Abstractions

FIRST AUTHOR

Schrödinger's cat is a famous example of the apparent contradictions inherent in quantum mechanics. In this 'thought experiment', a cat shut in a box stands a 50% chance of being poisoned, and so is deemed to be both dead and alive until the box is opened and the actual state of the cat is observed. This 'superposition' of two extremes — dead and alive — for the unobserved cat is a state that experimentalists have strived to create using quantum particles. Such entangled particles could be used in information processing.

On page 639, researchers at the US National Institute of Standards and Technology (NIST) in Boulder, Colorado, reveal a 'cat state' created from six atoms. And on page 643, Hartmut Häffner and his colleagues at the Institute for Quantum Optics and Quantum Information in Innsbruck, Austria, reveal a similar entangled state involving eight particles. Dietrich Leibfried, a physicist in the NIST group, talks to *Nature* about these results.

Entangled states have previously been achieved, although with fewer atoms. What is the significance of doing it with more?

The previous 'record' was five photons. But not every run of the experiment produced the desired state — a very large number of failed tries accompanied each successful creation. Also, the process destroyed the result; once you knew you had the correct state it was already gone. With the methods described in this week's papers, you can produce the state on demand, each time the experiment is run.

What is the difference between your approach and that of Häffner?

Both our work and that of Häffner's group is based on manipulating trapped ions with laser light. But there are differences. Our approach is like a conference call where all of the participants communicate with each other at the same time. Häffner uses an approach similar to a phone chain that has to grow in length as the number of participants increases.

What are the implications of these two papers for quantum computing?

Producing cat states is a benchmark for the ability to produce and manipulate fragile quantum states. Such benchmarks can be used to compare the performance of different approaches to practical quantum computing.

Any other implications or applications?

A clock based on a 'cat state' of six atoms would reach the same measurement precision six times faster than a clock using six unentangled atoms. This starts to become significant when you think that atomic clocks are typically measured for months to obtain the highest precision. ■

MAKING THE PAPER

Urs Frey

Statistical analysis provides a fresh perspective on asthma.

Urs Frey, a paediatrician at the University Hospital of Berne in Switzerland, has long been interested in respiratory diseases. In particular, his observations of children with asthma had led him to speculate about the nature of the disease. "Asthma is not just a steady state, it is a dynamic system," says Frey.

On page 667 of this issue, Frey's interest is resolved into research that could help predict both the timing and the severity of asthma attacks.

One of the keys to this work was Frey's collaboration with Béla Suki, a physicist at Boston University. Suki analyses complex nonlinear systems, such as the factors that contribute to avalanches, and wanted to apply his work to biomedical problems. Frey suggested that asthma would be a good place to start. "It is very difficult to understand why little triggers can launch big responses in asthma," Frey says.

Frey suspected that lungs have a 'memory' of previous asthma attacks, which makes asthmatics more susceptible to secondary attacks. So he and Suki analysed data taken over a short period of time that measured the respiratory symptoms of a small group of infants. "Béla began to use his mathematics and my clinical questions," Frey says. "That was an extremely fruitful collaboration."

The results were encouraging and provided some support for Frey's hypothesis, although the data set was too small and covered too short a time span to be conclusive. Frey needed another set of results to analyse, but he didn't know where he could find what he wanted.

By chance, a conversation with Mike Silverman, a paediatrician at the University of Leicester, UK, led him to the ideal data set. About ten years ago, a team in New Zealand had examined the lung function of 80 asthmatics over three periods of six months, measuring their lung function twice a day. This was perfect for Frey and Suki, as they could analyse fluctuations in the lung function of individuals to see how these variations related to the onset and severity of asthma attacks.

What they saw was a form of long-range correlation between current lung function and the state of lung function days, weeks and even a month previously. Based on this, Suki managed to create an algorithm to calculate the risk of the next attack — an achievement that Frey describes as "a weather forecast for asthmatics".

But the results go beyond prediction; they also shed some light on how the disease is treated. Short-acting bronchodilators are used to give quick relief from the symptoms of asthma. In some cases, they are also prescribed to be used four times a day, but are not used during the night. Frey and Suki found that this regular treatment affects the internal regulation of lung function, making the asthma less stable and harder to predict.

Frey suspects that other chronic diseases could benefit from similar algorithms — blood sugar levels could be tracked in diabetics, for instance. "If you know the internal dynamics of a chronic disease system you can use mathematical concepts from game theory to predict attacks," says Frey.

On top of that, Frey believes this fresh view of disease could have broader implications. "Considering a chronic disease as a dynamic process could also dramatically change how drug efficacy studies are done in the future," he says. ■

QUANTIFIED **AUSTRIA**

A numerical perspective on *Nature* authors.

Quantum computation is very much a team effort at the Institute for Quantum Optics and Quantum Information (IQOQI) and the University of Innsbruck in Austria. Everyone in the Austrian group shares responsibility at each stage — from setting up experiments to analysing results, says the institute's Hartmut Häffner.

Häffner's group also tries to involve other researchers. He says that discussions at conferences often lead to new ideas or experiments. And with the creation of the IQOQI two years ago, which brought together groups of experimental and theoretical physicists, stronger collaborations have grown within Innsbruck itself, Häffner adds. The fruits of one such partnership, looking at entangled quantum particles, are presented on page 643.

14 authors working in Innsbruck report on entangled quantum particles in this week's *Nature*.

13 papers with contributing authors working in Austria have been published in *Nature* in 2005 (793 papers have been published in total).

9% is the acceptance rate for papers submitted to *Nature* from Austria in the course of 2005.

11 Austrian institutes host authors of research published in *Nature* during 2005.