physicists a new tool for understanding the "evaporation" of nuclei. They might also shed light on the reverse process, the condensation of nuclei from smaller parts. "It's relevant to what happens in the formation of neutron stars," says Viola. If so, the work is likely to be a hit—a palpable hit.

–CHARLES SEIFE

SUPERCONDUCTIVITY

Perplexing Compounds Rejoin the Club

If you want to start a fight in a roomful of physicists, ask them how high-temperature superconductors (HTSCs) work. The compounds, which are based on layers of copper oxides, lose their electrical resistance at temperatures as high as 138 kelvin—almost 100 degrees warmer than the best conventional superconductor. By rights, they should be prime candidates for a unified theory. Yet 15 years after the discovery of HTSCs, every theorist seems to have a different explanation for their strange properties.

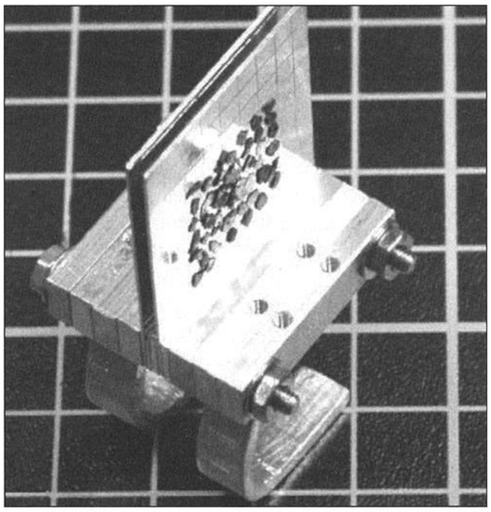
Now results of a laborious experiment, published online this week (www.sciencexpress.org), have solved a longstanding puzzle about the superconductors: why some, but not others, appeared to show a fundamental fingerprint of magnetic spin. Physicists have debated the reason vigorously since 1991, when researchers shooting beams of neutrons onto HTSC superconductors at the Institut Laue-Langevin in Grenoble, France, discovered an unusual pattern in their scattering data. Neutrons are like tiny bar magnets, carrying no electrical charge but a small amount of magnetic spin, a property they share with electrons. So the way these miniature magnets bounce off a superconductor can reveal what the material's electron spins are up to.

The French team discovered a faint peak that suggested the spins were conspiring in some collective resonant interaction, like a sea of compass needles all wiggling in unison. And because the resonant peak grew large and sharp when the material was superconducting, many thought that magnetic interactions might help solve the mystery of HTSC superconductivity.

The catch was that the resonance was seen only in HTSC materials the crystal structures of which had two or more layers of copper oxide; single-layer compounds such as lanthanum-strontium-copper-oxide, the first HTSC ever discovered, seemed exempt. Some physicists believed that meant spin resonances were a red herring that they could ignore.

Now the herring is back, and it's real. A collaboration between the Max Planck Institute for Solid State Research, two Atomic Energy Commission (CEA) labs in France, and the Institute of Solid State Physics in Chernogolovka, Russia, reports that the resonance occurs in a single-layer HTSC compound after all. Because the material they studied, a thallium-barium-copper oxide compound, hasn't been grown in crystals big enough for neutron scattering, the scientists had to devise a painstaking technical workaround. "We aligned several hundred small crystals so that they behave like one large crystal," says co-author Bernhard Keimer. With this composite specimen, they were able to carry out the neutron study. When they analyzed the data, the resonant peak was there. "This proves that the resonant mode is a generic property of these superconducting materials," Keimer says.

"This is a tour de force," says John Tranquada, an experimentalist at Brookhaven National Laboratory in New York. "Preparing and aligning 300 crystals was a tremendous task, and the measurements required considerable patience." Tranquada believes the data will stand up to scrutiny. Michael Norman, a theorist at Argonne National Laboratory in Illinois, agrees: "Now it's clear that this resonance is the rule rather than the exception."



Puzzle pieces. Precise alignment of hundreds of tiny superconductor crystals led to new spin observations.

