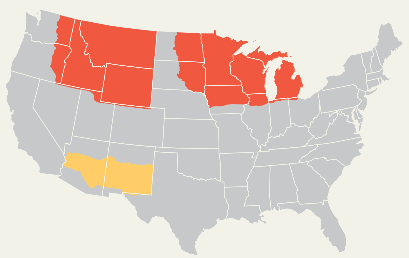
WOLF PACK

By October 2012, grey wolf populations in six US states had recovered such that they no longer needed protecting by the Endangered Species Act.



SOURCE: US FISH AND WILDLIFE SERVICE

▶ levels of gene flow and diversity. In 2005, he and his colleagues analysed mitochondrial DNA from specimens collected before wolves were decimated in the 1900s, and found that it contained twice as many variations as DNA from modern wolves (J. A. Leonard *et al. Mol. Ecol.* **14,** 9–17; 2005). The researchers estimated that the wolf populations in Mexico and the western United States had once reached 380,000 individuals. "Wolves have not recovered over a large part of their range," Wayne says.

But Gary Frazer, assistant director for endangered species at the FWS in Arlington, Virginia, says that the service exceeded its own minimum targets for wolf recovery as early as 2001, and thus it is a case of mission accomplished. "That was the plan from the beginning: to declare recovery, to delist the species, and to move on to other species that need our attention," he says, noting that the agency's resources are limited.

Wolves might occupy only a fraction of their historic range, but they are not in danger of extinction, adds Mark Boyce, a biologist at the University of Alberta in Edmonton, Canada. "We have 6,000 wolves in Alberta alone," he says. "Except for Mexican wolves, the populations in the lower 48 states add nothing to the genetic diversity of the species." Boyce believes that any expansion of the wolves' range would be costly for ranchers. In 2011, he co-authored a study that tracked wolves using the Global Positioning System, showing that each wolf pack in southwestern Alberta killed an average of 17 cattle every year (A. T. Morehouse and M. S. Boyce *Front. Ecol. Environ.* **9,** 440–445; 2011).

The wolf controversy highlights the strained relationship between science and politics. Vucetich and Wayne, along with Roland Kays of the North Carolina Museum of Natural Sciences in Raleigh, were, they claim, dropped in August from a panel to review the FWS proposal because they had publicly opposed the wolf's delisting. "I'm not mad about not being on the panel, but it doesn't seem like they were following proper procedure," Wayne says. "It was punitive," he claims.

The review process has since been restarted. "We still haven't figured out how to handle a situation where experts have outspoken views," Frazer says. "We are not an academic institution. We're trying to implement federal law." The public consultation period will close in October, but because the panel's peer review will not be complete by then, Frazer plans to reopen public comments in January 2014. "People are very passionate about wolves," he says. The final decision may take a year or more.

The future of US wolves will hinge mainly on public acceptance of their delisting. Groups such as Defenders of Wildlife in Washington DC protest against wolf hunting, whereas those affiliated with hunters and ranchers want wolves to be aggressively controlled. Some individuals have made death threats to ranchers who legally shot wolves that attacked livestock.

Vucetich thinks that the government is eager to pass the issue on to the states. "It saps the energy of people working on it," he says. ■

MATHEMATICS

Physicists net fractal butterfly

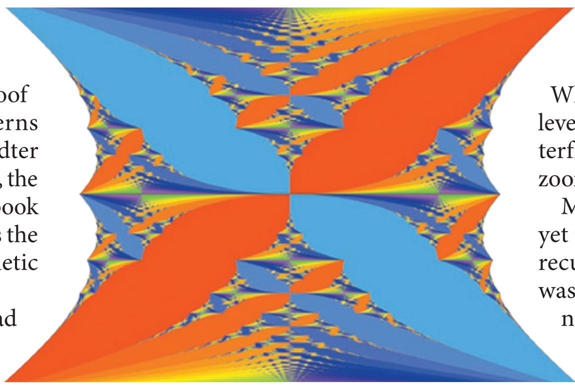
Decades-old search closes in on recursive pattern that describes electron behaviour.

