much of the town, combining with rain to collapse many roofs.

The United Nations' Department of Humanitarian Affairs says that the eruption displaced 45,000 people, but it has received no reports of casualties.

Geoscientists say the work of the researchers and civil defense officials at Rabaul averted untold fatalities. "The town is pretty much nestled inside a caldera — inside a volcano. This time, they managed to get everyone out before the eruption," says James J. Mori of the U.S. Geological Survey in Pasadena, Calif. From 1984 to 1988, Mori worked as a seismologist at the Rabaul observatory.

Rabaul is one of several active calderas — including Long Valley, Calif., and Yellowstone National Park — that have concerned volcanologists during the last decade. Because scientists have never witnessed such a large eruption, they remain unsure of how one starts. They suspect that several spots on the outside of the old caldera might become active, releasing magma around the entire rim of the crater. After such an outflow, the center of the volcano collapses to form a new caldera.

Scientists have worried about Rabaul because it seemed to fit this pattern of widespread unrest. Vulcan and Tavurvur both erupted strongly in 1937. In the 1970s and 1980s, the caldera produced significant quakes and other ominous signs, leading officials to draw up evacuation plans and prepare the populace.

"The eruptions in 1937 and this intense period of unrest starting in 1971 made people worry that the next event could unzipper the ring fracture and lead to a caldera-forming eruption," says volcanologist Daniel Dzurisin of the USGS' Cascades Volcano Observatory in Vancouver, Wash.

Instead, the current events seem a repeat of 1937. The blasts have weakened this week, but a USGS team is en route to set up monitoring devices in case the activity renews.

Satellite measurements indicate that the Rabaul eruption equals the 1980 Mount St. Helens blast in scale but has released far less climate-altering sulfur dioxide than the 1991 explosion of Mt. Pinatubo did. *— R. Monastersky*

Cold nuclei, magnetic order, and hot spins

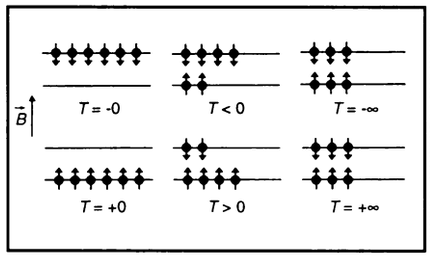
Striving for a new low in solid-state physics, researchers have chilled the nuclei of rhodium atoms to a temperature of 280 picokelvins (pK), just barely above absolute zero. These experiments have also produced negative temperatures as "high" as -750 pK.

The results stem from a long-standing research effort by Pertti J. Hakonen, Olli V. Lounasmaa, and their coworkers at the Helsinki University of Technology in Finland. Their goal is to study interactions between the spinning nuclei of metal atoms to glean insights into the nature of magnetism. Because these spin interactions are extremely weak, the experiments must be done at very low temperatures.

"Nuclear spins in metals provide good models to investigate magnetism," Hakonen and Lounasmaa report in the Sept. 23 SCIENCE.

Ordinarily, temperature (measured in kelvins) describes the average energy associated with either the motion of free particles, such as electrons, in a material or the vibration of particles bound to certain sites in the material. In a metal at ultralow temperatures, however, the spinning nuclei and the free electrons may coexist at different temperatures. Hakonen and his colleagues focus on the spin behavior of atomic nuclei, particularly silver and rhodium.

When placed in a magnetic field at temperatures below 1 microkelvin, these nuclei organize themselves so that their spins tend to line up in the same direction as the magnetic field (see diagram). As the temperature gets closer to absolute zero, the number of misaligned nuclear spins decreases. Spins that are initially oriented in the opposite direction of the magnetic field flip over to a parallel orientation, which has a lower energy.



Hakonen and Lounasmaa/SCIENCE

Energy-level diagram of silver (or rhodium) nuclei showing spin orientation in a constant magnetic field for positive (lower row) and negative (upper row) temperatures.

By suddenly reversing the magnetic field, the researchers can create a situation in which nearly all of the nuclear spins are oriented in the opposite direction, or antiparallel to the magnetic field. Because more nuclei are in the high-energy state than in the low-energy state, the nuclei are said to have a negative spin temperature.

