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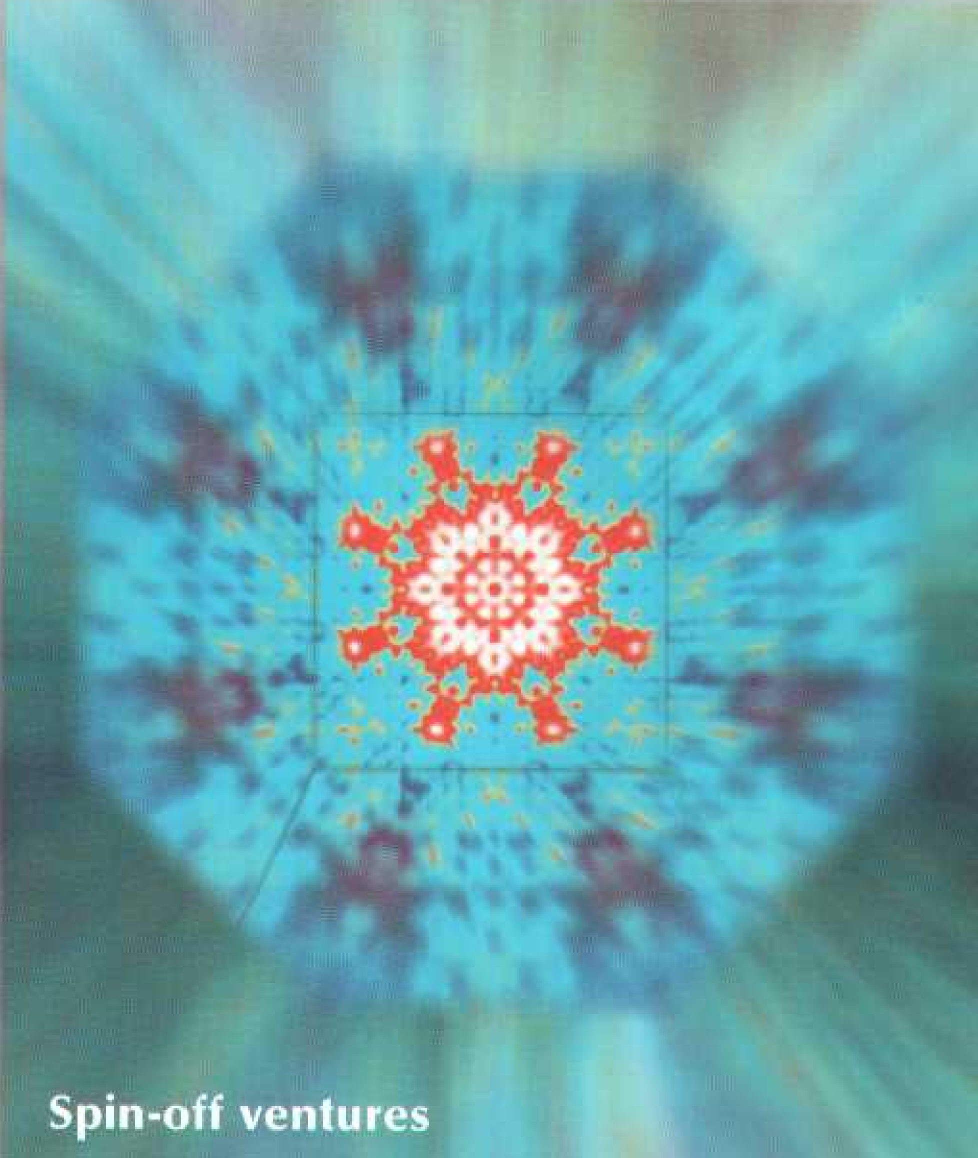
NEWSLINE



