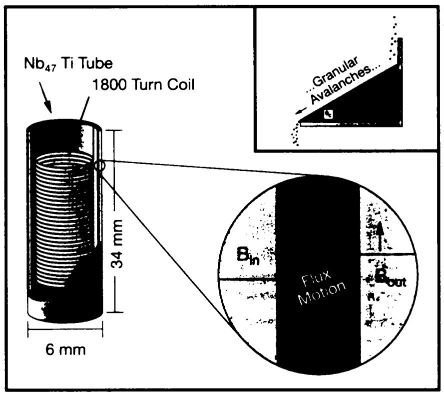
Vortex avalanches in superconductors

A steeply sloped sandpile represents a precarious balance between the friction keeping individual grains in place and the inexorable downward pull of gravity. Dropping additional particles onto the slope readily triggers avalanches, which can range in size from the movement of a few grains to massive slides along the entire slope (SN: 10/10/92, p.231).

Researchers have detected similar avalanche behavior in magnetic materials (SN: 3/31/90, p.207) and among cascading water droplets (SN: 10/23/93, p.261). Now, they have observed such activity among whirlpools, or vortices, of magnetic field trapped in a superconductor.

"Our work provides direct experimental confirmation of the existence of these vortex avalanches, as well as new insights into the nature of collective particle transport at the threshold of instability," says Stuart B. Field of the University of Michigan in Ann Arbor.



Field et al.

As new vortices of magnetic flux push into a superconducting tube from the outside, existing vortices spill into the tube's hollow interior. This leakage occurs in avalanches, like those that can happen in sandpiles (inset).

Field and his collaborators use a hollow tube made of a niobium-titanium alloy. Immersed in a liquid helium bath, this material becomes a superconductor, losing its electrical resistance.

An external magnetic field can penetrate the tube, creating vortices of magnetic field within the tube wall. Defects in the crystal structure of the superconducting alloy normally pin these vortices in particular locations.

Slowly increasing the magnetic field drives additional vortices into the tube's outer wall, pushing aside vortices already present. Some vortices spill into the tube's hollow interior, where a detector records the electrical pulses caused by these exiting bundles of magnetic field.

"The striking feature of the signal is that it consists of a succession of very pronounced pulses with a wide distribution of sizes and lifetimes," Field says.

In other words, vortices emerge from the tube not at a smooth, steady rate but in erratic surges. These vortex avalanches may vary from as few as 50 to as many as 5,000 vortices. Such behavior resembles that observed in sandpiles and other physical systems existing in a critical state on the verge of instability.

Field described his team's work last week at an American Physical Society meeting held in San Jose, Calif.

— I. Peterson

Hubble constant: Controversy continues

Like contestants in a never-ending tennis match, teams of cosmologists continue to argue back and forth about the numerical value of the Hubble constant. This hotly debated number, which relates the recession velocity of a galaxy to its distance from Earth, provides a measure of the age and size of the expanding universe.

Last fall, Wendy L. Freedman of the Carnegie Observatories in Pasadena, Calif., and her colleagues announced a new distance to the galaxy M100, a member of the Virgo cluster of galaxies, based on Hubble Space Telescope observations. From this measurement, they calculated a Hubble constant of 80 kilometers per second per megaparsec. This indicates a cosmos between 8 and 12 billion years old (SN: 10/8/94, p.232).

That poses a predicament because it makes the universe appear younger than its oldest stars, believed to be 16 billion years old.

Last week, cosmologists heard from Allan R. Sandage of the Carnegie Observatories, a longtime proponent of a smaller Hubble constant and an older universe. He announced that two new observations with the Hubble telescope have each yielded a Hubble constant of about 50. The findings, which agree with his team's earlier results, would make the cosmos about 20 billion years old, avoiding any conflict with the age of its elderly stars.

"I firmly believe there is no [cosmological] crisis," Sandage asserted at the Particles, Strings, and Cosmology symposium in Baltimore.

In their study, Sandage and his collaborators employed a special strategy to measure the distance to two galaxies, NGC 4496A and NGC 4536. Using one type of distance indicator, youthful pulsating stars known as Cepheid variables, the team calibrated the true brightness of another indicator in the same galaxies, exploded stars known as type 1a supernovas.

