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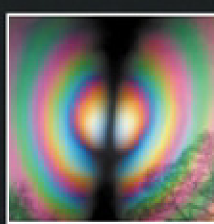
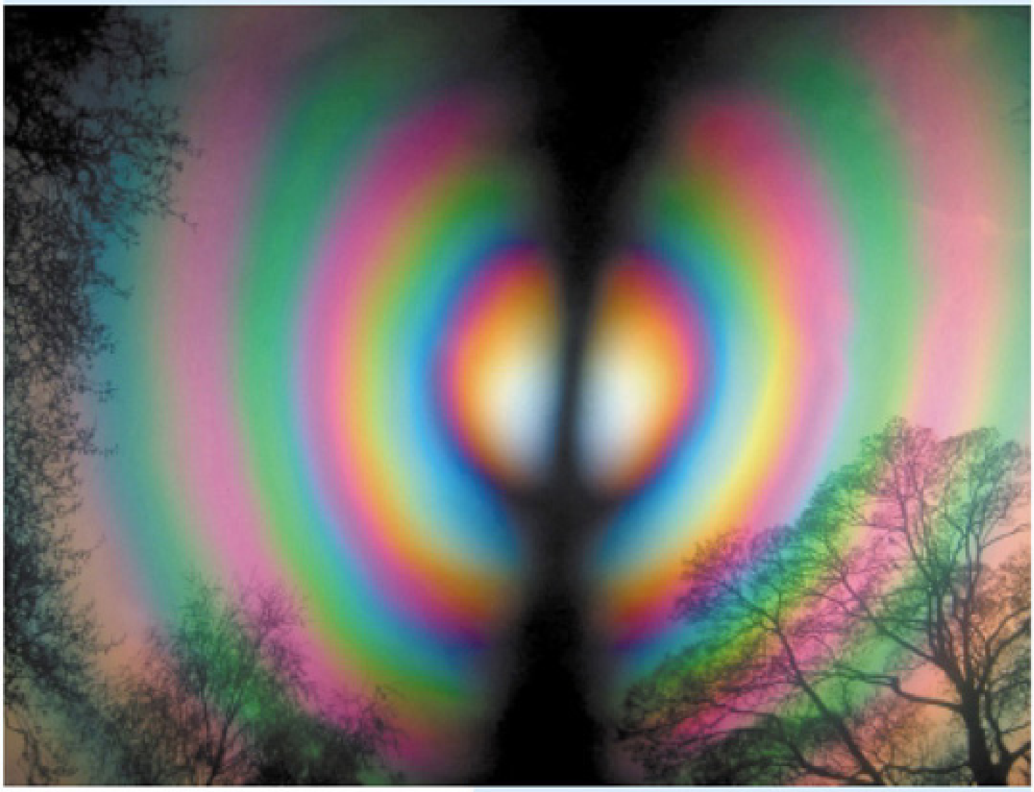
Deep Earth

Research before Birth

The Art of Physics



Sir Michael Berry is a Royal Society Research Professor, based in the University's Physics Department. *Snapshots from recent research* graphically represent various aspects of the research Berry does at Bristol.



