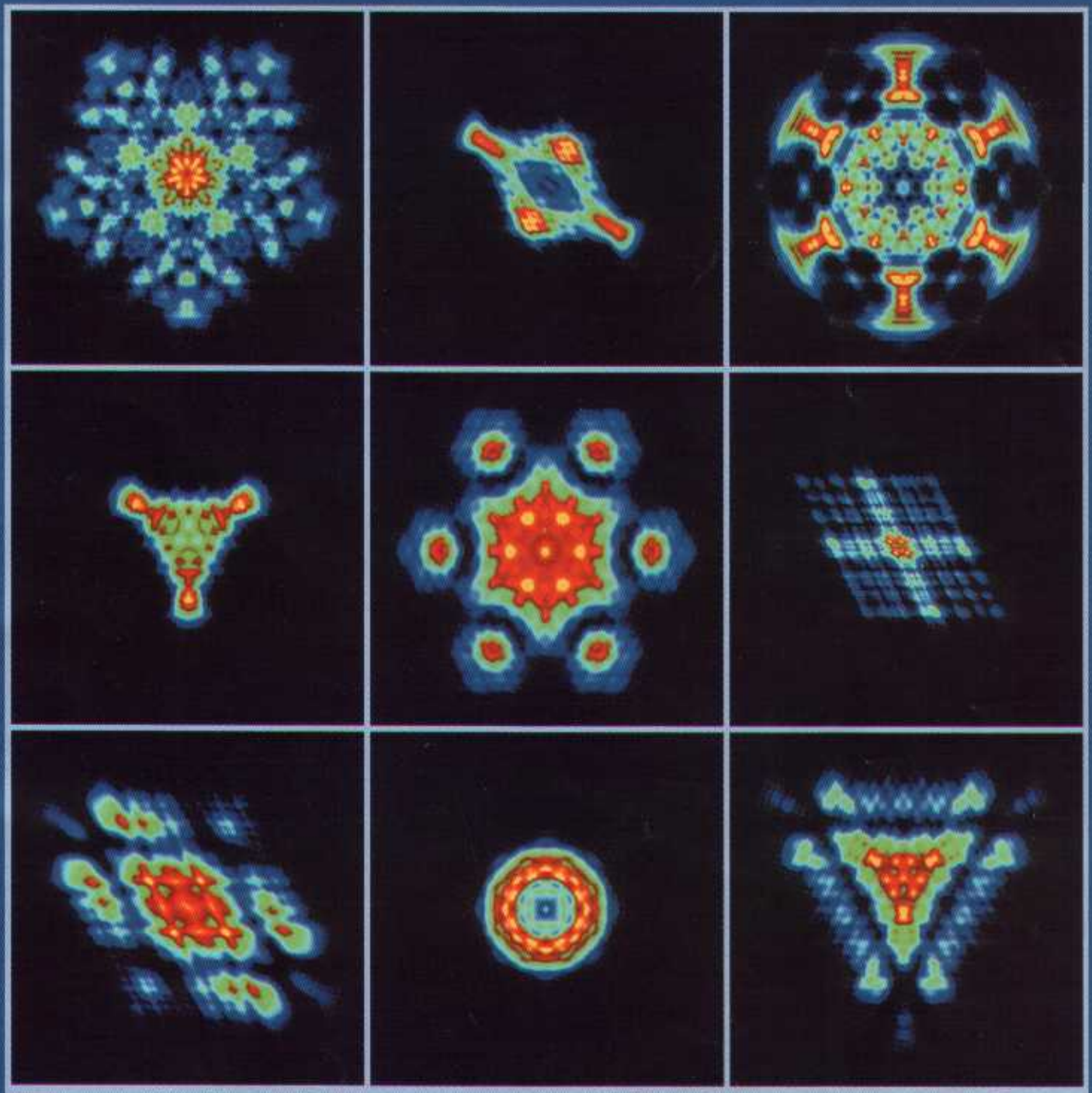
Opto & Laser Europe
Issue 67 October 1999



Fractals discovered in laser modes

Quantum fountains make a big splash

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Terawatt pulses put a lamp in the sky

Kaleidoscope laser emits modes of fractal patterns

By Oliver Graydon, QE-14, Manchester

Fractals, the beautiful mathematical patterns that describe the shape of snowflakes, leaves and coastlines, have been found in the modes of a laser.

An Anglo-Dutch research team made the discovery while investigating the noise behaviour of an unstable resonator. It found that introducing geometrically shaped apertures into the cavity generates transverse modes of astonishing complexity and beauty.

"These are the first natural fractals found in laser physics," Geoff New of Imperial College, London, told delegates at the fourteenth Quantum Electronics and Photonics Conference (QE-14) in Manchester last month. "The mode profiles are very beautiful and when magnified they show self-similarity."

This self-similarity is the signature of fractal patterns, which were discovered by Benoit Mandelbrot in the 1980s. The patterns are unusual because they keep their complex structure under repeated magnification. They are also in stark contrast to the usual TEM_{00} mode of a laser, which is a circular beam with a Gaussian intensity profile.

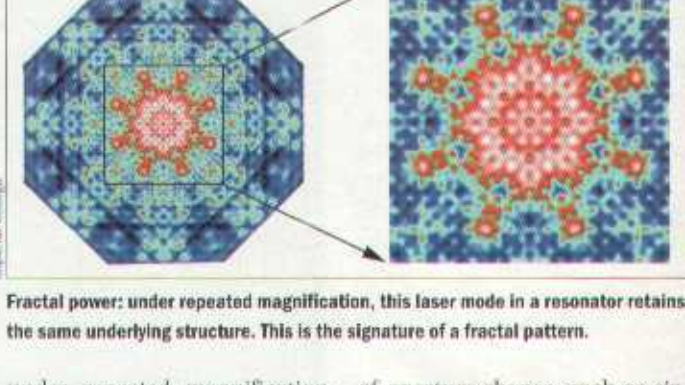

Image: Imperial College

Fractal power: under repeated magnification, this laser mode in a resonator retains the same underlying structure. This is the signature of a fractal pattern.

New and his University of Salford colleague Graham McDonald have been modelling the laser's unusual modes. Meanwhile, Han Woerdman and Gerwin Karman at the University of Leiden have conducted lab experiments.

The subject of their study is a high-gain HeXe laser containing an iris diaphragm, the size and shape of which can be precisely controlled. "We've tried all kinds of aperture shapes, such as circles, squares, triangles and hexagons," explained New. Each shape generates a different family of fractal modes (see front cover).

The optical physics responsible for the fractal modes is about to be published. "Quantum noise leaks into the resonator and seems to gets trapped," said New.

The researchers have decided to call their novel resonator the "kaleidoscope" laser because its beautiful modes remind them of the images that are generated by the kaleidoscope toy, invented by David Brewster in 1816.