Earth's, so most researchers aren't yet ready to embrace martian plate tectonics. "You wouldn't say this is a dead ringer for the sea floor," notes paleomagnetist Robert Coe of the University of California, Santa Cruz. The martian stripes are 10 times wider than Earth's, implying faster spreading, slower magnetic field reversals, or both; they are also far less regular in shape and spacing; and the symmetrical pattern of stripes on either side of a spreading center, the clincher in the plate tectonics debate, is not yet apparent. Indeed, there's no sign of a "spreading center" at all. Says Merrill: "If plate tectonics was operating on Mars, it worked differently or it was recorded differently by the rocks."

Another sign of that difference is the "staggering" intensity of the recorded magnetism, says Merrill. To achieve it, Connerney calculates that each martian plate would have to be 30 kilometers thick, assuming that they were uniformly magnetized as intensely as the uppermost few hundred meters of Earth's ocean crust. "It's hard for me to understand how that could happen on Mars," says geophysicist Sean Solomon of the Carnegie Institution of Washington. On Earth, the upper ocean crust is intensely magnetized because seawater cooled it rapidly, forming tiny, easily magnetized crystals. But cooling a 30-kilometer slab would take tens of millions of years, leading to larger crystals that would be less easily magnetized. This prompts researchers to wonder if perhaps the stripes formed not through creation of new crust but through some other means, such as slow chemical alteration.

"There's so much we don't know," says Solomon. "You have to remember how difficult it was to convince people about seafloor spreading in the 1960s. It'll keep people scratching their heads for quite a while."

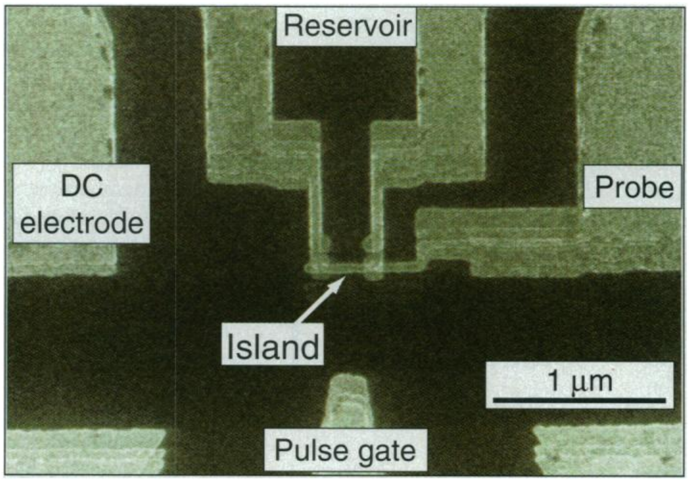
–RICHARD A. KERR

QUANTUM MECHANICS

Quantum Computing Makes Solid Progress

It's no wonder that the prospect of quantum computers gets people excited. If harnessed, the essential fuzziness of the quantum world could allow researchers to breeze in minutes through computations that would take today's supercomputers billions of years to crunch. Although quantum computing researchers have managed to carry out a few simple logic operations in the quantum regime, these typically have relied on ions poised in beams of light or jiggling molecules in a solution. Just getting them to serve as a single quantum circuit element required roomfuls of lasers, magnets, or other control equipment—a far cry from the millions of circuits that can be crammed onto a conventional silicon chip. But now a team of Japanese researchers has turned a simple metal- and silicon-based device into the key component of a quantum computer.

In this week's issue of *Nature*, physicist Yasunobu Nakamura of the NEC Fundamental Research Laboratory in Tsukuba, Japan, and his colleagues describe how they created the first electrically controlled bit of quantum data, or qubit, in an electronic device that in theory could be reproduced manyfold. "It's an extremely significant success," says David Awschalom, a physicist at the University of California, Santa Barbara. "It opens the door to building a solid-state quantum computer that's scalable. In computing, that's the name of the game." Still, Awschalom and others caution that making complex solid-state quantum computers is still many years away, and researchers must first learn how to keep their quantum data from decaying almost the instant they're made. Says Dmitri Averin, a quantum computing expert at the State University of New York, Stony Brook, "It will definitely be a long and difficult challenge."



Data point. A superconducting electron pair oscillates between the island and reservoir, forming an indecisive quantum bit, or qubit.