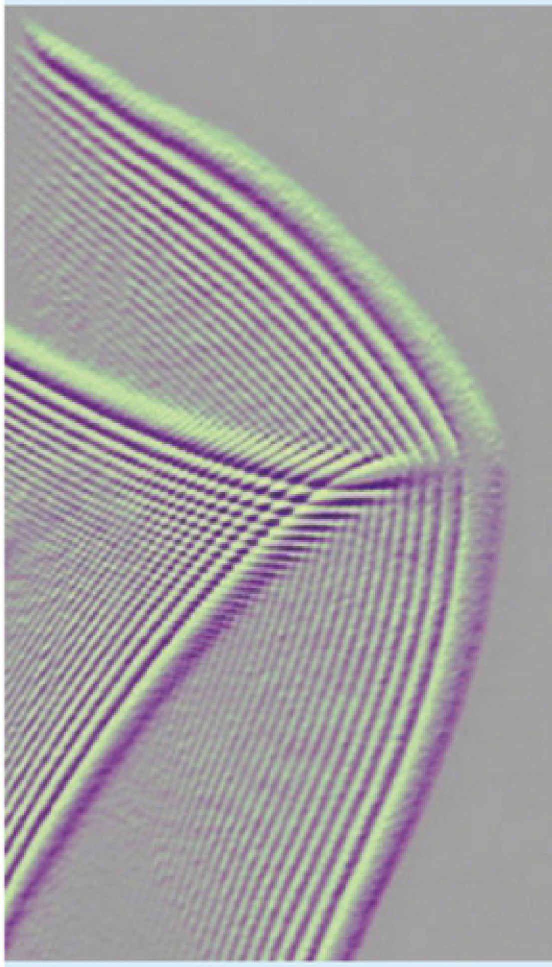
Sky with bullseye

Interference rings of polarised light decorate the sky above the Royal Fort gardens in Bristol. I photographed them through a 'sandwich' in which the 'filling' was a sheet of overhead-projector transparency film and the 'bread' was two sheets of polaroid film. The explanation of the rings was a triumph of nineteenth-century physics, now being clarified using modern geometrical ideas. Originally the theory applied to light in crystals, and it was unexpected to see them in this plastic film. The black 'brush' crossing the bullseye is an example of the geometric phases pervading the physics of waves. ■

www.phy.bris.ac.uk/staff/berry_mv.html

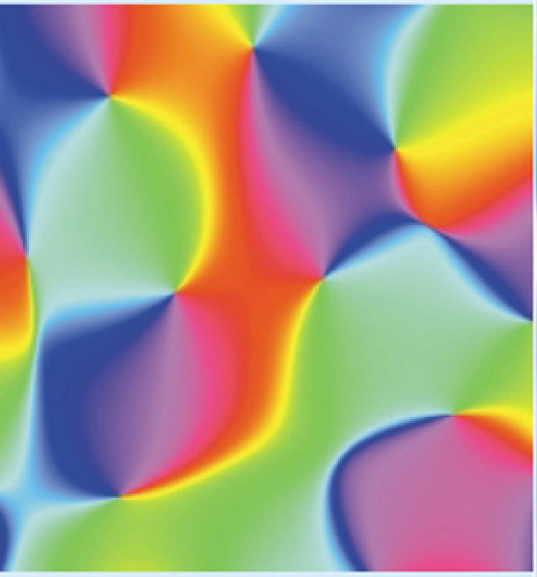
Bathroom window waves

A laser beam shines through a sheet of randomly undulating bathroom window glass onto a screen. I photographed the magnified image and then embossed it digitally. Rays within the beam that pass through different parts of the glass landscape, are bent in different ways. Consequently, more than one ray can reach the same part of the screen. They then interfere with each other, generating the delicate lines in the picture. The brightest lines are the boundaries of regions reached by different numbers of rays, where focusing occurs. Patterns like this, of naturally focused waves, are classified by the mathematics of catastrophe theory. ■



Random phases

A graph of the phase of several interfering waves, all with the same colour (wavelength) but travelling in different directions. 'Phase' describes the stage of any periodic process, like the phases of the moon or the angles of clock hands; here 'phase' is colour-coded by hue. All colours meet at the 'phase singularities' - points where the wave intensity is zero. The study of phase singularities is now a major activity worldwide. This pattern could represent speckled laser light, the microwave background radiation filling the universe, or the quantum wave for an electron moving chaotically. ■



Random phases won first prize in the 2002 Novartis/Daily Telegraph 'Visions of Science' competition in the 'Science as Art' category.

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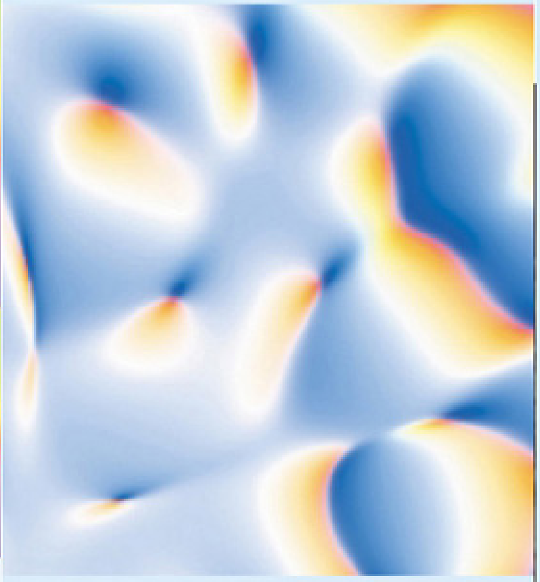
The Art of Physics
Snapshots from recent research

Colours of dark light

If the pattern of *Random phases* is created in white light, the constituent colours are separated, because the way that waves add or subtract depends on their wavelengths. The separation is greatest in the dark regions, so the colours are dim and indistinct. But if the wave is digitally scaled so the intensity is the same everywhere, as in this picture, a surprising pattern of colours is revealed in miniature in each of the dark places: red fading into yellow, separated from blue by a white stripe. This 'chromascopic' prediction is being tested by experiment. ■



"Many incompletely understood phenomena lurk in the borderlands between physical theories – between classical and quantum, between rays and waves. These borderlands – the domain of physical asymptotics – are my intellectual habitat, with an emphasis on geometrical aspects of waves and chaos."