In this case, achieving even lower negative temperatures means adding energy to flip more spins into the higher-energy, antiparallel state. Thus, negative temperatures are actually "hotter" than positive ones, the researchers say. Similarly, a temperature of -750 pK is, technically speaking, warmer than one of -800 pK. *— I. Peterson*

Cesium atoms for optical computers

The task of computing largely involves comparing pieces of information.

A typical personal computer will size up small bits of data, matching one against another. Usually, it does so in series, one bit at a time. Even parallel computers, which run many processors simultaneously, ultimately fall back on step-by-step analysis.

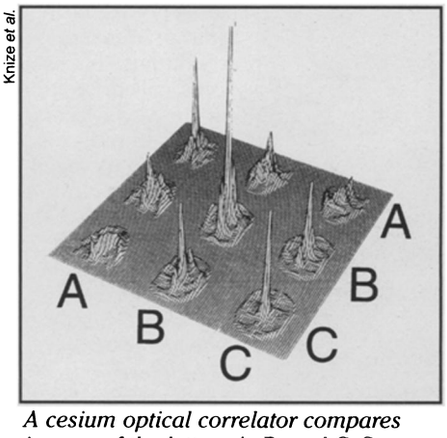
The ability to compare, say, a million pieces of information in one deft stroke would therefore offer tremendous computational advantages. Optical computers, which rely on transmissions of light rather than electricity to perform calculations, might provide such benefits. To date, though, no good material for making the machinery to handle optical comparisons has been found.

Seeking to supply this missing link, Randall J. Knize, a physicist at the University of Southern California in Los Angeles, and his colleagues describe fabricating an optical correlator, a device that uses a vapor of cesium atoms to compare images. They report their work in the Sept. 22 NATURE.

"Optical computing aims to take advantage of the massive parallelism of light," says Knize. "If you expand a laser beam so that it can carry a million pieces of information, then process all of that information at the same time, you could make massively parallel computations in a way that isn't possible with ordinary electronic computers."

"This optical correlator offers a way to process information by comparing two images to see if they are similar," he says. Two laser beams carrying information about two images pass through a glass cell containing a cesium vapor. The cesium cell senses similarities and differences, then emits a third signal that reveals where the two images do and do not overlap.

"We chose cesium vapor because of its enormous sensitivity, which is much



Knize et al.

A cesium optical correlator compares images of the letters A, B, and C. Same-letter matches yield tall spikes.

greater than that of most semiconductors," says Knize. "It's also very nonlinear optically, meaning that it emits much more light than it receives. And it reacts strongly with the particular wavelengths of light that our diode laser emits."

Knize stresses the importance of nonlinear optical materials in computing. "With linear optics, where you get out the same amount of light that you put in, you can't do very much that's useful. You need a material that will give out more than just the sum of the two laser beams going in. They must interact [to] create new information."

To test their new system, the researchers had the optical correlator compare minuscule images of the first three letters of the alphabet, each letter only 230 micrometers high and printed with lines only 35 μm thick. The comparisons took only 30 nanoseconds. "The combination of its low-power operation and its fast response makes cesium vapor a candidate for the most sensitive material demonstrated in a correlator to date," they conclude.

The scientists believe this sort of device could eventually improve computerized vision systems, which rely on quick and subtle pattern recognition. For instance, a security system might need rapid fingerprint comparisons. Or a pharmaceutical company might benefit from a quick inspection of pills on an assembly line.

Next, Knize and his colleagues plan to compare moving images, perhaps at 1,000 frames per second, fed to the correlator by a video system. This will allow them to explore image analysis "in real time," says Knize. — *R. Lipkin*

Exercising reduces breast cancer risk

Women who exercise 3 or more hours a week in the decade following menarche — the onset of their menstrual cycle — can lower their risk of breast cancer 30 percent by age 40, compared to their more sedentary peers. Continuing that moderately active lifestyle until at least age 40 can cut their risk by almost 60 percent, a new study reports.

What makes these findings particularly important, says study leader Leslie Bernstein of the University of Southern California School of Medicine in Los Angeles, is that unlike many risk factors for this cancer — such as early menarche, late menopause, having a mother or sister with the disease, and higher socioeconomic status — exercise is something over which women have considerable control.

