Highlights at Clea: a preview
Ultraviolet lasing from xenon
The News in Focus

Xenon-laser race ends in a photo finish but Northrop team attains highest power

The race to achieve vacuum-ultraviolet laser action in xenon gas is over, and the winner appears to be a research team from the Northrop Corp. and Los Alamos Scientific Laboratory. A three-way photo finish was indicated March 14 during a postdeadline session of the Optical Society of America’s meeting in Denver. Those results still are being studied while additional returns continue to appear.

- A. Wayne Johnson of Sandia Laboratories presented experimental data that demonstrated lasing from the lowest bound diatomic states of xenon to the repulsive ground state. In addition to spectral narrowing, which Johnson called “a necessary but not a sufficient condition for net optical gain,” he emphasized that the stimulated-emission crosssection was larger than the photoionization crosssection at wavelengths near 1,730 angstroms.

- M. L. Bhaumik of the Northrop Corp. reported the first observation of strong laser oscillations with specular mode patterns burned into mirrors. From the energy required to melt aluminum mirror coatings Bhaumik, E. Ault and their colleagues at the Los Alamos Scientific Laboratories inferred output of one joule of laser energy, at 0.1 joule per cubic centimeter. Lasing was inferred from spectral narrowing from 150 to 2.5 angstroms, with a thousandfold increase in intensity, and from well-defined mode patterns observed.

- During a discussion following the two papers, William Krupke disclosed that laser action from xenon gas also had been obtained at the Lawrence Livermore Laboratory by Charles Rhodes and Paul Hoff. The Livermore researchers will describe their results late this month at the Conference on Laser Engineering and Applications, Krupke added. The Livermore researchers have observed a propagating beam with both spatial and temporal coherence as well as spectral narrowing.

- The developments revived speculation that Soviet researchers may be withholding information about progress — including possible lasing — from xenon gas (LF Jul p20).

This type of laser is sought because of its potentially high power in the vacuum ultraviolet, high quantum efficiency, possibly high net efficiency, and wavelength tunability. Furthermore, lasing in xenon gas opens the prospect of a new class of lasers based on molecular association. Participants in the March 14 discussion mentioned, among others, helium lasing at 600 angstroms, lithium-xenon at 9,000, sodium-xenon around 7,000, and mercury at 3,340 or 4,850.

The Northrop experiments

Both Sandia and Northrop energized the gas with powerful electron beams. The Northrop researchers, working with a team from Los Alamos, used a 0.5-MeV beam at Maxwell Laboratories to deliver 80-nanosecond pulses at 150 kiloamperes transversely to the 12-centimeter-long cell containing xenon at 12 atmospheres. Average current density inside the Monel gas cell was estimated to be 1,000 amps per square centimeter, providing about 1,000 joules input to the gas.

The optical cavity was formed by a five-meter total reflector on a Pyrex substrate 12 centimeters from a plane-output mirror on a substrate of MgF2. The mirrors were prepared by aluminum coating with an overcoat of MgF2. Alignment was accomplished with a helium-neon laser.

The laser diagnostics were accomplished primarily by spectral measurements to observe lasing. Dispersion of a spectrograph near 1700 angstroms was about 10 angstroms per millimeter with maximum resolution of 0.1 angstrom.

Densitometer traces show that laser emission occurred at 1,727.5 to 1,732 angstroms with a linewidth of 2.5 angstroms. Bhaumik reported, while spontaneous-emission width was 150 angstroms centered at 1,730 angstroms. Resolution of the doublet on the film followed the spectrometer’s resolution, he added, eliminating the possibility of any artifact causing the doublet.

The mode structure, as depicted by the symmetric burn pattern on both mirrors, is shown in the photograph accompanying this article. “The pattern is obviously multimoded,” Bhaumik explained, “since the fundamental mode waist is calculated to be about 0.1 millimeter.” The burn spot became smaller and moved toward the electronbeam entrance window when the pressure was increased to 20 atmospheres, showing that the electrons' energy was not sufficient to go through the highpressure gas.