Critics argue that Sandage and his coworkers underestimate the Hubble constant because they don't account for the possibility that some of their 1a supernovas may be intrinsically brighter than average (SN: 2/18/95, p.106). But Sandage argues it's unlikely that all five of the exploded stars his team has examined are unusually bright.

However, Mark M. Phillips of the Cerro Tololo Inter-American Observatory in La Serena, Chile, says that's a distinct possibility. Sandage's team relies on 1a supernovas in galaxies that contain lots of Cepheids. Such galaxies may tend to harbor 1a supernovas with higher intrinsic brightnesses, Phillips notes. He adds that published data on two of the stellar explosions, one in 1895 and another in 1960, aren't reliable.

Meanwhile, Freedman says that her team has corroborated their initial finding and expects much more data. "It feels like we're drinking from a firehose. Within a year to 18 months we'll have much more to say about the Hubble constant."

— R. Cowen

Think big to save birds on the edge

Bird lovers often take comfort in the small plots of forest left in their neighborhoods, thinking that these trees provide a haven for forest-loving birds.

But a new, large-scale study shows that small nature preserves fail to protect birds' nests from predators, such as cowbirds, which lurk along forest edges, report Scott K. Robinson of the state-run Illinois Natural History Survey in Champaign, Ill., and his colleagues.

Indeed, in some small woodland plots certain species now lose so many of their eggs and nestlings that their overall deathrates exceed their birthrates. Birds moving in from heavily forested areas help sustain the populations in the smaller forests, the scientists assert in the March 31 Science.

To do their study, Robinson and his many coworkers staked out more than 5,000 nests in five midwestern states between 1989 and 1993. They monitored eight species of neotropical migrant birds, which breed in North America and winter in the tropics, and observed nests of the northern cardinal. The species in the study have become scarcer in recent years, although none is yet in danger of extinction.

The nests occupied nine plots from 20 to 200 hectares in size on land ranging from more than 90 percent agricultural to more than 90 percent forested. Nests in areas with less forestation suffered higher rates of destruction and cowbird invasion, Robinson and his colleagues report.

Cowbirds lay their eggs in other birds' nests; the surrogate mothers raise the baby cowbirds and may neglect their own offspring. Nest predators include raccoons, snakes, and other creatures.

Previous studies have suggested that cowbirds and many nest predators avoid large, dense woodlands and instead frequent the smaller forests near farms and suburbia.

Most wood thrush nests in areas with less than 55 percent forest had several cowbird eggs in them, Robinson and his colleagues report. "In some landscapes, there were more cowbird eggs than wood thrush eggs per nest," they note. Every day, predators threatened the homes of warblers that nested near or on the ground in the most fragmented areas, which have only small patches of forest.

Audubon Naturalist Soc.

Warblers are among the migrating birds suffering from the decline in forests.

"Even the indigo bunting, which prefers forest edges, nests more successfully in less fragmented landscapes," the scientists report.

"Our results suggest that a good regional conservation strategy for migrant songbirds. . . is to identify, maintain, and restore the large tracts [of forest] that are most likely to be population sources," they conclude.

Other studies have also suggested that birds have better reproductive success in larger forests. Researchers see a "consistent, catastrophic loss of forest migrants" in smaller forests but not in woodlands larger than 100 hectares, Robert A. Askins of Connecticut College in New London notes in an accompanying article. Scientists have also found that old-growth forests attract a wider variety of species than do younger stands (SN: 6/18/94, p.399).

However, Askins adds, "although previous studies have suggested a [negative] relation between nesting success and the amount of nonforested habitat . . . Robinson and colleagues now report the first conclusive test of this hypothesis."

No one had previously monitored such a wide swath of the United States, says Ted R. Simons of North Carolina State University in Raleigh. The study by Robinson's team shows that the problem "is not just happening at a few isolated locations," he asserts. — *T. Adler*

New glasses arise from liquid's slow flow

An elegant goblet, a cathedral's iridescent windows, a sculpted dove. Each of these objects embodies a mysterious material: glass.