BY DEVIN POWELL

After a nearly 40-year chase, physicists have found experimental proof for one of the first fractal patterns known to quantum physics: the Hofstadter butterfly. Named after Douglas Hofstadter, the Pulitzer prizewinning author of the 1979 book *Gödel, Escher, Bach*, the pattern describes the behaviour of electrons in extreme magnetic fields.

To catch the butterfly, scientists have had to fashion innovative nets. Since May, several groups have published experiments that sought the pattern using hexagonal lattices of atoms; last month, others reported seeking it with atomic laser traps. Some physicists say that studying the pattern could help in the development of materials with exotic electric properties. But the main point of the chase was to check whether the butterfly looks as predicted.

"Hofstadter's concept was initially disturbing to a lot of people," says Cory Dean, an experimental physicist at the City College of New York. "Now we can say his proposal wasn't so crazy after all."



DOUGLAS HOFSTADTER

Hofstadter's butterfly describes electron motion.

Hofstadter, now a cognitive scientist at Indiana University Bloomington, sketched out the pattern in the 1970s while a graduate student in physics. It was known at the time that electrons under the influence of a magnetic field would race around in circles. But Hofstadter found that in theory, if the electrons were confined inside a crystalline atomic lattice, their motion would become complicated.

As the magnetic field was cranked up, the energy levels that define the motion of electrons would split again and again. When represented on a graph, those energy levels revealed a pattern that looked like a butterfly — and continued to do so, even when zoomed in to infinitely small scales.

Mathematician Benoit Mandelbrot had yet to popularize the term 'fractal' for such recursive patterns, and Hofstadter's adviser was unimpressed. "He scornfully called the nesting pattern that this upstart youngster claimed to see, 'mere numerology'," says Hofstadter. "He even told me that I would be unable to get a PhD for this kind of work." Hofstadter published[1] his description of the butterfly in 1976, after finishing his PhD.

The idea was difficult to test. The strength of the required magnetic field depends on the spacing between the atoms in the lattice. In conventional materials, in which atoms are separated by less than one-billionth of a metre, the pattern can emerge only in fields on the order of tens of thousands of tesla. The best available magnets can reach only about

100 tesla, and for just a fraction of a second.

But smaller fields are sufficient in lattices with larger spacings, which can be created by layering materials in stacks. In May, researchers reported[2] that they had stacked a single sheet of graphene, in which carbon atoms are arranged like a honeycomb, on top of a sheet of honeycombed boron nitride. The layers create a repeating pattern that provides a larger target for magnetic fields than the hexagons in each material — effectively magnifying the field.

After applying a field, the researchers measured discrete changes in the conductivity of the composite material — stepwise jumps that result from splits in the energy levels of its electrons. These were not a direct detection of the expected electron behaviour, but were a proxy for it. Hofstadter's butterfly had not quite flown into the net, but it had revealed its existence. "We found a cocoon," says Pablo Jarillo-Herrero, an experimental physicist at the Massachusetts Institute of Technology (MIT) in Cambridge. "No one doubts that there's a butterfly inside."

Nobel laureate Wolfgang Ketterle, another physicist at MIT, is going after the butterfly in a different way: by making atoms act like electrons. To do this, he chills rubidium atoms to a few billionths of a degree above absolute zero, and uses lasers to trap them in a lattice with egg-carton-like pockets.

When zapped by an extra pair of crisscrossed lasers, the atoms tunnel from one pocket to another. Tilting the grid allows gravity to guide the atoms into paths that mimic the circular motions of an electron in a magnetic field — although no actual magnetic fields are involved. The system can easily track the motion of individual atoms, and should be able to mimic a magnetic field strong enough to produce a Hofstadter's butterfly. "Cold atoms will give us an enormous freedom," says Ketterle, whose team posted its study on the preprint server arXiv last month[3]. But the set-up has a liability: the lasers tend to heat the cold atoms, limiting the ability to control the energies of the particles and reveal the fractal pattern.

