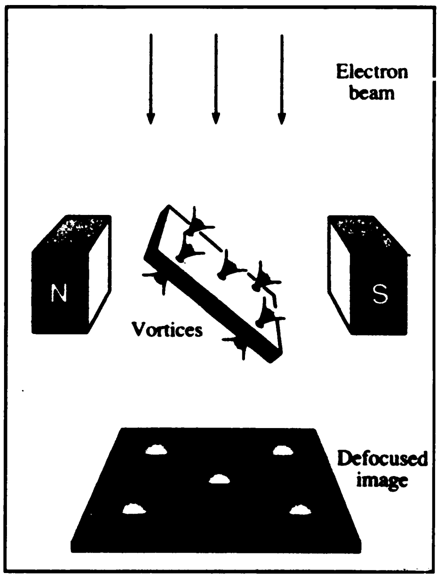
Capturing the motion of magnetic vortices

Applying a new imaging technique, researchers in Japan have for the first time directly observed the movement of tiny whirlpools of magnetism trapped in a superconducting material. Their observations help settle a long-standing debate concerning the behavior of these vortices as the temperature of an oxide superconductor — placed in a magnetic field — is varied.



Hitachi

To observe vortices, researchers sent an electron beam through a sample of bismuth strontium calcium copper oxide placed in a magnetic field.

Akira Tonomura and his co-workers at the Advanced Research Laboratory of Hitachi, Ltd. in Saitama, Japan, report their findings in the Nov. 15 PHYSICAL REVIEW LETTERS.

"To those in the superconductivity business, these images are nothing less than spectacular," comments David J. Bishop of AT&T Bell Laboratories in Murray Hill, N.J., in the Nov. 18 NATURE. "It is a truly outstanding piece of experimental physics."

A superconductor normally shields itself from the effects of magnetic fields in which it is placed by preventing such fields from penetrating its interior. For oxide superconductors, however, once this external magnetic field exceeds a certain value, it begins to enter the material. This penetrating magnetic field exists within the superconductor in the form of separate vortices — whirlpools of electric current. At low temperatures, the vortices arrange themselves into a distinctive pattern, or lattice.

The behavior of these vortices has a great influence on how well a superconductor carries electricity, particularly at high currents, when the vortices get in the way. But researchers have been unsure whether a vortex lattice remains intact below a certain temperature and "melts" into disarray above this temperature (SN: 4/1/89, p.197).

The Hitachi team confirmed that at low temperatures, the vortices form a lattice. As the researchers raised the temperature, the vortices moved a little with each temperature step but eventually settled again into a stationary pattern. However, once a certain temperature — a critical point — was reached, the lattice melted. A previous result indicated vortices start moving well below this temperature.

"Many of us have been consumed for the past six years by the issue of whether magnetic flux lattices could indeed melt," Bishop says. Now, "seeing is believing."

— I. Peterson

Agent from the sea has antitumor promise

A very preliminary human trial of a compound extracted from a marine animal hints that this agent may have a future as an antitumor drug.

While the rain forest is commonly thought of as a source of novel drugs, this study shows that the sea also may provide oncologists with a rich source of cancer-fighting compounds, comments Andrew S. Kraft of the University of Alabama at Birmingham. The agent, bryostatin 1, is obtained by grinding and purifying a small sea creature called *Bugula neritina*.

A raft of studies had previously demonstrated bryostatin 1's cancer-killing muscle in the test tube or in laboratory animals. For example, scientists have shown that it can halt the proliferation of human leukemia cells growing in a petri dish. In addition, the compound has been shown to shrink skin tumors in mice.

"This study is the first to use the drug in humans," says Philip A. Philip, formerly at Churchill Hospital in Oxford, England, who coauthored the report in the Nov. 17 JOURNAL OF THE NATIONAL CANCER INSTITUTE.

Before they can test its efficacy in humans, Philip and his colleagues must show that bryostatin 1 is safe. So the team designed a trial in which they gave various doses of the drug to 35 people with a variety of advanced malignant tumors. Not all recruits were candidates for or had failed conventional anticancer treatments, Philip notes.