Less clear is how theory will accommodate the new observations. "This is where the real debates start," Norman says, "and it's a mine field." Physicists are stepping lightly, because each theory has a different idea of what makes the HTSCs tick and no theorist is going to yield ground easily. All superconductors work because the electrons (or holes) become glued together in pairs; in conventional materials the pairing is due to one electron's distorting the crystal lattice and attracting another—like two bowling balls on a mattress. The pairs then waltz through the material without resistance. Most theorists believe some other kind of "glue" will be needed for the HTSC materials. Boosters of theories that invoke magnetic or spin effects to glue the charge carriers together will likely gain the most encouragement from the new data.

Keimer stresses that linking HTSCs through spin resonance is a first step, not a knockout punch. "Our experiment will not end the debate about a final theory of superconductivity," he says, "but it may help tilt it in a specific direction."

–DAVID VOSS

GENE THERAPY

Blood Test Flags Agent In Death of Penn Subject

Exactly what killed Jesse Gelsinger, the first volunteer to die in a human gene therapy trial, remains a mystery, but last week researchers in Germany fingered a feature of his immune system as a prime suspect. They also believe that a simple blood test might be able to prevent similar tragedies in future gene therapy trials.

In September 1999, 18-year-old Jesse Gelsinger took part in a trial designed to test the safety of using a form of adenovirus to transport new genes into patients. Adenovirus normally only causes mild colds. Nonetheless, within hours of the injection of the virus "vector," Gelsinger's immune system went into overdrive. Four days later he died of multiple organ failure. James Wilson, leader of the trial and head of the Institute for Human Gene Therapy at the University of Pennsylvania in Philadelphia, initially suggested that another viral infection or undetected genetic condition might have triggered the harsh immune response to the adenovirus that investigators concluded had killed Gelsinger (*Science*, 17 December 1999, p. 2244, and 12 May 2000, p. 951). After further studies in monkeys, he pointed to the proteins in the coat of the vector as a possible source of the immune response revolt. Wilson was unavailable for comment on the new findings.

Günter Cichon of the Max Delbrück Center for Molecular Medicine in Berlin and his colleagues sought to find out how adenovirus provokes the body's defenses. They mixed blood samples from 18 individuals with adenovirus that was "externally identical" to the one used in Wilson's trial. The virus set off a forceful response from the complement system, a natural and powerful defense against invading pathogens, but only in samples that already contained antibodies against adenovirus. Reporting in the current issue of *Gene Therapy*, the team concludes that a viral dose comparable to the one Gelsinger received raised the con-

CREDIT: H. HE ET AL.

centration of a key component of the complement system to a level that could start a damaging immune reaction.

Cichon notes that Gelsinger was known to have "suffered a chest infection some time before the trial," so his complement system might have been sensitized already. In the bloodstream, the proteins of the virus coat would combine with antibodies, forming complexes that activate the complement system. This can cause inflammation in the vessel walls of liver, lungs, and kidney, and ultimately multiple organ failure. "Exactly the same symptoms were observed in the case of Gelsinger," says Cichon.

Gene therapist Prem Seth of Des Moines University in Iowa thinks that complement activation could indeed cause some of the adverse reactions observed in gene therapy trials with adenovirus vectors. Several years ago, he observed that the coat proteins of the virus initiate a strong immune response in human blood. "I have always argued that the virus should only be applied locally, not into the bloodstream," he told *Science*. And he agrees with Cichon that complement activation should be measured in blood samples to see if the test can predict which patients are likely to suffer strong adverse reactions. "All patients should be screened for their complement response," he says. "It is an easy test."

Phil Noguchi, director of the Food and Drug Administration (FDA) division for gene therapy, agrees that this finding is "a new piece in the puzzle" but emphasizes that the fatal trial probably had "multiple sources." He says that the FDA is considering how to use a complement-sensitivity test in gene therapy trials. —**ADAM BOSTANCI**

EXTRASOLAR PLANETOLOGY

Jupiters Like Our Own Await Planet Hunters

Astronomers have had plenty of luck lately finding planets circling other stars. But they've had no guarantees that the greatest prizes—planetary systems like our own, with a potential for life—are out there to be found. Due to limitations of the searches so far, the 77 newly discovered extrasolar planets either are gas giants orbiting much closer to their stars than Jupiter or are far more massive than Jupiter. No one can yet detect the most prominent hallmark of our solar system: planets resembling Jupiter in mass (at 70% of the solar system's total planetary mass) and in orbital distance (five times Earth's). But two new studies—one extrapolating from the oddball planets discovered so far and another modeling the way planetary systems form—give added hope that systems like ours are out there in abundance. Astronomers could start finding Jupiter-like exoplanets within a few years (also see p. 616).

