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China emphasizes laser research

One of the eight scientific fields receiving special emphasis in the People's Republic of China these days is lasers. At the International Quantum Electronics Conference to be held in Boston this June, seven of the fifteen papers submitted from China were accepted. For the conference as a whole, 150 papers were accepted out of 450 submitted, suggesting that the Chinese are now competitive internationally.

Generally, the most advanced laser research I saw during my recent three-week visit to China (PHYSICS TODAY, March, page 32) was at the Institute of Optics and Fine Mechanics in Shanghai. But a number of other institutes and university physics departments also showed me laser research or development projects.

Laser research began in China in 1961, and three years later Academia Sinica established the Shanghai Institute of Optics and Fine Mechanics as a center for laser research, vice-director Teng Hsi-ming told me. At present, the Institute has 1400 staff members. However, 600 of them are doing production of equipment and parts, because they are unavailable commercially. Of the remaining staff, 500 are university graduates, and of those, 200 are PhD level or equivalent.

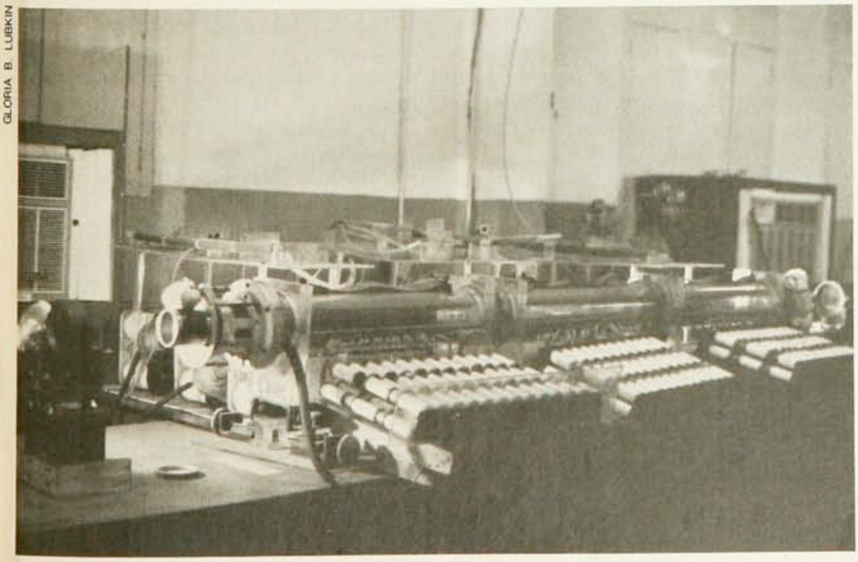
In 1964, physicists at the Shanghai Institute of Optics and Fine Mechanics, using a neodymium-glass laser with 100-MW output, observed air breakdown and nonlinear transmission of a laser beam, three years after nonlinear optical effects were first observed in the US. In 1965, inertial-confinement experiments began there with a neodymium-glass laser. The following year the ten-year Cultural Revolution began, undoubtedly hurting laser research throughout China, even the applied work. But by 1973, with a single beam emitting 10 GW, experimenters heated a frozen deuterium plane target and observed 1000 neutrons (with a boron trifluoride detector and with a plastic scintillator). A year later, the laser output was increased to 100 GW with a pulse length of 2–4 nanosec. Again using a plane target—either LiD_2 or CD_2—they observed 2×10^4 neutrons.

Shortly after the end of the Cultural Revolution—in 1977—experiments at the Institute began with a six-beam laser; each beam produced 100 GW for 1 nanosec. Each final output rod of the laser has a 70-mm diameter. The system has now been improved to operate in 100-picosec pulses, too. (For comparison, the six-beam Zeta laser-fusion facility at the University of Rochester produces 3–4 TW at 50 picosec or 1 kJ at 1 nanosec; each of its six beams has a final rod diameter of 90-mm.)

In 1977, when the Shanghai experimenters aimed their laser at a glass microballoon filled with neon gas, they observed compression of the shell (by means of an x-ray pinhole camera). Now the system is being used to irradiate a glass microballoon filled with either deuterium or neon.

