to scatter light asymmetrically, in such a way the radiation pressure it experiences strongly depends on its angular tilt with respect to the beam's optical axis. Eventually, by adequately distributing the different cells symmetrically with respect to the centre of mass of the macroscopic flat object, the object experiences a restoring torque whenever it rotates out of its equilibrium orientation (Fig. 1b). Remarkably, the authors show that this passive stabilization feedback (in opposition to active feedback that would require to constantly monitor the object status and to act accordingly on the propelling beam to keep it stable) can compensate for both lateral shifts and angular tilts, and hence automatically keep the object in a stable trajectory. According to the results presented by the authors, only two different unit cells are needed to compensate for any destabilization of the substrate.

The work by Ilic and Atwater represents a change of paradigm in optical manipulation where the nanostructuration of the manipulated system is used to engineer the experienced force. This is an important result for the Breakthrough Starshot initiative and beyond as it eliminates the need for focusing or steering the propelling beam. Despite these encouraging results, there is still a long way to go to implement experimentally such a proposal with multiple challenges. First, the precise nanopatterning and handling of an ultrathin (of the order of one micrometre) macroscopic substrate is a delicate task. Also, the loading of the wafer in the laser beam will be difficult as it will require the system to be released in a very controlled way. Finally, when looking on a longer timescale, a realistic propulsion experiment to space will require taking into account the multiple external factors that may affect the trajectory of the spacecraft. ❐

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LASERS

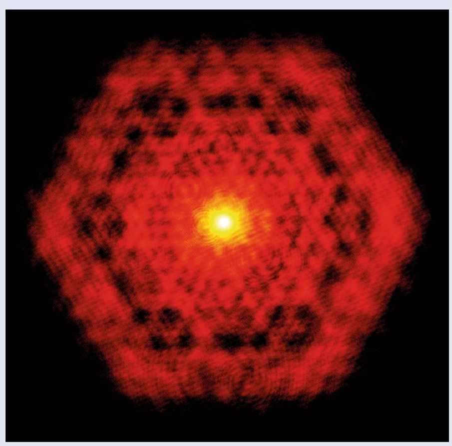
Fractal behaviour

Almost 20 years after they were first theoretically predicted, transverse laser modes with a fractal shape have now been experimentally observed within an unstable laser cavity by a team of scientists from South Africa and the UK.

In 1999, in a Brief Communications in *Nature*, researchers from Leiden University in The Netherlands and Imperial College London, UK, predicted that the transverse intensity cross-section of eigenmodes in an unstable canonical resonator should have fractal characteristics (G. P. Karman, G. S. McDonald, G. H. C. New and J. P. Woerdman, *Nature* **402**, 138; 1999).

Now, Andrew Forbes and co-workers from the University of Witwatersrand and the University of Glasgow have experimentally confirmed that this is indeed the case (H. Sroor et al., *Phys. Rev. A* **99**, 013848; 2019). The team built a flashlamp-pumped L-shaped laser cavity featuring two concave high-reflectivity end-mirrors, a Nd:YAG crystal and a polygonal aperture. They then used a CCD camera to image the spatial pattern of the laser light within the cavity at different longitudinal positions.

When they imaged the self-conjugate plane of the laser cavity, which lies inside the laser crystal, the intensity pattern that they recorded on the CCD camera showed a very strong self-similarity when magnified, a clear signature of fractal behaviour (pictured).



Credit: A. Forbes

As to why it has taken so long to achieve an experimental realization, Forbes commented: "I think a few people tried. What we found in looking closely at the theory was that contrary to expectation the fractal mode does not actually come out of the cavity — it exists in a very particular plane inside the cavity. I think many people missed that."

As for future work in the area, Forbes says that he is keen to further explore the system, in particular the existence of 3D fractals. "Johannes Courtial (co-worker at Glasgow) ran some lovely simulations and predicted that fractals should also exist in the longitudinal direction and not only the transverse direction," he told *Nature Photonics*. "To verify this will take an even more precise experiment. In my lab, we have developed some tricks that just might make this possible."

It should be noted that Forbes' recent paper is not the first experimental observation of fractal laser modes. Just last year, scientists from the University of Illinois in the USA reported the generation of fractal transverse modes in microlaser resonators (J. A. Rivera, T. C. Galvin, A. W. Steinforth and J. G. Eden, *Nat. Commun.* **9**, 2594; 2018). In this case, a close-packed 2D array of microspheres (either polystyrene or silica) was introduced inside a Fabry–Pérot laser cavity filled with a liquid gain medium of water-soluble colloidal quantum dots. Fractal laser patterns were seen to form at the gaps between the spheres. ❐

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