NONLINEAR OPTICS

Transmuting Light Into X-rays

Despite all the recent advances in laser technology, one dream device remains elusive: No one has yet figured out how to make a tabletop instrument that can pump out a beam of high-intensity, coherent x-rays. Such a device would give researchers Superman-like eyes to peer into living cells or catch the swift dances of molecules during a chemical reaction. Now researchers have the beginnings of such a tool. A report on page 1412 describes a trick for boosting visible laser light efficiently into the soft x-ray range.

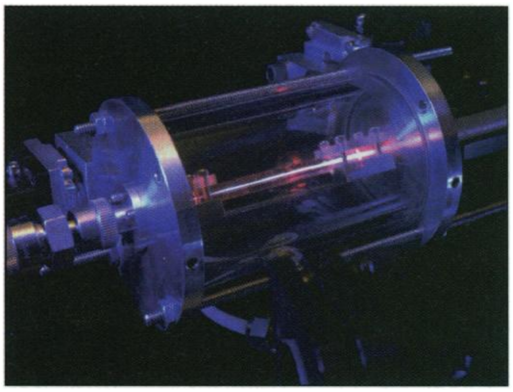
In principle, making a laserlike beam of x-rays, whose waves march in lockstep with each other, is straightforward: Start with a visible light laser, then use a series of crystals to double the frequency of the light, boosting its energy until it reaches the x-ray range. The technique works well for reaching ultraviolet frequencies, but unfortunately, standard frequency-doubling crystals are opaque to x-ray light. So scientists have had to look elsewhere for the energy kick, and most have focused on replacing the crystal with a gas that can more easily transmit x-rays.

When a laser plows into gas, it ionizes most of the atoms, creating a storm of free electrons. But occasionally, says Henry Kapteyn, a physicist at the University of Michigan, Ann Arbor, the laser can pull an electron far out of its orbit and then "slam it back down onto the same atom." When that happens, the atom shoots out a photon that can pack several hundred times the energy of an individual photon in the original laser beam. The process, harmonic conversion, can generate photons in the x-ray range.

But harmonic conversion is horribly inefficient, in part because the gas tends to slow down the laser light much more than it does x-rays. So if the laser blasts through a long volume of gas (which would be necessary to produce a significant quantity of x-rays), the x-rays generated at the front are out of step with those made further back. "[The x-rays] tend to cancel each other out," says physicist Margaret Murnane, also at Michigan.

Murnane, Kapteyn, and their colleagues found a way around this problem by equalizing the speed of the laser light and the x-rays in the gas. First they put the gas, argon in this case, in a precisely machined glass tube that acts as a "waveguide." The waveguide corrals and speeds up the laser light as it zigzags through but doesn't disturb the higher frequency x-rays. Then the team adjusted the pressure of the gas, which fine-tunes the velocity of the two beams, until they marched along at the same pace.

At a "magic pressure of 30 torr," says physicist Andy Rundquist, x-rays shot out of the 3-centimeter-long tube with a surprising intensity when the team blasted the gas with light from a titanium-doped sapphire laser. "At 2:00 in the morning, I was yelling and screaming in the lab," he recalls. Roughly one in 100,000 photons made the jump to x-rays, at least 100 times the proportion seen before, he says. The device, which emits x-ray pulses lasting just 20 femtoseconds, is "the first practical, coherent soft x-ray source," says Kapteyn.



WILLIAM PELLETIER / PHOTO SERVICES

Blue lightning. A 3-centimeter glass waveguide boosts the conversion of laser light to x-rays.

That has some researchers itching to build one of their own. "This will be a wonderful new tool," says Ken Kulander, a physicist at Lawrence Livermore National Laboratory in California, who hopes to use it to excite molecules and watch how they fall apart. "You could even think of using [such] lasers to manipulate [or control] chemistry." Visible-light lasers can drive reactions, he says, "but this opens up a whole new set of states that you can probe."

The technique is "very clever," agrees Janos Kirz, a physicist at the State University of New York, Stony Brook. But he points out that it's not yet capable of making the higher energy x-rays needed for imaging cells. "What everyone wants," he says, is x-rays of wavelengths between 2.3 and 4.3 nanometers, a region called the "water window." In this range, x-rays can slip undisturbed through water and scatter off very small objects, allowing scientists to make detailed images of tiny structures in live cells, which are mostly water.

Several other groups are beginning to see similar gains with waveguides and think a high-intensity x-ray beam in the water window may be in sight. "We could do it in a few years," says Eric Clement, a physicist at the University of Bordeaux in France. Christian Spielmann, a physicist at the University of California, San Diego, is more cautions. It will take a very high intensity laser to make enough x-rays in the water window to be of use, he points out. And such high intensities may, in turn, ionize so many atoms that it spoils the harmonic effect, he says: "This is a first step, but there are many more steps to go."

–David Kestenbaum

BEHAVIORAL GENETICS

New Clues to Alcoholism Risk

The going's been mighty slow, but the ardor for nailing down genes related to alcoholism continues undimmed. At a press conference held last week in Washington, D.C., researchers in the multicenter Collaborative Study on the Genetics of Alcoholism (COGA), now into its 10th year, reported what they called some "significant milestones." Those included debunking one candidate for an "alcoholism gene," coming up with some new hot spots in the human genome where such genes might be located, and firming up a link between alcoholism and a certain type of genetically influenced brain wave.

Looking ever more dubious, according to the COGA people, is the controversial hypothesis that a gene encoding a particular variant of a receptor for the neurotransmitter dopamine increases a person's risk of alcoholism and other addictions. Biologist Howard Edenberg of Indiana University School of Medicine in Indianapolis reported that "we found absolutely no evidence" for such a link. In 105 families of alcoholics, the suspect gene was not transmitted any more often to alcoholics than to nonalcoholics.

Psychiatrist Ernest Noble of the University of Texas Health Science Center in San Antonio, a leading proponent of the dopamine-receptor gene hypothesis, says he is undeterred by the findings. Family-based linkage studies—as opposed to association studies done in the general population—lack sufficient "power" to detect the effect, he says; and besides, the COGA researchers are looking only at alcoholism when the effect may not rise to significance unless other compulsive disorders are also taken into account.

COGA researchers have, however, found hints of other genes that might increase the risk of alcoholism. Psychiatrist Theodore Reich of Washington University School of Medicine in St. Louis described a linkage study in which researchers scanned 291 markers (segments of