much as nine times the fusion output of the corresponding doughnut tokamak, according to Masa Ono of the Princeton Plasma Physics Laboratory, a co-leader with Peng of NSTX. What's more, it's "simpler and smaller engineering construction," says Sykes.

Although the performance achieved by these first attempts is promising, "they are quite a long way off from a reactor," says Cordey. The spherical tokamaks must increase their temperatures 10-fold to reach that in JET and ITER—about 150 million degrees Celsius—while still keeping the plasma stable, he says. Sykes worries that such a small spherical machine may require impossible power densities when working as a real reactor. ITER remains the main focus for fusion researchers. Delaying or rejigging this $4.2 billion project "would be a big mistake," says Cordey. The hope is to develop ITER and spherical tokamaks in tandem. "It may be that after ITER, when utilities want to build a fusion power plant, they find that the spherical tokamak is a more economical way of doing it," says Sykes.

–ANDREW WATSON

Andrew Watson is a writer in Norwich, U.K.

HIGH-ENERGY PHYSICS

Atom Smasher Probes Realm of Nuclear 'Gas'

"Oh, that this too too liquid nucleus would evaporate." If Hamlet were a nuclear physicist, he might be feeling a bit more cheerful. Strange as it may seem, atomic nuclei do sometimes act like liquids, and when blasted apart at high enough energies they can sizzle into gas. Now scientists working at Brookhaven National Laboratory in Upton, New York, have charted the conditions under which gold nuclei make that leap, information that might help unravel the secrets behind the birth of a neutron star.

The work builds on a model that physicists cooked up in the 1930s to explain the fission of uranium. A neutron striking a nucleus more than 200 times its mass doesn't just knock off a chip or two; it splits the nucleus neatly in two. Physicists realized that the uranium nucleus is behaving like an oversized drop of water. When it is struck by a neutron, the nucleus oscillates, stretches out, and then blurps into two roughly equal parts (throwing off a few smaller fragments, such as neutrons, in the process). "Everyday garden-variety nuclei behave like a liquid," says Victor Viola, a physicist at Indiana University, Bloomington. "It's a very successful description."

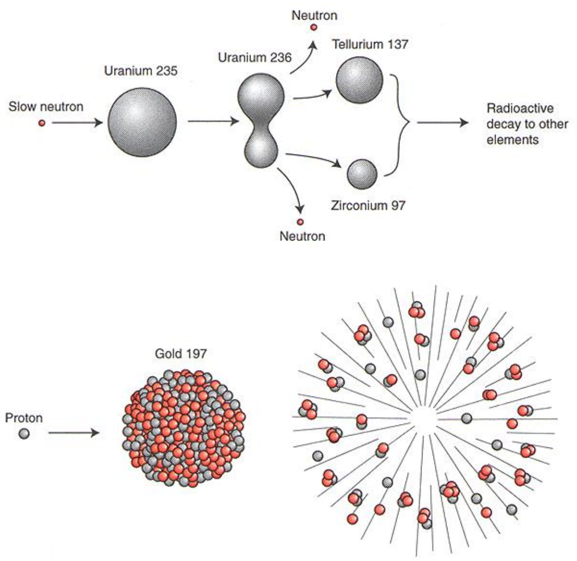
Viola and colleagues decided to take the liquid analogy one step further by determining the nucleus's equation of state—the relations between pressure and temperature that govern when the nucleus behaves like a gas and when it behaves like a liquid. At Brookhaven, they shot protons, pions, and antiprotons at thin gold foil, adding energy that brought the gold nuclei to a boil. Meanwhile, a device called the Indiana Silicon Sphere (ISiS)—a beach ball–sized sphere studded with 450 detectors—kept careful track of the size and energy of the particles that flew off.

The physicists analyzed the readings in two different ways. The first starts with the distribution of the sizes of chunks that fly out of the nucleus. "In boiling water, you don't get individual water molecules coming off," says Viola. "You get dimers, trimers, tetramers. The temperature of the vapor is related to the relative numbers of those clusters." By comparing the energy added to the nucleus (hence its "temperature") with the relative abundances of fragments, the physicists figured out the properties of the nuclear "liquid," including its critical temperature: the point above which the liquid phase can no longer exist, which they calculate at about 7 million electron volts (MeV). The second analysis directly models the breaking and making of nuclear bonds and comes up with a slightly higher critical temperature, slightly above 8 MeV.