The most notable side effect of the new drug seems to be muscle pain, which was severe enough to necessitate stopping treatment in six patients, Philip reports. Patients did not experience the nausea or vomiting associated with the all-out blitz of chemotherapy, he says.

Although this trial is not designed to determine efficacy, bryostatin 1 did show a glimmer of effectiveness in two people suffering from malignant melanoma, a deadly type of skin cancer that is very resistant to treatment, says Philip, now at the University of Texas M.D. Anderson Cancer Center in Houston. After experimental treatment with bryostatin 1, the patients' tumors shrank by at least 50 percent, a remission that lasted up to 10 months in one case.

Bryostatin 1's mechanism of action is likely to be complex. For example, laboratory studies have demonstrated that this compound stimulates the activity of protein kinase C, an enzyme that regulates cancer cell growth, notes Kraft, who wrote an accompanying editorial. What's more, Philip adds, bryostatin 1 may trigger the immune system's attack on malignant cells.

— K.A. Fackelmann

Ancient Maya trade: Tracing salty swaps

Underwater excavations off the coast of Belize have uncovered a site where the Classic-era Maya produced salt from seawater more than 1,000 years ago, both for local use and as a valued item for trade with nearby communities.

"What we're seeing is evidence of regional trade of salt from coastal to inland sites in southeastern Belize," says project director Heather McKillop of Louisiana State University in Baton Rouge. "This shows that there has been an overemphasis [by scientists] on long-distance trade in Classic Maya civilization."

McKillop described the ongoing research last week in Washington, D.C., at the annual meeting of the American Anthropological Association.

The discovery of short-range salt trading by the Maya during the Classic period, which extended from around A.D. 250 to A.D. 900, occurs as other investigators explore the remnants of mountain settlements where the Maya simultaneously exploited various minerals to support another regional trading network (SN: 8/7/93, p.84).

Classic Maya towns clustered in the lowlands of Central America, where salt proves difficult to obtain, McKillop notes. The closest salt flats lie in northern Yucatán, several hundred miles away from ancient Maya cities. Coastal Belize offered easier access and thus stoked interest in extracting salt from seawater, she asserts.

Ironically, water now covers several Classic-era salt-production sites. Geological surveys of the coast along Belize have documented a dramatic rise in sea level that occurred in the last 100 years of the Classic period, coinciding with the abandonment of many coastal settlements, according to McKillop.

Underwater surveys located one such outpost, known as Stingray Lagoon, in 1991. Excavations conducted through this year have yielded numerous well-preserved items once used in salt production, McKillop reports. Inhabitants of Stingray Lagoon apparently boiled seawater in large, thick-walled open bowls, each of which sat on three bolts embedded in a clay base. Numerous examples of all these artifacts emerged from the site, the Louisiana anthropologist says.

Investigators also found abundant pieces of charcoal and the remains of a hearth, clear signs of extensive fire use.

Many ceramic artifacts at Stingray Lagoon, such as pots bearing distinctive stamped designs and figurine whistles, apparently came from inland communities that traded with the salt producers, McKillop holds.

Salt probably left the site in bulk quantities, she adds. The lack of fish bones at Stingray Lagoon indicates residents did not use salt to dry fish for transport elsewhere.

Several additional underwater Maya sites in the vicinity of Stingray Lagoon show signs of less intensive salt production, McKillop says. One of them, known as Wild Cane Cay, has also yielded obsidian objects and other items intended for elite groups. That settlement may have served as one hub for regional trade routes, she suggests. *– B. Bower*

Evidence of disks in middleweight stars

For years, stars just a few times more massive than the sun have seemed the neglected stepchildren of astronomers. Deemed too massive to form planets yet too lightweight to strongly influence the interstellar medium, these stars' evolution was largely overlooked by researchers. Now, astronomers have for the first time caught some 2,000 intermediate-mass stars in the act of forming.

Ranging from three to eight times the mass of the sun, these stars belong to a Milky Way cluster known as NGC 6611. Based on visible-light and infrared observations, astronomers find indirect evidence that some 20 percent of these newborns have disks or spherical envelopes of dust surrounding them, says Lynne A. Hillenbrand of the University of Massachusetts at Amherst.