Still, if the heat can be handled and the butterfly simulated, this system could be a starting point for exploring quantum behaviours in solids, such as materials that can conduct electricity on the surface but are insulators at the core. Dieter Jaksch, a physicist at the University of Oxford, UK, says, "I expect that a wealth of new phenomena and insights will be found when exploring the butterfly." ■

1. Hofstadter, D. R. *Phys. Rev. B* **14,** 2239–2249 (1976).
2. Hunt, B. *et al. Science* **340,** 1427–1430 (2013).
3. Miyake, H., Siviloglou, G. A., Kennedy, C. J., Burton, W. C. & Ketterle, W. Preprint at http://arxiv.org/abs/1308.1431 (2013).

ENVIRONMENTAL SCIENCES

Hackles rise over privatization plan

UK Natural Environment Research Council proposes to cut four institutes loose, but scientists fear for long-term data.

BY DANIEL CRESSEY

The UK Natural Environment Research Council (NERC) is in a quandary. The government body, which channels money to environmental scientists, has for weeks been soliciting evidence on whether it should hand funding control of four of its five key research institutes to the private sector. The move is meant in part to decrease the institutes' reliance on waning government funds, but leading scientists have now gone public with their concerns that it could jeopardize research and data of crucial importance to environmental science in the United Kingdom and around the world.

At stake are the futures of the National Oceanography Centre, the British Geological Survey, the Centre for Ecology and Hydrology and the National Centre for Atmospheric Science. (The British Antarctic Survey, which NERC also runs, is not affected.) As well as conducting research on a variety of environmental topics, all four are closely linked to specialist centres that collect long-term data, such as the British Oceanographic Data Centre, hosted by the National Oceanography Centre in Liverpool. In total, the institutes have a budget of about £400 million (US$628 million).

"We need safeguards for these unique assets and long-term, large-scale perspectives."

"The NERC centres uniquely provide long-term consistent data, and make them freely available for the benefit of ecological science and to improve our understanding of the natural world," says William Sutherland, president of the British Ecological Society in London. "These data include studies that are undertaken over the course of decades, protected from changes in fashion or the fluctuations of short-term demands. Any change in ownership of the centres must preserve this."

Helen Snaith, a remote-sensing researcher at the National Oceanography Centre in Southampton and a trade-union representative, notes that advice that the centres provide to the government could be compromised if they start generating significant income from private sources. "There's the potential for a very clear perceived conflict of interest," she says. She also worries that the roughly 1,750 members of staff at the four centres, about two-thirds of whom are researchers, could get a worse deal on pay and benefits under private ownership.

Duncan Wingham, NERC's chief executive, stresses that no decision has yet been taken. If the centres are moved out of the public sector, he says, it would not necessarily mean that they become profit-making. They could, for example, become part of universities. He has also emphasized that the decision on the centres' futures will not consider cost savings, which most interested parties concede.

There may also be advantages, adds Wingham — notably that freeing the institutes of public-sector constraints on pay and promotion, and from reliance on government funding, could give them better flexibility to respond to new opportunities.

Steve Ormerod, an ecologist at Cardiff University and chairman of the Royal Society for the Protection of Birds, acknowledges this. He sees advantages if the Centre for Ecology and Hydrology can develop partnerships on its own terms with international agencies and businesses, and says that being independent might allow the centre to win more funding and attract more researchers.

But there are risks, he says. "We need safeguards for these unique assets, skills and long-term, large-scale perspectives that have always provided crucial support for impartial, highly rigorous, evidence-based advice."

NERC's call for evidence on the proposal closed at the end of August, and submissions are being reviewed. The NERC board will decide on the institutes' futures in December. If the research council does choose to divest itself of these centres, the decision would represent almost the end of an era for government-controlled science in the United Kingdom. According to its 2011–12 report, the UK Biotechnology and Biological Sciences Research Council has made arrangements to "remove [its] ability to exert control" over some of its institutes; and the Medical Research Council is transferring some of its in-house units to universities. ■