Astronomers have found 77 exoplanets so far by watching how each parent star wobbles, pulled by an unseen planet orbiting it. The wobble shows up as a rhythmic variation in the star's color due to Doppler shifting; the more massive the planet or the closer it orbits the star, the bigger the wobble. In a paper posted on the preprint server astro-ph (0201003v1) on 2 January, physicists Charles Lineweaver and Daniel Grether of the University of New South Wales in Sydney, Australia, identified a subset of 44 exoplanets circling stars that had been monitored long enough to discover all the bodies orbiting at least as close as Mars orbits the sun and as large as or larger than Jupiter.

More than an artist's conception? There are new signs that planets like Jupiter—possibly with moons and rings—orbit other stars.

CREDIT: LYNETTE COOK

Extrapolating from trends in mass and orbital distance within this more representative subset, the Australian physicists find that "Jupiters are probably very typical" of the as-yet-unobserved exoplanets, says Lineweaver. They predict that 22 new Jupiter-like exoplanets—as big as Jupiter or larger, orbiting from just beyond the distance of Mars to a bit beyond the distance of Jupiter—will be found orbiting around the 1000 or so stars that have been monitored for more than 3 years. The prospect of familiar-looking planetary systems is more encouraging than earlier extrapolations had suggested, says Lineweaver, because by focusing only on well-studied stars they reduced observational bias and they also included the latest discoveries. (Extrapolation to the abundance of exoplanets as small and distant as Saturn is not yet advisable, the pair says.)

A second group has come up with a similar result by taking a more theoretical approach. In a paper submitted to *Astronomy and Astrophysics*, astronomer David Trilling of the University of Pennsylvania in Philadelphia, cosmochemist Jonathan Lunine of the University of Arizona in Tucson, and astrophysicist Willy Benz of the University of Bern in Switzerland consider how planetary systems created in a computer model compare with the exoplanets observed so far. Their model of planetary system evolution has a swirling disk of gas and dust of the sort from which planets agglomerate. But the disk can also destroy newly formed planets by interacting gravitationally with them and driving them into their star.

Planetary system formation is thus an old-fashioned cliffhanger, with planets heading for the furnace unless someone turns off the conveyor belt in time. Survival in real planetary systems depends on the mass of the planet, the mass of the disk, the lifetime of the disk, and the inherent ability of disk material to drag on the planet. Trilling and his colleagues varied these properties one at a time over plausible ranges in a series of simulations. In each they inserted a single planet into the disk at the distance of Jupiter and noted its fate by the time the disk had dissipated.

To judge by their simulations, "Planet formation is an 'easy come, easy go' business," they write, "with many planets created and many planets destroyed. …" Two-thirds of all model planets migrate too fast and are consumed by their stars before disk dissipation. Ten percent to 30% of the surviving planets come to a stop close to their star. That fits the discoveries so far if about 30% of sunlike stars form planets. But 70% to 90% of surviving giant planets, according to the modeling, should remain too far out to have been found by past searches. Jupiters should be among them. And in such systems, unlike those observed to have giant planets near their stars, there could be room for small, rocky planets like Earth at a comfortable, habitable distance from the star.

Astrophysicist Scott Tremaine of Princeton University sees these results and Lineweaver and Grether's extrapolation as reasonable quantifications of trends hinted at by the discoveries so far, and he looks forward to coming discoveries. As some monitoring records approach the requisite 12 years, Doppler detection of extrasolar Jupiters may not be far off. And searches are in the works for terrestrial-sized planets by looking for planets passing in front of their stars. But Tremaine remains cautious about what these searches will turn up. Speaking as a theorist, he notes that "most every prediction by theorists about planetary formation has been wrong."

—**RICHARD A. KERR**