That compares with the 60 percent of low-mass stars thought to have disks (SN: 1/16/93, p.36). But the new observations may have found only the tip of the iceberg. Intermediate-mass stars have a far shorter youth and their disks may last for just a million years – one-tenth the average lifetime of dusty material encircling a low-mass star – Hillenbrand says. In fact, she adds, the study hints that disks play as important a role in the evolution of intermediate-mass stars as they seem to play for less massive ones.

Hillenbrand and her colleagues report their study in the November ASTRONOMICAL JOURNAL.

Disks around sun-like stars may survive long enough to provide the raw

Nat. Optical Astronomy Observatories

Stars in the young cluster NGC 6611, with the Eagle nebula at center.

material for planets, but those around heavier bodies are most likely dragged into the stellar core before planet making begins. Regardless of mass, however, the formation of a disk may funnel material into a developing star and hasten its growth, Hillenbrand speculates.

The team also finds evidence that some members of cluster NGC 6611, known as Be and Ae stars, are much younger than believed. Astronomers had thought that bright emission lines in the spectra of these stars stemmed from mass loss that occurs when the stars reach about 100 million years of age. But that's inconsistent with the youthfulness of the rest of the cluster stars, which are no more than a few million years old.

The researchers suggest that the Ae and Be stars in the cluster are newborns and that starbirth processes account for the spectra. *– R. Cowen*

Minor climate change can unravel a forest

A modest climate cooling several hundred years ago upset the balance of tree species inhabiting southern Canada, suggesting that even changes spread over several centuries can dramatically alter forests and reduce their productivity, two Canadian scientists report.

Ian D. Campbell of Forestry Canada in Edmonton, Alberta, and John H. McAndrews of the University of Toronto studied how forests in southern Ontario responded to the Little Ice Age, a global cooling that lasted from roughly 1200 A.D. to 1850 A.D. in Canada. Studies of pollen deposited in lakes during that period suggest that the predominantly beech tree forest gave way first to oak and then to pine trees after the start of the cooling. But while pollen can reveal the composition of an ancient forest, it cannot provide information about the land's productivity – the number of trees present.

To test the impact of the climate cooling on woodlands, the researchers simulated the period using a forest model run on a supercomputer. Campbell and McAndrews mimicked the Little Ice Age by gradually lowering the mean annual temperature in southern Ontario by 2°C over the 650-year cool span.

The simulation showed a succession of tree types resembling the pattern of change recorded by ancient pollen. Going beyond the pollen record, the computer experiment also provided a measure of the total amount of biomass within the forest. The biomass declined by 30 percent during the Little Ice Age, indicating that the cooling knocked the region's woodlands far out of equilibrium.

"Nobody had ever demonstrated before that such a minor climate change could have such a large impact," Campbell says.

The finding relates to concerns about future global warming, he notes, because it indicates that climate change does not simply alter the mix of trees in a forest by swapping cool-temperature species for warm, or vice versa. Instead, the slow cooling of the Little Ice Age caused a cascade of reactions that is taking centuries to play out.

The forest biomass declined steeply because the disappearance of beech trees cleared large sections. This prompted the spread of oak, which thrives in open spaces. Once the forest thickened, the oak died back, giving way to more shade-tolerant pine trees. By the end of the simulation, the year 2000, the forest still had not recovered its former productivity, the researchers report in the Nov. 25 NATURE.

Climate experts debate how the Earth will react to the buildup of greenhouse gas pollution in the atmosphere, but most predict that the warming will proceed several times faster than the cooling modeled by Campbell and McAndrews.

"Most people are predicting fairly significant and rapid climate change. It's a warming instead of a cooling. But my research shows it was the rapidity of the change that was important, not the direction," Campbell says.

Some ecologists note that Campbell and McAndrews did not demonstrate that the model they used accurately represented how the real forest responded to the Little Ice Age. In particular, the simple model did not incorporate wildfire and other types of disturbance that other researchers have shown to play an important role during shifts in climate. *– R. Monastersky*