During a lab tour, I saw the huge laser array, visited the target-chamber room, and saw a variety of diagnostics: BF_3 detector, plastic scintillator, x-ray pinhole camera, x-ray line spectrometer with a spatial resolution of several tens of microns, a cw spectrometer, an x-ray calorimeter and a Faraday cup.

GLORIA B. LUBKIN



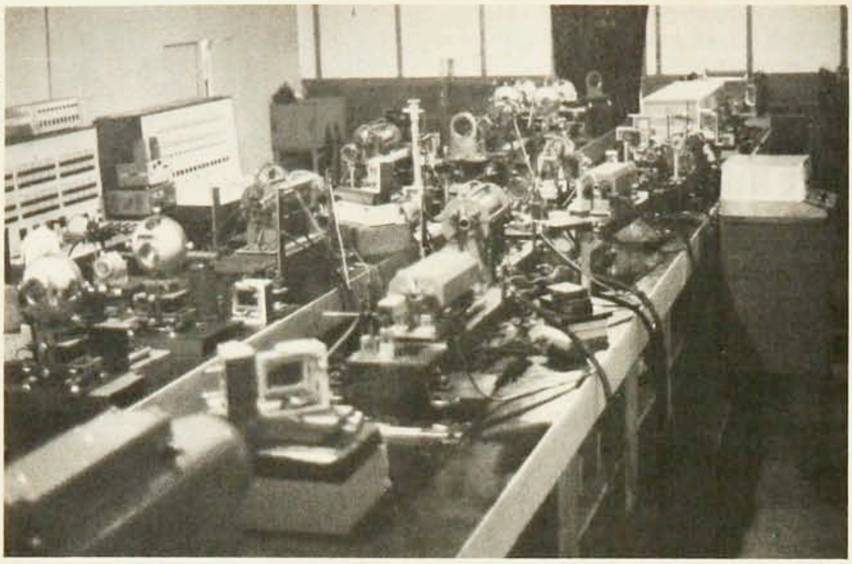
TEA carbon-dioxide laser at Academia Sinica's Institute of Optics and Fine Mechanics in Shanghai has an output of 20 J lasting 1.5 nanosec. Its amplifier is electron-beam controlled.

In 1978, a group at the Institute of Physics in Peking reported using four-wave mixing to study the properties of liquid crystals. One of the group members was Yuen-Ron Shen of Berkeley, who was spending his sabbatical in Peking. A similar experiment was subsequently reported earlier this year by Amnon Yariv and his Caltech collaborators. The Institute of Optics and Fine Mechanics showed me four-wave mixing of two-phase conjugation in a dye solution. They had been interested in demonstrating that the effect could be produced in a highly absorbing medium as well as a transparent one. By modulating the infrared output of a laser, the Institute of Optics and Fine Mechanics experimenters were able to produce a visible output—putting on a colorful demonstration for me in the bargain. Conversion occurs in a nanosecond. Wu Tsun-kai told me he believes the quantum efficiency of the system can be greater than unity.

At the Institute of Optics and Fine Mechanics, Teng told me, is an active program to study nonlinear optical distoration of materials; the Institute is trying to raise the threshold for self-focusing. Teng also showed me a TEA carbon-dioxide laser with an output of 20 J lasting 1.5 nanosec. Its amplifier was electron-beam controlled. (For comparison, the Helios CO_2 laser at Los Alamos has produced 4 kJ in a 1.5-nanosec pulse.)

The Institute of Metallurgy in Shanghai started doing laser annealing in the fall of 1978, with the help of Bernhard Deutch from Aarhus University in Denmark. Since then the Institute has used the technique in a layer of silicon or gallium arsenide after ion implantation to raise the solubility limit—resulting in a higher conductivity. The Institute is also doing laser epitaxy: After depositing an amorphous layer (several thousands of angstroms thick) on a substrate, the experimenters convert the layer to a crystalline form with laser annealing. The Institute has also been doing laser metallization: The experimenters evaporate a thin film of AuGe on a GaAs substrate and then use laser annealing to produce an ohmic contact between the GaAs and the AuGe.

