Wang points out, culling is simply not practical when it comes to bats, which can just fly away. Satellite collars on fruit bats carrying Nipah showed they could fly between Thailand, Sumatra and Malaysia, and the horseshoe bats linked with SARS range across Asia, Europe and Australia.

Preventing future emergences may instead focus on human behavior. Just as SARS is potentially linked to animal markets, so was Nipah linked to pigpens encroaching on bat habitats. And people living in Ebola-endemic areas eat the bats harboring the virus. Knowledge that bats can carry dangerous viruses could work to prevent epidemics, notes Peter Daszak, executive director of the New York City–based Consortium for Conservation Medicine, which studies the connection between emerging diseases and human interactions with the environment. Keeping bats from the wildlife trade might have dramatically cut the risk of SARS emerging, perhaps saving $50 billion worldwide in loss to travel, trade and health care costs "and hundreds of lives," Daszak says.

Charles Q. Choi is a frequent contributor.

PHYSICS

Ion Power

ATOMIC IONS PROVE THEIR QUANTUM VERSATILITY **BY GRAHAM P. COLLINS**

In their quest to build a computer that would take advantage of the weirdness of quantum mechanics, physicists are pursuing a number of disparate technologies, including superconducting devices, photon-based systems, quantum dots, spintronics and nuclear magnetic resonance of molecules. In recent months, however, teams working with trapped atomic ions have demonstrated several landmark feats that the other approaches will be hard-pressed to match.

A quantum computer operates on quantum bits, or qubits, instead of ordinary bits. A qubit can be not just 0 or 1 but also a superposition of the two, in which proportions of zero-ness and one-ness are combined in a single state.

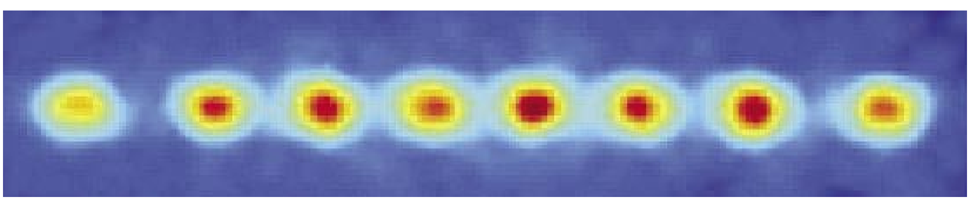
An important class of multiqubit superpositions are entangled states. In these configurations, the state of each qubit is linked in a subtle way to the state of its companions, a linkage that Albert Einstein disparaged as "spooky action at a distance." For example, in a so-called Schrödinger cat state, all the qubits will give the same result—0 or 1—on being measured, even though the choice between 0 and 1 is totally random. (The name comes from the famous thought experiment in which 0 and 1 correspond to the cat being dead or alive and the individual "qubits" are all the particles in the cat's body.)

Cat states are a fundamental building block of techniques for correcting errors in qubits. Such errors inevitably plague all the standard approaches to quantum computation, because states of qubits are exceedingly fragile.

Researchers at the National Institute of Standards and Technology in Boulder, Colo., led by David J. Wineland and Dietrich Leibfried, have now created cat states involving four, five and six beryllium ions.

NEED TO KNOW: SCALING UP

Experiments with atomic ions involve custom-built, bulky electromagnetic traps to confine the ions in a vacuum. Though fine for experiments with a small number of ions, they are utterly impractical for the large-scale system that a quantum computer would need to be of any significant use. Now University of Michigan at Ann Arbor researchers Christopher Monroe, Daniel Stick and their co-workers have demonstrated a 100-micron-size ion trap on a semiconductor chip. They used their chip to trap a single cadmium ion and move it to different locations in the trap by applying electrical signals to electrodes. The trap was built using standard lithography techniques, so, Monroe says, it could be scaled up to include hundreds of thousands of electrodes using existing technology.



HARTMUT HAEFFNER *University of Innsbruck*

ENTANGLED: Eight calcium ions held together in a trap are in a special quantum condition known as a W entangled state, in which their properties are subtly correlated. Such states are of use for error-correction schemes in quantum computers. Entangled states become harder to create and maintain as the number of particles increases.

An electromagnetic trap holds the ions in a row in a vacuum, and lasers manipulate their states. The team estimates that their six-ion cat states last for approximately 150 microseconds.

In Austria, Rainer Blatt and Hartmut Haeffner of the University of Innsbruck and their colleagues relied on a similar technique to produce an entangled state of eight calcium ions. In this experiment a "W state" was created, not a cat state. A W state is in many ways more robust than a cat state. For example, an ion can be lost from a W state and the remaining ions will still be in a W state. Losing an ion from a cat state spoils the entire state.

An important feature of both experiments is that in principle the techniques can incorporate larger numbers of ions. An impediment to scaling up these approaches, however, was that the quality of the entangled state decreased as the number of ions increased. To reduce this error, the scientists might adjust the details of the laser pulses, use different states of the ions to represent 0 and 1, or work with a different ion species altogether.

For a quantum computer to be of use, one must not only create special qubit states but also manipulate them in ways that preserve their quantum characteristics. That is, one must run quantum algorithms on the computer. A group at the University of Michigan at Ann Arbor led by Christopher Monroe and Kathy-Anne Brickman has now demonstrated an algorithm known as Grover's quantum search on a system of two trapped cadmium ions.

The search algorithm rummages through a database with entries in random order. Searching for a particular item would usually demand the examination of every entry. The quantum search algorithm is magically faster because the quantum computer can poll all the database entries at once in a superposition. The speedup becomes more dramatic for larger databases. For example, a million-entry database would take only about 1,000 quantum lookups instead of the full million.

The Ann Arbor experiment operated on the equivalent of a four-entry database, the four entries being represented by two qubits. The researchers say that their system can be scaled up to larger numbers of qubits.

With results coming so thick and fast, it is no wonder that, as Monroe says, "many feel that ion traps are well ahead of other technology in the quest to build a large-scale quantum computer."