Lasing plasma makes 'soft' X-rays

An X-ray laser has long been a goal of researchers. But the short wavelength needed to accomplish this makes it more difficult to produce the lasing effect. (Lasers began as long-wave, infrared devices.) Two sets of experiments described this week at the meeting in Boston of the Division of Plasma Physics of the American Physical Society now bring lasers to the edge of the X-ray portion of the spectrum. Dennis Matthews and Mordecai Rosen from the Lawrence Livermore National Laboratory in Livermore, Calif., are calling their achievement a soft X-ray laser. Szymon Suckewer from the Princeton (N.J.) Plasma Physics Laboratory (PPPL) of Princeton University is not quite ready to make that claim.

Both sets of experiments use plasmas— that is, ionized gases—as the lasing medium. The plasmas are made by irradiating small samples of solid material with light from visible, or infrared, lasers. The laser light vaporizes and ionizes the solids. The Livermore experiments used selenium and yttrium as lasing materials; PPPL used carbon. Livermore's selenium produced wavelengths of 209 and 206 angstroms; its yttrium yielded 155 angstroms. In some of the selenium runs — there were more than 50 experiments at Livermore altogether — the X-rays were amplified up to 700 times what the material would have emitted spontaneously without a laser effect. The PPPL experiments amplified 182-angstrom radiation up to 100 times what the carbon would have emitted spontaneously.

The procedures of the two sets of experiments differ somewhat in detail, but basically, when the lasing material has been ionized, a great deal of energy is invested in the high-energy states of the outermost electrons. This condition is called a population inversion, as it is contrary to the material's normal condition, in which the high-energy states would have a small share of the available energy.

While the population inversion is present, some ion within the plasma loses energy, producing a photon, or light particle, of a certain wavelength. As this photon moves through the material, it stimulates other ions to radiate at the same wavelength and in phase with each other. This procedure, with the ions radiating in chorus so to speak, delivers an intense burst of coherent radiation at a particular wavelength. Without the stimulated emission—that is, the laser effect—the material would radiate randomly and incoherently.

The amount of amplification produced by the stimulated emission depends on the so-called gain factor and on the length of the column of plasma that radiates. The PPPL experimenters claim a gain of 6.5; the Livermore group calls theirs 5.5. However, the greater length of the plasmas involved in the Livermore experiments accounts for their greater amplification factors. The PPPL announcement states that a gain of 10 would be characteristic of an entry into a full laser regime. Matthews told Science News that a review committee of prominent laser physicists advised him not to be so modest and to "call it a laser."

If X-ray lasers can move from experiment to practical technology they could have many uses. X-ray holograms could reveal three-dimensional pictures of such biological structures as DNA. Coherent X-rays might also simplify such procedures as computer-assisted tomography (CAT scans). Solid-state physicists would have a new and sharper means of probing the structure of solids and their surfaces. Technologically, coherent X-rays might be used for lithography, "printing" microcircuit designs on a suitable substrate.

The Livermore announcement suggests that use of still other materials could in principle make X-ray lasers at shorter and shorter wavelengths. Whether such extensions are experimentally and technologically practical remains to be seen. It is a long way down to the domain of medical X-rays, which are much "harder," ranging around half an angstrom, or about 1/200 to 1/400 of the wavelengths in the present experiments.

Lasers at visible-light wavelengths increase their amplification by using mirrors at the ends of the column of lasing material to reflect the light back and forth through it many times. These experiments, however, do not use mirrors. Until recently, mirrors that could reflect X-rays perpendicularly did not exist, but technology now can produce some carefully made, layered materials that will do this kind of X-ray reflection, and the Livermore announcement suggests that someday X-ray lasers may use such mirrors.

—D.E. Thomsen

Interspecies gene-transfer ban rejected

The major federal advisory group on recombinant DNA research this week unanimously voted down two proposals to prohibit transfer of genetic traits between mammalian species. Both of the proposed amendments to the current National Institutes of Health guidelines — the rules governing genetic engineering research in the United States—were sought by Jeremy Rifkin of the Foundation on Economic Trends in Washington, D.C. One proposal would have banned the transfer of a genetic trait from one species into the germ line (reproductive cells) of a mammalian species with which it cannot mate and produce offspring. The other proposal would have prohibited the transfer of genetic traits from any human being into the reproductive cells of a mammal of another species, or from another mammalian species into human reproductive cells.

Not only did the Recombinant DNA Advisory Committee (RAC) reject the proposals, but it also passed a resolution stating that the potential benefits of such gene-transfer research "make it a moral imperative that we strongly oppose the blanket prohibition of this class of experiments." The work, according to the committee, offers long-term possibilities for treatment of human and animal disease, as well as for the development of more efficient food sources.

The Rifkin proposals, published in the Sept. 20 Federal Register, triggered an exceptionally large response. Letters, almost entirely in opposition to the proposed amendment, came from more than 50 scientists and more than 250 laypersons. Many of these letters came from a few towns in Ohio and Kentucky, and were inspired by a family with two young children who have a rare, fatal genetic disease.

Rifkin told the committee he opposes the gene-transfer experiments because they "begin to eliminate the concept of species boundaries in nature" and will eventually "reshape our concept of life."

In support of the Rifkin resolutions, Michael Fox of the Humane Society of the United States described disorders that have arisen in farm and domesticated animals as a result of traditional breeding for desirable characteristics, and suggested that genetic engineering would also produce such problems. He also stated concern that animals will be turned into biological machines, to be milked or bled for hormones and other biological substances. "I hope you will look through the eyes of animals when you come to address these issues," he said.

One example of a gene-transfer experiment already being performed is the transfer of the human growth hormone gene into pigs and sheep in an attempt to make livestock that grow more efficiently. Rifkin and Fox recently filed a suit against the U.S. Department of Agriculture in an attempt to stop these experiments (SN: 10/13/84, p. 229).

In other action at the meeting, the committee heard a report from its newly formed "working group on human gene therapy," which will review proposals for experiments in this field. The group decided to concentrate on somatic (nonreproductive) cell gene therapy, rather than the ethically more difficult and practically more distant possibility of inserting genes into the human germ line. The committee expects to receive the first somatic cell gene-therapy proposal within the next six months.

—J. A. Miller