Even creating a single qubit was no simple task. Like all quantum computing schemes, this one makes use of the superposition principle of quantum mechanics, which states that, until it's measured or observed, a quantum system—such as the magnetic orientation of an atomic nucleus, or the location of an electron—exists as a superposition of all its possible states at once. Unlike the classical bits of data in a computer, which are decidedly either a zero or a one, qubits hover in an indecisive fog somewhere between these two values. When this fuzzy two-state bit is plugged into a logical operation, the computer in essence computes both outcomes simultaneously. Couple together just 300 qubits and a computer would instantly compute all 2^{300} possible outcomes—roughly the same number as there are elemental particles in the universe.

The difficult part, however, is coupling qubits together. Since the mid-1990s, researchers have managed to make qubits from the magnetic spin of atomic nuclei in atoms or molecules and from the polarization of light, but these schemes are hard to miniaturize into working computers. "It's difficult to imagine scaling up an atomic or molecular system" to create the dozens or hundreds of qubits needed for sophisticated quantum computing, says Awschalom. In conventional computers, solid-state components have made it possible to shrink circuit elements to the scale of a few hundred nanometers. But the solid state seemed too unruly for quantum computing, for electrons in solids can have innumerable quantum states that are impossible to tell apart. For a qubit, you need easily distinguishable on-off states.

One class of solids, superconductors, offers a simpler quantum environment, as their electrons all share the same quantum state and travel together in pairs. So the NEC team designed a set of tiny electrical components, made from metals that superconduct at very low temperature, that enabled single electron pairs to jump between a tiny bar-shaped metal island and a nearby metal reservoir. Applying a brief voltage pulse to a control electrode connected to the island creates equivalent energy states for electron pairs on both the island and the reservoir. The result is that the superconducting electron pairs oscillate back and forth between the two locations, representing the one and zero of a digital system. Such a setup does not work in semiconductors, where electrons' oscillations are disrupted by heat, lattice vibrations, and other troublemakers.

In a working quantum computer, researchers would have to find a way for the state of this first qubit to influence the behavior of a second. But for this experiment with just one qubit, the NEC researchers simply read out the electrons' location. To do so, they apply a continuous voltage to a so-called DC electrode. This boosts the energy level of electron pairs on the island, causing them to break their superconducting bond to one another and hop to a nearby

CREDIT: NAKAMURA ET AL.

probe, which then channels them to a detector. "The probe can take two electrons if the [island] contains one extra electron pair, but zero electrons if the [island] doesn't have the electron pair," says Nakamura. "That's why we can distinguish the two electron states."

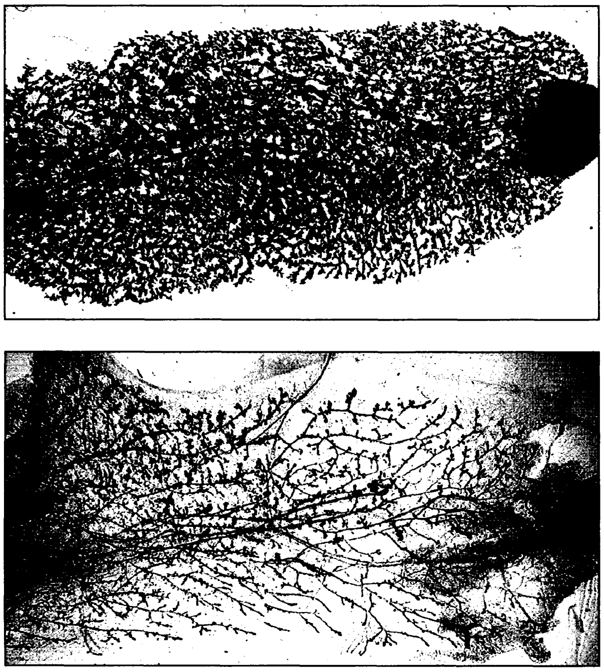
Still, Nakamura acknowledges that this simple demonstration remains far from a useful quantum computer. The main problem is that the paired electrons oscillate back and forth for only about 2 nanoseconds before they are torn apart and siphoned off by the probe electrode. "That's not enough to do any computation," says Nakamura. To be useful, researchers would like their qubits to be stable indefinitely. Efforts around the globe are now likely to focus on that goal, as well as on stringing a number of electronic qubits together to construct the first electrically controlled quantum computer.

–ROBERT F. SERVICE

CANCER RESEARCH

New Model for Hereditary Breast Cancer

Breast cancer strikes about one out of nine Western women in their lifetime and is second only to lung cancer as a cause of cancer deaths in women. For women who have mutations in *BRCA1*, one of two genes linked to the 5% or so of the cases that are hereditary, the disease is even more fearsome. They have a 70% chance of getting it. Now, researchers have an important new clue about how breast cancer develops, at least in these women.



