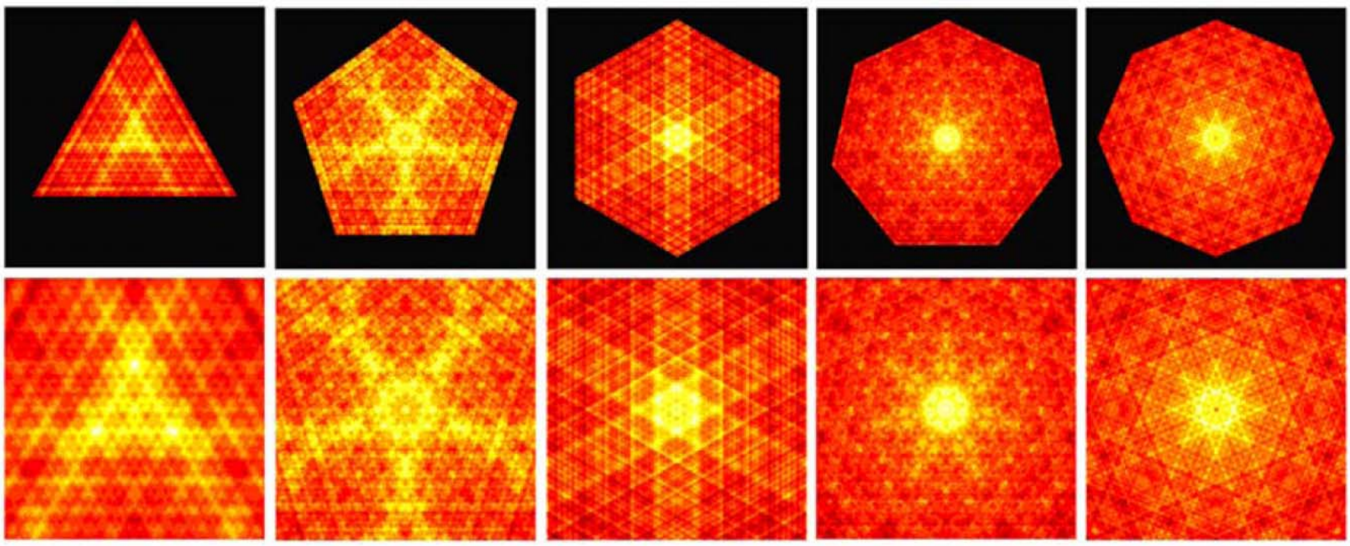

Figure 1. Lowest-loss eigenmode patterns for 'kaleidoscope fractals lasers' with N_{eq} = 30 and M = 1.5.

We further proposed fractal light generation through entirely-nonlinear mechanisms [2]. The context examined was a single configuration with a particular nonlinearity. Generalisation of this work to new contexts - with profoundly different nonlinearities and experimental configurations, such as ring cavities and cavity-less contexts – will be summarised.

The huge spatial bandwidths associated with fractal sources have potential exploitation within novel technological contexts. We conclude with a brief account of such potential new technologies.

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