He attributed this blockage to excessive scattering by the high-pressure gas or to “some other nonlinear phenomenon,” since the gas’s classical stopping power is much too low to cause such a drastic reduction in E-beam intensity.

The burn spot on the mirror was repeated in every shot. When the mirrors were misaligned or one cavity mirror was removed there was neither a burn spot on the mirror nor any line narrowing with increase in intensity. “This proves,” he said, “that the observed mirror burn spot could not be due
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to some artifact like damage by scattered E-beam, pressure-wave or superradiant emission."

From the mirror burns and the mass of the evaporated coating on the semitransparent window, he estimated that the coating absorbed nearly 0.34 joules. Since the coating on the total reflector was thicker, it apparently did not evaporate completely. But since the absorption by the coating and the spot size were nearly the same on both mirrors, the total reflector "should have absorbed another 0.34 joule," he said. He added: "Considering the energy necessary to heat the coating to melting point, together with the heat of fusion and also to burn off the MgF₂ overcoats, the total laser energy is estimated to be at least one joule."

Turning to the possibility of other lasers based on other molecular associations, he observed that these emissions are inherently broadband, "indicating the possibility of tunable, highpower lasers over a wide range of frequencies."

He ended his talk in Denver by noting that only 25% of the excited volume had been extracted, showing an efficiency of about 0.5%. "Much higher efficiencies should be possible under optimum conditions," he added. "Since the deposition of E-beam energy is expected to have efficiency of 30% to 50% and quantum efficiency is 80% to 90%, an over-all laser efficiency of 10% to 20% seems quite reasonable."

Johnson's coauthor was J. B. Gerardo. Bhattacharjya's think photonics!

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were W. Hughes and R. Jensen of Los Alamos and A. Kolb and J. Shannon of Maxwell.

The Livermore results

In reporting stimulated emission at 1,722 ± 1 angstroms in high-pressure xenon gas, Hoff described strong line-narrowing, spatial coherence "corresponding to a few times the diffraction limit," a sharp oscillation threshold, and an output-time dependence "radically different from the spontaneous emission observed without an optical cavity or below threshold." This combination of results, he concludes, is "an explicit and unequivocal demonstration of a coherent stimulated-emission process."

With the gas near 200 pounds per square inch, they found that spectral linewidth, measured photographically, narrowed from about 160 angstroms without mirrors to a halfwidth of about 15 angstroms with the optical cavity.

In addition to the xenon laser, the researchers observed oscillation in pure krypton at 1,460 ± 2 angstroms with an eight-angstrom linewidth. "The most difficult task in getting krypton to lase," he said, "was minimizing xenon impurities which deactivate the krypton dimer and introduce loss near the peak" of the Kr+ spontaneous-emission contour.

Slight changes in federal standard fail to satisfy laser manufacturers

A proposed federal standard for laser products has advanced another step toward enactment.

The draft, prepared by the Bureau of Radiological Health, received the approval of the agency's technical advisory group, the Technical Electronic Product Radiation Safety Standards Committee. The document now attains the status of a "proposed standard," and probably will take effect late in 1974 following publication in the Federal Register and further comments from affected parties.

But laser companies made clear their continued dissatisfaction, despite a few modifications of the version that had been subjected to lengthy criticism at a public hearing in February (LF Apr p36).

Some of the modifications represent concessions to manufacturers and users who contend that the standard is unnecessarily restrictive. Other changes bring the federal standard for manufacturers into closer agreement with a users' standard that is expected to be adopted by the American National Standards Institute.

Changes since February

The principal modifications by the bureau following the February hearing are as follows:

• Accessible emission levels will be expressed as energy or power detectable within a circular aperture of 80-millimeter diameter. Size of the collecting aperture was ignored in the earlier draft. For beams of diameter less than 80 mm, other suitable measurements are acceptable.

• Scanned lasers are covered in a section that was

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14 Circle No. 44 LF May 1973