Duct reducer. Mammary tissue from a normal mouse *(top)* shows a dense network of ducts, whereas tissue from a *BRCA1* conditional knockout *(bottom)* has far fewer ducts.

CREDITS: (LEFT PAIR) XU *ET AL.*; (RIGHT) USGS

The clue, in the form of an animal model for the disease, comes from the joint effort of two teams led by Chu-Xia Deng and Lothar Hennighausen at the National Institute of Diabetes and Digestive and Kidney Diseases (NIDDK). In a paper in the May issue of *Nature Genetics*, the researchers report that they have inactivated, or knocked out, the *BRCA1* gene in mice exclusively in the cells where breast cancer normally originates—the epithelial cells lining the milk ducts.

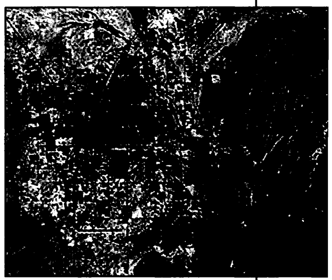
Previous efforts in which genetic tinkers knocked out one or both copies of the gene in all mouse tissues produced disappointing results. Women with *BRCA1* mutations are born with one inactive copy, while the other becomes inactivated later. But the animals with one inactivated copy did not get tumors at all, and those with two inactivated copies from the beginning died before birth. In contrast, the NIDDK team found that their animals do develop breast cancers, starting when they are about 10 months old. "This is quite exciting. Such an animal model is invaluable for understanding the role of *BRCA1* in familial breast cancer," says Andrew Futreal of Duke University Medical Center in Durham, North Carolina, a *BRCA1* co-discoverer.

In keeping with previous work indicating that *BRCA1* is involved in repairing defective genes, Deng, Hennighausen, and their colleagues have found that breast cells lacking an active *BRCA1* gene are prone to accumulating additional defects—most prominently the loss of the *p53* tumor suppressor gene—that might be crucial contributors to cancer development. What's more, Futreal says, the new animals could prove useful in evaluating new treatments or chemopreventive drugs that might delay or even block the onset of breast tumors.

To knock out the gene specifically in breast tissue, Deng and Hennighausen engineered a so-called conditional mutant mouse strain. They first created mice with a genetic tag, called a loxP sequence, at two different spots within the *BRCA1* gene. Then the team crossed the loxP mice with another transgenic strain carrying the gene for a molecular scissors, an enzyme called Cre recombinase. To make sure that the *Cre* gene is active only in the mammary epithelial cells, the researchers combined it with the regulatory DNA elements of a milk protein produced only in this tissue. The Cre recombinase recognizes the

ScienceScope

Earth to NASA Researchers continue to have concerns about NASA's blueprint for a new generation of Earth-observing missions. Echoing earlier reviews, a National Research Council (NRC) panel last week said that although the space agency is on the right track with plans to launch a new group of smaller, cheaper, and more sophisticated probes starting in 2003, NASA still needs a science strategy to make sure it gets the most out of its orbiting fleet, which will monitor everything from land uses (right) to ocean temperatures.



The NRC group, led by atmospheric scientist Marvin Geller of the State University of New York, Stony Brook, also warned the agency against relying on a proposed polar orbiting satellite system to collect long-term climate data after an array of current instruments expire early next decade. "There is skepticism about putting all the eggs in that basket," says one academic. NASA earth science chief Ghassem Asrar was unavailable for comment, but one colleague predicts he "will be able to live with these recommendations."

New Blood Infusion Europe's top fusion research center is getting a change in leadership. After 18 years at the helm, Klaus Pinkau will step down on 1 May as scientific director of the Max Planck Institute for Plasma Physics in Garching and Greifswald, Germany. The new boss will be Alexander Bradshaw, director of the Fritz Haber Institute in Berlin and president of the German Physical Society.

Bradshaw, a chemist who switched to synchrotron studies of matter, inherits one of the continent's most active fusion programs. It is the European headquarters for the International Thermonuclear Experimental Reactor (ITER) project and is building Wendelstein 7-X, an experimental reactor, in Greifswald.

Pinkau—who will stay on as an ITER adviser through the end of the year—will be a hard act to follow, says Martin Keilhacker, director of the Joint European Torus in Abingdon, Britain. But he says Bradshaw is "a very good scientist and administrator."

Contributors: Eliot Marshall, David Malakoff, Alexander Hellemans