The California researchers studied 545 Los Angeles County breast cancer patients — all age 40 or younger — and an equal number of cancerfree neighbors of the same age with the same number of children. Questionnaires documented in detail each woman's exercise and reproductive history.

Bernstein and her coworkers focused on premenopausal women because previous studies by several groups, including hers, had shown that moderate exercise can reversibly shut down ovulation in adolescents and young women. This tends not to be true of women beyond their middle to late 20s, Bernstein notes. Because it appears that the more often a woman ovulates — each time boosting the circulation of certain reproductive hormones — the greater her breast cancer risk, the California group reasoned that early exercise might prove most protective and show up best in young women.

In fact, consistently exercising about 4 hours per week appeared to be protective, even if begun well after adolescence, the group now reports in the Sept. 21 JOURNAL OF THE NATIONAL CANCER INSTITUTE.

"That to me was the most surprising finding," says Bernstein, because it suggests that exercise affects hormone production beyond young adulthood. How? It may lower the secretion of ovulatory hormones in each menstrual cycle, she speculates, "so estrogen levels may not peak as high."

Moreover, the study found that exercise exerts this effect independent of other factors, such as weight, age at menarche, or number of children.

A companion study is examining cancer risk in 8,000 women 35 to 64 years old. Personally, Bernstein says, "I think we will also see an effect [of exercise] among postmenopausal women."

In an editorial accompanying the new study, Louise A. Brinton of the National Cancer Institute in Bethesda, Md., notes that earlier studies had hinted that exercise might lower breast cancer incidence. But Bernstein's team offers "fairly convincing evidence," she says, that "physical activity can lead to substantial reductions in breast cancer risk." — *J. Raloff*

Bacteria found deep below ocean floor

Earth's biosphere — the area its living creatures call home — is larger and has more life in it than scientists had realized. Studies of sediment laid down more than 4 million years ago in the Pacific Ocean reveal that bacteria are living at least 500 meters below the ocean floor.

"We have a much thicker veneer to our planet which is living and responding to chemical inputs and geothermal inputs than we previously thought," says R. John Parkes of the University of Bristol in England.

Scientists had believed that pressure and heat this far below the seafloor would prevent life from establishing a foothold there, he says. They also did not imagine that microorganisms could dine off the organic matter available at such depths. But some geochemists had begun to suspect that the degradation of organic material seen in the deep ocean could be attributed in part to bacteria, Parkes notes.

Other teams have reported finding microorganisms far beneath the ocean bottom, but investigators think those bacteria may have been introduced into the lower depths during drilling, Parkes asserts.

To ensure that this was not a problem in their work, Parkes and his colleagues took samples at a range of depths. They found populations of organisms that were much larger than the groups above them, the team reports in the Sept. 29 LANCET. Bacterial contamination during drilling couldn't account for the deeper groups' larger numbers, Parkes contends.

Using a microscope, the scientists observed the organisms directly in the sediments without growing them in laboratory cultures, he says. "Some of them we catch in the act of division" — a sure sign of their viability, he adds.

The number and activity of bacteria vary with the availability of food, the team asserts. At 360 m below the seafloor, the researchers found a significant increase in both anaerobic bacteria and the methane and other hydrocarbons the creatures feed on.

The scientists cultured sulfate-reducing bacteria that they found 80 m below the seafloor. The DNA of these microorganisms resembles that of organisms living closer to the surface. However, "in terms of their growth and metabolism, they are very different. They are new," says Parkes. The researchers believe the sediment samples contain additional novel bacteria.

These hardy underseafloor creatures may one day prove useful in biotechnology, he adds.

The Parkes team "did a very thorough and careful job," says Derek Lovley of the U.S. Geological Survey in Reston, Va. In addition to showing that the biosphere is bigger than previously thought, the investigators demonstrated for the first time that microorganisms continue to act on ancient, deep-ocean sediments, he says. The findings also greatly extend previous research on deep terrestrial aquifers (SN: 3/5/88, p.149), he adds.

— *T. Adler*