cholesterol and other lipids in the gut, thus facilitating the absorption of these otherwise water-insoluble materials. Bile acids and cholesterol that fail to be absorbed or reabsorbed by the gut are excreted in the feces.

Despite the cholesterol-lowering potential of the rexinoids, drug researchers caution that the current drugs may not be usable because of their side effects. For example, a rexinoid derived from LG268 is approved for treating certain types of late-stage cancer and is being tested on others, but it raises levels of lipids called triglycerides in the blood, which could worsen obesity and cardiovascular disease. That may be acceptable for people with late-stage cancer who "have no other choice," says Vincent Giguère, a molecular biologist at McGill University Health Centre in Montreal. But "side effects become a big issue" for otherwise healthy people who may take cholesterol-lowering drugs for decades. Drugs that target LXR rather than RXR might be safer, because they would activate a smaller group of genes, Giguère suggests. Still, he adds, "these findings augur well for the future of cholesterol-controlling drugs."

–DAN FERBER

Dan Ferber is a writer in Urbana, Illinois.

INFORMATION THEORY

'Ultimate PC' Would Be A Hot Little Number

If gigahertz speeds on a personal computer are still too slow, cheer up. Seth Lloyd, a physicist at the Massachusetts Institute of Technology, has calculated how to make PCs almost unimaginably faster—if you don't mind working on a black hole.

Lloyd has used the laws of thermodynamics, information, relativity, and quantum mechanics to figure out the ultimate physical limits on the speed of a computer. His calculations show that, in principle, a kilogram of matter in a liter-sized container could be transformed into an "ultimate laptop" more than a trillion trillion trillion times as powerful as today's fastest supercomputer. Although presented in whimsical terms, other scientists say Lloyd's work marks a victory for those striving to figure out the laws of physics by investigating how nature deals with information.

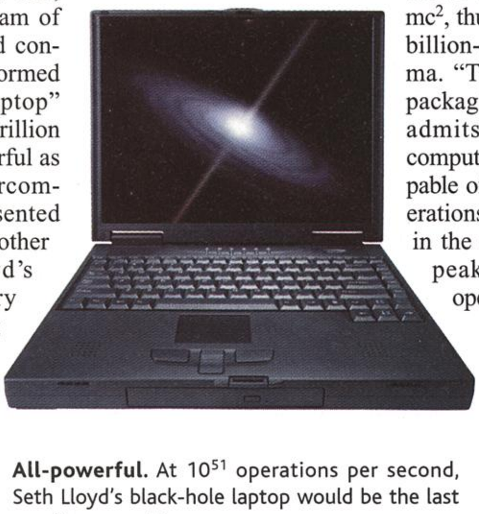
"It's incredibly interesting—bold," says Raymond Laflamme, a physicist at the Los Alamos National Laboratory in New Mexico. In addition to its theoretical importance, Laflamme says, the study shows what lies ahead. "Right now we are on roller skates. [Lloyd] says, 'Let's get on a rocket.'"

Lloyd's unconventional calculations are based on the links between information theory and the laws of thermodynamics, specifically entropy, a measure of the disorder of a system. Imagine dumping four balls into a box divided into four compartments. Roughly speaking, entropy is a measure of the probabilities of how the balls can land. "Ordered" outcomes (such as all four balls landing in a single compartment) are rare and have low entropy, while "disordered" outcomes (such as two balls in one compartment and a single ball in each of two others) are more common and have higher entropy.

In 1948, Bell Labs scientist Claude Shannon realized that the thermodynamic principle of entropy could also apply in the realm of computers and information. In a sense, a system such as a box with balls in it or a container full of gas molecules can act like a computer, and the entropy is related to the amount of information that the "computer" can store. For instance, if you take your box and label the four compartments "00," "01," "10," and "11," then each ball can store two bits' worth of information. The total amount of information that a physical system can store is related to entropy.

In the 31 August issue of *Nature*, Lloyd uses this principle to show that a 1-kilogram, 1-liter laptop could store and process 10^{31} bits of information. (A nice-sized hard drive holds about 10^{11} bits.) Then he figures out how quickly it could manipulate those bits, invoking Heisenberg's Uncertainty Principle, which implies that the more energy a system has available, the faster it can flip bits. Lloyd's ultimate laptop would convert all of its 1-kilogram mass into energy via Einstein's famous equation $E = mc^2$, thus turning itself into a billion-degree blob of plasma. "This would present a packaging problem," Lloyd admits with a laugh. The computer would then be capable of performing 10^{51} operations per second, leaving in the dust today's planned peak performer of 10^{13} operations per second.