"I do think it's a really nice piece of work they've done," says Joseph Natowitz, a physicist at Texas A&M University in College Station, who thinks that physicists will resolve the discrepancy once they get a better grip on how the nucleus expands and breaks up after the collision. "I have some ideas."

Even though wrinkles need to be ironed out, the results have given

ILLUSTRATION: C. SLAYDEN



Steamed. Physicists gave liquid-drop model of fission (top) a new twist by "evaporating" gold nuclei (bottom).

ScienceScope

Bioweapons Cleanup The United States and Uzbekistan are close to finalizing plans for a $6 million cleanup of a former Soviet bioweapons facility. The effort is aimed at preventing terrorists from harvesting live anthrax spores from a secret dumping ground.

For nearly 60 years starting in the 1930s, the Soviets released anthrax, plague, and other weaponized pathogens on Vozrozhdeniye (Resurrection) Island in the middle of the Aral Sea. In 1988, at the end of the Cold War, weaponeers buried tons of a particularly potent strain of powdered anthrax at the site, mixing the bacteria with bleach in steel drums to kill it. But several years ago testers found that some of the anthrax is still alive, and water diversions from the shrinking Aral Sea have since opened a land bridge to the once isolated island. Fearing that terrorists might try to harvest ready-made bioweapons from the site, U.S. officials agreed in October to pay for destroying the anthrax and a nearby testing facility.

Next month, U.S. experts—including researchers at the Department of Energy's Sandia National Laboratory in Albuquerque, New Mexico—are expected to meet with Uzbeki authorities to work out the details, Richard Tucker of the Monterey Institute of International Studies last week told a briefing organized by the Carnegie Endowment for International Peace in Washington, D.C. One possible approach, researchers say, is to soak the 11 burial pits with a strong antibacterial solution.

Backtracking The Jones Institute for Reproductive Medicine, which drew heavy criticism last summer when it revealed it had fertilized donated human eggs solely for the purpose of generating stem cells, has changed its priorities. Last week the institute, a private clinic that is part of Eastern Virginia Medical School in Norfolk, announced that it won't be generating any new human stem cell lines.

The reasons are partly political, according to Roger Gosden, the institute's new scientific director. After a state lawmaker recently introduced legislation that would have criminalized the creation of embryos for research, "my scientific priorities had to become public," says Gosden. The bill was withdrawn, but Gosden says the institute hopes to secure federal funds that can't go to research involving the controversial embryos. The institute will now focus on animal studies to identify molecules involved in reprogramming a cell's nucleus so that it will revert to a primordial state.

Contributors: Eliot Marshall, David Malakoff, and Constance Holden

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.

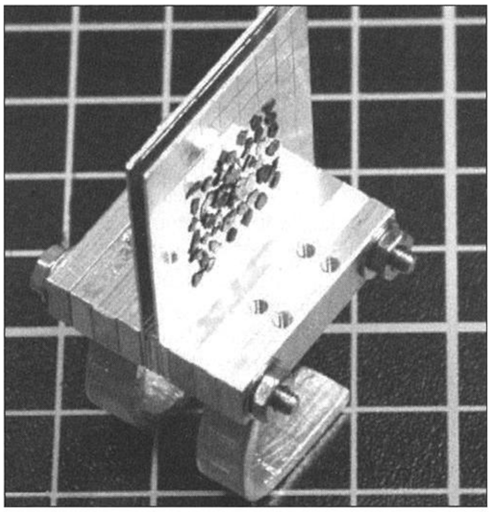
Now results of a laborious experiment, published online this week (www.sciencexpress.org), have solved a longstanding puzzle about the superconductors: why some, but not others, appeared to show a fundamental fingerprint of magnetic spin. Physicists have debated the reason vigorously since 1991, when 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-

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