Spin-off ventures

Precious GEM

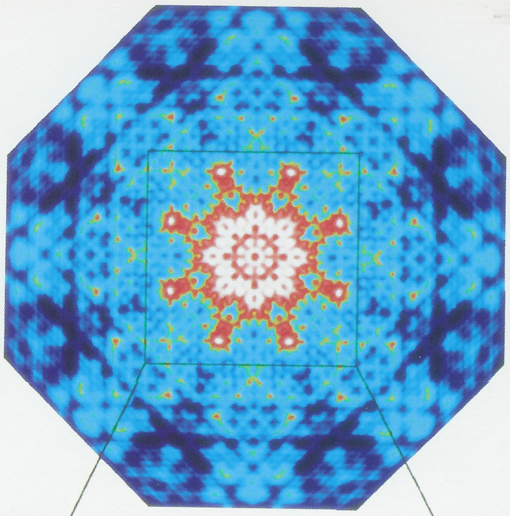
Winged wonders

High finance

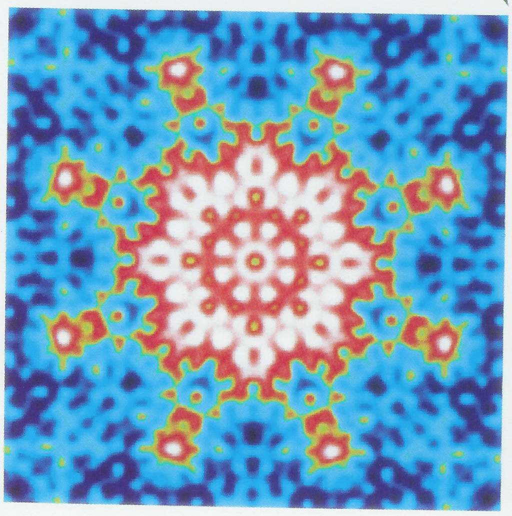
Degrees of prestige

Lasers that look like child's play

Kaleidoscopes have just gone hi-tech. A group of physicists working at Imperial College of Science, Technology and Medicine and the University of Leiden, in the Netherlands, have made what they call a 'kaleidoscope laser'. It produces beautiful images, similar to those found in the children's toy invented nearly 200 years ago.



Computer fractal mode profiles for unsteady resonators with different intra-cavity aperture shapes.



As well as being pleasing to the eye, these laser images are fractal or 'self-similar': examine them on a finer scale, and the small-scale structure of the images repeats the larger-scale features. Fractals have been found to occur almost everywhere in nature, from the structure of snowflakes to the shape of the British coastline. They have proved to be a vital tool in the study of chaotic systems.

Professor Geoff New, of Imperial College, and Dr Graham McDonald, now at Salford University, were surprised when their work on unstable resonator lasers with Dutch colleagues Professor Han Woerdman and Dr Gerwin Karman, produced the fractal images. "We stumbled on them when we were heading for somewhere else," says Professor New, who holds an EPSRC grant for the study of unstable cavity lasers.

Lasers of this type have markedly different properties from more familiar devices. The latter, used to scan barcodes at a supermarket checkout, for instance, have a tube-like cavity in which light, bouncing between concave mirrors at each end, is focused down to a narrow beam inside the cavity. When the light escapes, it forms a pencil-like beam that typically has a circular profile: on hitting a surface, it produces a small dot that is bright at the centre and fades towards the edge.

A typical unstable resonator, on the other hand, might be formed by a large concave mirror facing a smaller convex mirror. In this case, the mirrors increase the width of the circulating beam, filling the whole cavity with light, which spills out round the edge of the smaller mirror. Magnification of the beam as it bounces between the mirrors results in 'multiple diffraction' effects: that is, each time the light hits the edge of the convex mirror it is spread out further and distorted.

The researchers found that the end result of magnification and multiple diffraction is that the escaping laser beam has a fractal profile whose characteristics depend on the size and shape of the smaller mirror. A triangular mirror, for example, produces a triangular 'fractal mode' of the laser. Repeated magnification of the mode pattern reveals smaller and smaller triangles. Analogous features are found when the triangle is replaced by a pentagon, a hexagon, an octagon or, in fact, any polygon.

Unstable resonators are useful where high-powered lasers are required. "There are commercial applications; you can often get more energy out of them," says Professor New. The striking fractal patterns were a serendipitous discovery, but they could well prove to be a useful in other ways. "This is certainly of great interest from both a fundamental and an applications viewpoint," Professor New says. "It will also be very valuable in understanding the mathematical background of how lasers work."

The researchers now plan to study the fractal properties of unstable cavity lasers in greater depth. "So far we have only looked at regular polygon configurations. We don't know, for instance, what would happen when laser cavities are constructed more like conventional kaleidoscopes," says Professor New. That could mean looking at the properties of a laser cavity with walls composed of three strip mirrors arranged to form a triangular tube. They also plan to analyse the images in more detail and to characterise the fractals more precisely. "There are lots of aspects of this that we haven't yet explored," Professor New says.

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