But processing speed is only half of the story. If you *really* want to speed up your computer, Lloyd says, you must also slash the time it takes to



All-powerful. At 10^{51} operations per second, Seth Lloyd's black-hole laptop would be the last word in computing.

CREDIT: PHOTODISC (LAPTOP); AFP/CORBIS/NASA (BLACK HOLE)

ScienceScope

GMO Scientists Unite! Hoping to bring a voice of reason to the debate over transgenic crops, a group of scientists is launching the first society and journal to specifically address their risks.

The idea grew out of a series of international meetings, held biannually since 1988, that brought together an ad hoc group of scientists to discuss science-based regulatory policy for genetically modified organisms (GMOs). At its July meeting, organizers decided to form a permanent International Society for Biosafety Research. After years of getting hammered by "both the Greens and industry people," explains Mark Tepfer, who studies virus transfer at INRA, France's national agronomy research institute, "we need a clearer voice for scientists in the field." He and others hope to exercise "complete neutrality" in studying such hot-button issues as Bt corn's impact on butterflies.

The group's journal, *Environmental Biosafety Research*, will be launched early next year by Elsevier. Alan McHughen, a plant geneticist at the University of Saskatchewan, says it will feature research that other journals often turn down—including "negative results" studies showing that a transgenic crop appears no different from its traditionally bred counterpart.

Microbial Month Now that it is nearly finished sequencing its share of the human genome, the Department of Energy's Joint Genome Institute (JGI) has decided to tackle as many as 17 microbes—all in 1 month.

Microbial genomes typically are less than 10 million bases long, so decoding the bugs should be a snap compared with assembling the 3-billion-base human genome, says JGI's Trevor Hawkins. He predicts the Walnut Creek, California, facility will have no trouble sequencing about 2 million bases a day, enabling his team to take six or eight passes through each microbe's DNA. JGI doesn't plan to "finish" the genomes, however. Instead, it will post the data on its new "Genome Portal" Web site.

On JGI's sequencing hit list are two plant pathogens and several bacteria that fix nitrogen or sequester carbon. Two others are magnetotactic—which means they sense and move toward sources of magnetism. Stuart Levy, a geneticist at Tufts University School of Medicine in Boston, hopes his bug, a soil-dwelling *Pseudomonas* with potential for breaking down pollutants, will be among the first sequenced. That information, he says, "will move the research along much more quickly."

Contributors: David Malakoff, Michael Balter, Jocelyn Kaiser, Elizabeth Pennisi

communicate with itself—that is, to transfer information back and forth. The trick, he says, is to squeeze the computer down to the most compact possible size. Lloyd shows that a computer made of the most compressed matter in the universe—a black hole—would calculate as fast as a plasma computer. It would also communicate in precisely the same time that it takes to flip a bit—the hallmark of the ideal computer. Coincidence? Perhaps not, Lloyd says: "Something really deep might be going on."

At present, scientists have no idea how to turn a laptop into a black hole (Windows 98 jokes aside). But Laflamme says that just thinking about such extreme scenarios might illuminate deep physical mysteries such as black holes. "It's not just what insight physics brings to information theory, but what information theory brings to physics," he says. "I hope that, in the next 10 or 15 years, a lot of insight into physics will be due to quantum computing."

–CHARLES SEIFE

ASTROPHYSICS

Neutron Stars Imply Relativity's a Drag

Matter warps space; space guides matter. That, in a nutshell, is Einstein's general theory of relativity. Now three astronomers in Amsterdam may have confirmed a much subtler prediction of Einstein's: warped space-time with a twist.

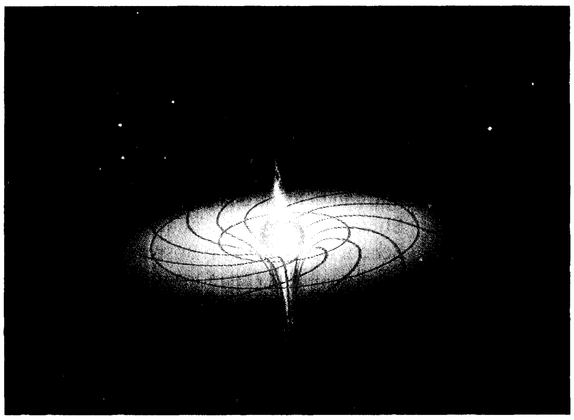
The general theory explains how the sun's gravity curves the surrounding space (actually space-time), bending nearby light waves and altering the orbit of Mercury. The new finding, based on x-rays from distant neutron stars, could be the first clear evidence of a weird relativistic effect called frame dragging, in which a heavy chunk of spinning matter wrenches the space-time around it like an eggbeater. "This is an extremely interesting and beautiful discovery," says Luigi Stella of the Astronomical Observatory in Rome, Italy.

