Abstractions

FIRST AUTHOR

Some semiconductors and mobile-phone amplifiers include components known as two-dimensional electron systems (2DES). To design such devices, the first, fundamental piece of information you need is the energy spectrum of the system. This gives an indication of how much current flows for a given applied voltage. But the energy spectrum of a 2DES also contains much more subtle information and can reveal unusual quantum effects. Previously, such detailed information could be obtained only from theoretically calculated spectra, as the available experimental techniques generated heat and blurred the results. Now, Oliver Dial at the Massachusetts Institute of Technology and his colleagues have developed a method that can directly measure this spectrum at high resolution (see page 176).

How is this different from previous work?

The ocean makes a good analogy. Until now, researchers looked only at how ripples — system disturbances — affected the ocean's surface, or the lowest energy states available. Now, we can look at how many energy states are available at any place in the ocean — we can see the mountains and valleys on the ocean floor. In other words, the high energy states as well as the low. We get an information-rich spectrum, with peaks that tell us at what energy a particle can be put into the system and how long it can stay at that energy.

How does your method work?

It's difficult to look at the high-energy spectrum of a 2DES without it heating up. Among the challenges, we had to figure out how to inject electrons at energies of 100 kelvin, while keeping the experiment temperature at 100 millikelvin. Most researchers in this field want to do in-plane electron-transport measurements in 2DES. If you imagine an electron system as a flat sheet of paper, this involves adding electrons at one end and taking them out of the other, but this generates heat. Instead, we're pushing electrons into the middle of the sheet of the paper from above or below, with electrodes above and below to drive the current.

What was your most surprising finding?

One of the basic questions to ask in 2DES is 'How do the electrons get along together?'. One way to learn about this is to know what happens to an added electron. We might think that an extra electron would be bumped by the ones already there and wouldn't stay at the energy at which it was injected for very long. Remarkably, such electrons are quite stable. As a result, even though this is a complicated system, we can think about the extra electron as if it were alone. ■

MAKING THE PAPER

Andy Hector

Calculating how much biodiversity makes an ecosystem churn.

The idea that biodiversity is linked to how well ecosystems function can be traced back to Charles Darwin. However, serious experimental testing of this concept didn't begin until the early 1990s. One of the most important studies was the BIODEPTH project, which tested plant-species biodiversity and ecosystem properties in test plots at eight grassland sites around Europe. This generated a vast amount of data, and Andy Hector, who worked on the project, has now figured out a way to pull it all together.

BIODEPTH spanned three years and tested how different numbers of plant species affect ecosystem functions, such as total hay production or how well the ecosystem retains certain nutrients. The data produced were standardized and each ecosystem function or process analysed, but only on an individual basis.

Hector, now an ecologist at the University of Zurich in Switzerland, wanted to know how important biodiversity's role is when all of these processes are put together. After much thought, he came up with a way to do this — by switching from conventional statistical theory that relies on probability to information theory. This approach allowed all possible combinations of species to be compared and a best set of species to be selected for each ecosystem process.

At this point, Hector recruited his colleague Robert Bagchi, now at the University of Oxford, UK. "He brought the maths to formalize our basic ideas of analysis and the programming skills to implement it," says Hector. The two used the Akaike Information Criteria (AIC) to calculate the set of species that influenced each of seven ecosystem processes at each site. Simply put, the AIC balances explanatory power and simplicity to find the best model.

Hector and Bagchi then determined the overlap between pairs of ecosystem processes for all possible pair combinations. The average overlap varied from 0.2 to 0.5, meaning that in any given pair only one-fifth to one-half of the species were important to both ecosystem functions. They conclude that individual analyses of ecosystem functions underestimate the biodiversity required to keep multifunctional ecosystems healthy (see page 188).

"So far, all the work on ecosystem functions has broken them apart individually," says Hector. "We are the first to do a serious, quantitative analysis of multiple functions of ecosystems." He admits their analysis has limitations, but says it's reasonable to expect that the findings for these test plots will extend to real-world ecosystems, typically valued for their multiple functions.

Although 'the more biodiversity the better' seems obvious for ecosystem functioning, Hector says scientists have been working on these questions for only a decade and are still arguing about how to analyse the data. He hopes to apply his scientific findings to real-world problems, such as reforestation. In this example, the choice of which species or mix of species to plant would involve looking at factors including total overall production (for future logging) and carbon sequestration.

The study also refutes the old adage that biologists shy away from mathematical heavy-lifting. "The mathematics of ecology may not be as elegant as that of other disciplines, but it is often very, very complex," says Hector. "You need people who can work with partial differential equations who can also climb up a 70-metre rainforest tree to collect pollen." ■

FROM THE BLOGOSPHERE

Nature Network (http://network.nature.com) featured in *Guardian Unlimited* last week (http://tinyurl.com/2haapa). "Welcome to Facebook for professors, postdocs and PhDers in the sciences — otherwise known as Nature Network," states the article.

Although *Guardian* reporter Jessica Shepherd can't resist leading with the network's more imaginative possibilities, notably romantic ones, the article sums up the service nicely, including this quote from Matt Brown, editor of Nature Network London: "Traditionally scientists have met, collaborated and swapped ideas through conferences and the pages of scholarly journals. These can be time consuming and rely to some extent on serendipity. Our vision for Nature Network is that every scientist in the world will have a personal profile on the site. Who knows, many years from now, traditional activities such as writing an academic paper could be peer-reviewed online."

You can join Nature Network to blog, meet and discuss online for free. We hope you will try it out, as a hub for collaboration, to help your career prospects, or even to find a partner. ■

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