Michael Berry

The Art of Physics
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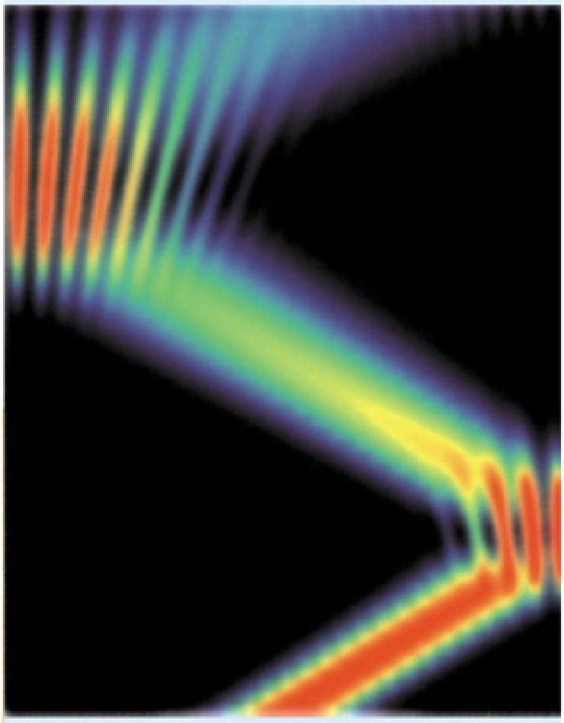
Knotted nothings

This trefoil knot, and the twisted chain threading it, are lines where the probability of finding an electron in a hydrogen atom is zero. In this unusual computer-generated representation of a complicated quantum wave, the zero-lines form a 'skeleton' of the pattern - like the grin of the Cheshire cat in Wonderland. Knotted zeros in waves - in light as well as quantum physics - were discovered recently as a mathematical phenomenon, and are being explored experimentally. ■

For a gallery of Berry's images see www.phy.bris.ac.uk/research/theory/Berry/gallery.html

Bouncing and spreading

Graph of a wave representing a quantum particle bouncing between two walls. The walls are at the left and right sides of the picture, and time increases upwards. Intensity (probability of finding the particle) is colour-coded, with red brightest and black zero. Initially the wave is localised and moving to the right. It hits the wall and interferes with its reflection. The wave then moves to the left and spreads before it gets reflected at the left wall and interferes again. Irene Marzoli and I generated this wave by computer, from the Schrödinger equation of quantum mechanics. ■



Bouncing and spreading won third prize in the 2002 Novartis/Daily Telegraph 'Visions of Science' competition in the 'Science Concepts' category.

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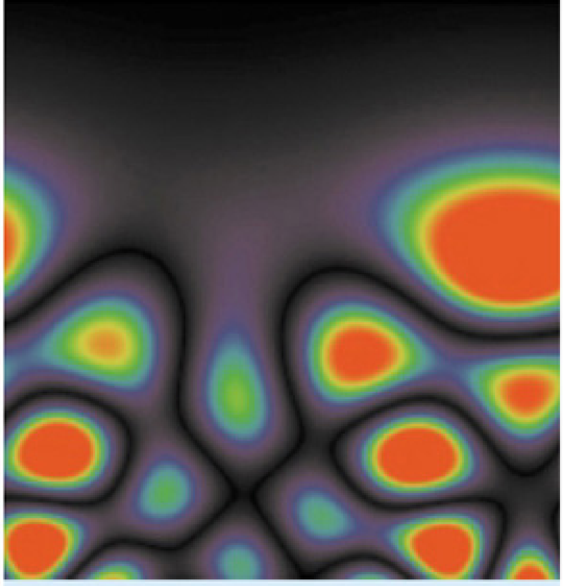

Chaotic quantum falling

Neutrons, all initially travelling at the same speed, are thrown upwards in random directions and then fall under gravity. The wave shown here represents these quantum particles, and its strength gives the probability of finding one. Red indicates the brightest places in the wave, and the black snakes are the zero lines where the particle will never be found.
In classical physics, the particles would never get above a certain height (here about two-thirds up the picture); in quantum physics, the waves occasionally penetrate this 'classical boundary' and reach greater heights. The study of patterns like this is part of an international research effort in 'quantum chaology'. ■

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