Peter Jonker of the University of Amsterdam, the Netherlands, and his colleagues Mariano Méndez (now at the La Plata Observatory in Argentina) and Michiel van der Klis announced their results in the 1 September issue of *The Astrophysical Journal*. To describe such exotic behavior of space-time, Jonker goes beyond the astrophysicist's standard image of a bowling ball resting on a stiff sheet.

"Frame dragging is comparable to what happens when you cover the ball with Velcro and rotate it," Jonker says. The effect occurs only in the immediate neighborhood of very massive, swiftly rotating bodies. To study it, astronomers have to observe distant neutron stars—the extremely compact leftovers of supernova explosions, whose near-surface gravity is so strong that they make ideal testbeds for general relativity.

Using data from NASA's Rossi X-ray Timing Explorer, Jonker and his colleagues found circumstantial evidence for frame dragging in the flickering of three neutron stars in binary systems. The flickering spans a wide range of x-ray frequencies. According to theoretician Frederick Lamb of the University of Illinois, Urbana-Champaign, the most prominent "quasi-periodic oscillations" probably come from orbiting gas that a neutron star tears off its normal-star companion. The hot gas accretes into a whirling disk and gives off x-rays as it spirals toward the neutron star's surface at almost the speed of light.

The new evidence comes in the form of less prominent peaks close to one of the main frequency peaks. These so-called sidebands showed up only after the researchers carefully combined almost 5 years' worth of data. The Amsterdam astronomers say the peaks could be due to frame dragging, which would cause the accretion disk to wobble like a Frisbee. The wobble frequency would imprint itself on the main frequency peak, just as amplitude modulations do on the carrier wave of a radio broadcast.



It's a wrap. According to general relativity, a massive neutron star (shown spinning counterclockwise) could warp and twist space-time in its near neighborhood.

Some physicists, however, are unconvinced. Lamb says calculations done with his Illinois colleague, Draza Markovic, show that the frequency separation between the main signal and the sidebands is probably too large for the sidebands to have been caused by frame dragging. A similar false alarm occurred 3 years ago, he says, when Stella and Mario Vietri of the Third University of Rome cited a low-frequency, 60-hertz x-ray flicker in a couple of neutron stars as evidence of frame dragging (*Science*, 7 November 1997, p. 1012). The frequency of that earlier flicker clashed with theoretical calculations by Lamb's group and others. Lamb suspects that the flicker arises from a neutron star's intense magnetic field interacting with the accretion disk. Although the sidebands aren't as far out of step with theory, he says, "it's unlikely that [they] are produced by frame dragging."

Even so, the sidebands are "a very important result," Lamb says. "The discovery of sidebands is a real breakthrough, regardless of what causes them. This may be the key to unlocking what is generating the main oscillations." They may also provide information on the mass, the radius, and the physical makeup of neutron stars.

But Stella says frame dragging can't be so lightly dismissed. Taken as a whole, he says, the sidebands and his earlier evidence "fall together in a very nice fashion. The frequency differences pose no problem at all." Indeed, in a paper submitted to *The Astrophysical Journal*, Dimitrios Psaltis of the Harvard-Smithsonian Center for Astrophysics in Cambridge, Massachusetts, presents a model of a relativistically oscillating disk that overcomes the frequency problem.

The Amsterdam astronomers hope to use the Rossi satellite to study the neutron stars in more detail and look for sidebands in other sources. If the sidebands are indeed caused by frame dragging, Van der Klis explains, their frequency should shift along with that of the main oscillation in a specific way that will provide a decisive test of the hypothesis. "In principle," he says, "these kinds of observations could prove Einstein right or wrong."

–GOVERT SCHILLING

Govert Schilling is an astronomy writer in Utrecht, the Netherlands.

ECOLOGY

Forest Fire Plan Kindles Debate

Forest fires burning in the western United States have already scorched over 2.5 million hectares this summer. Now a federal proposal to prevent them by paying loggers to cut smaller trees is generating heat among ecologists, who say the approach may not be right for all forests—or all fires.

Leaders of western states have sharply criticized the Clinton Administration for not doing enough to prevent the blazes, the worst in nearly a century. They say that re-

CREDIT: ARTWORK BY JOE BERGERON, COURTESY SKY & TELESCOPE