Seemingly a translucent solid, glass is in fact a fluid unable to flow. Yet a careful look at the molecular properties of this amorphous, highly viscous liquid has spawned a diversity of new glass materials, improved manufacturing and coating techniques, and a better understanding of protein folding, researchers report in the March 31 SCIENCE.

"Structurally, a glass is barely distinguishable from the fluid substance it was before it passed, quite abruptly in some cases, into the glassy state," says Charles A. Angell, a chemist at Arizona State University in Tempe. "Why did this particular substance or solution suddenly undergo a dramatic slowing down in the diffusive motions of its particles?"

"Why do glasses not form a precisely ordered cystalline material at some precisely defined freezing point, like so many other, more 'normal' substances?" Angell wonders.

Investigating these questions, researchers have found alternative methods for forming glass, beyond the traditional techniques of rapidly cooling a liquid, Angell says.

Types of glass forged from metal alloys are giving rise to new kinds of high-strength, corrosion-resistant materials, reports A. Lindsay Greer, a materials scientist at Cambridge University in England. Scientists make the so-called amorphous metallic alloys by rapidly cooling a thick metal liquid, a technique that prevents the molecules from crystallizing.

Metallurgists, for example, can form glass from many types of metal, most easily from iron and palladium. Aluminum, on the other hand, resists forming a glass. But Greer points to recent successes in fashioning glasses from aluminum-based alloys that previously would not produce a glass. Researchers in France and Japan, for instance, have successfully forged light, ductile glass alloys containing more than 80 percent aluminum.

"This opens up all sorts of possibilities for making metal machine parts that are completely glassy," says Greer. "Amorphous metal alloys have no fixed molecular structure, so it's much easier to mold them into fine shapes. These alloys could be used for devices implanted in the human body."

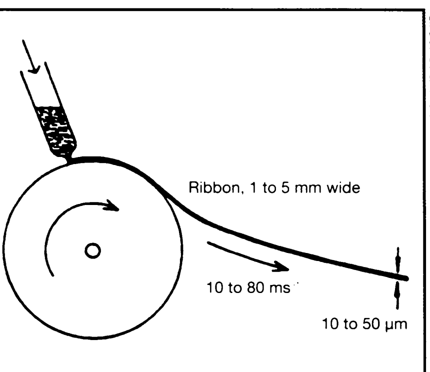
Such new materials promise applications for strong, lightweight, corrosion-resistant engine parts often needed in the aerospace and automotive industries, as well as in microelectronics. Micrometer-sized machines, including small motors and gears, would also find improved performance when fashioned from metallic glass alloys.

New methods for producing metallic glasses efficiently in large quantities may make them more accessible to industry, says Greer. "It has always been thought that, to form a metallic glass, you must cool liquid metal extremely fast, nearly 1 million degrees a second. But some new alloys show that glasses can form by cooling much more slowly."

Wear-resistant coatings for more mundane items, such as kitchen appliances (even frying pans), have an allure for industry, says Greer. Manufacturers could deposit thin metallic glass films from a vapor onto items or try glazing a metal surface with a laser or an electron beam.

"A laser would melt a thin surface layer," says Greer. "It's the sort of thing one might do to the lining of a cylinder in a car engine."

Researchers are gleaning insights into glass formation by observing natural processes, Angell says. Scientists have realized that most of the water in the universe exists in a "glassy state," condensing onto comets from gas in frigid interstellar space without forming the crystals found in ice.



Greer et al./ SCIENCE

In melt spinning, the most common method of making metallic glass, a molten alloy flows onto the rim of a fast-spinning wheel. The process yields a thin metallic glass ribbon.

In addition, studies of food preservation and methods that insects use to protect themselves from droughts are showing how some biological molecules change into a glasslike state, Angell says.

Such observations are leading researchers to see similarities between the chemical transitions of some proteins and polymers and that of glasses, Angell says. Proteins contain so many moving components that materials scientists now liken them to a "many-particle glass-forming system."

Both in computer simulations and laboratory experiments, certain proteins appear to fold into their three-dimensional structures by moving through a glass transition state. — *R. Lipkin*