The Institute of Physics in Peking is exploring new methods for optical information processing. Chen Yuan-song showed me his group's efforts to produce a Walsh transformation optically, as has already been done elsewhere for Fourier transformations. The group is working with a one-dimensional eight-sequence complex Walsh matrix. Their coherent source is a helium–neon laser. Their optical components are computer-generated holographic lenses. Each lens has six degrees of freedom; so 24 degrees of



Six-beam neodymium-glass laser is being used for inertial-confinement experiments at the Shanghai Institute of Optics and Fine Mechanics. Each beam produces 100 GW in 1 nanosec.

freedom are present. The main experimental difficulty is controlling the phase angle and alignment (to within 10 microns).

Laser research and development appears quite widespread in China. For example, lectures on laser spectroscopy given by Arthur Schawlow (of Stanford University) at Shanghai Normal University in November were attended by over 100 physicists representing 56 institutes from all over China. Even at the generally less well equipped university physics departments, I saw some laser activities. For example, at Northwestern University in Sian, I saw work on optical-glass coating and nonlinear optics. Both Northwestern and Tsinghua University in Peking have small factory operations, which produce commercial helium-neon lasers. However, these university-based factories are remnants of the Cultural Revolution that appear to be on their way out.

—GBL

Long-term goals for nuclear science

The emerging quark–gluon picture of the strong force promises nuclear physics for the first time a theoretical basis for describing the short-range interactions in nuclei. This is one of many recent advances discussed by the Nuclear Science Advisory Committee in its report entitled *A Long-Range Plan for Nuclear Science*. The Committee was set up two years ago by the Department of Energy and the National Science Foundation as a permanent advisory body for planning and funding in nuclear physics and related areas (see PHYSICS TODAY, February 1978, page 77).

The Advisory Committee's report, prepared for DOE and NSF under the chairmanship of Herman Feshbach of MIT, sets out to identify the important scientific questions that ought to be attacked in the next decade, and to outline the nuclear-science capabilities that will be needed for these attacks.

A similar survey was undertaken three years ago by the Ad Hoc Panel on the Future of Nuclear Science, headed by Gerhart Friedlander of Brookhaven. Unlike the Friedlander Panel, which was under the auspices of the National Research Council, the Nuclear Science Advisory Committee's report was solicited by the primary funding agencies themselves. In accordance with the DOE/NSF request, the Advisory Committee has attempted to be realistic about funding prospects in preparing what Feshbach describes as "a minimal program, including only those components essential . . . to address the important scientific issues of the next decade."

The Advisory Committee's report begins by surveying significant advances in the past few years in various areas of nuclear science, the questions they raise and the opportunities they afford:

▸ Quarks. The recent spectacular successes of quantum chromodynamics in high-energy physics raise the question of how the quark–gluon structure of the nucleons manifests itself in the properties of nuclear matter. Feshbach pointed out to us that the "MIT bag," which seeks to describe confinement of quarks in the nucleon, has a radius of about a fermi. These quark bags would therefore seem to fill up the nuclear volume. Quantum chromodynamics, the report says, may provide us for the first time with a short-range description of the nuclear force.

▸ Diproton states. In the past two years polarized proton–proton scattering experiments have provided surprising evidence that there may be resonances in the diproton system. Because the naive proton–proton potential is too weak to bind a pair of particles as light as protons, this result strongly suggests that heavy isobars play an important role in the nuclear force. It should be possible, the report suggests, to determine the probability of finding an isobar such as the Δ (1236 MeV) inside the nucleus. The diproton resonances point up the importance of polarized beams and targets.

▸ Hypernuclei. Techniques have recently been developed to produce hypernuclei systematically in well defined states. Incident K^- beams convert nucleons to Λ hyperons, producing short-lived hypernuclei of strangeness -1. A number of energy levels have been seen, but the measurements have not been sufficiently extensive or accurate to determine the pattern of these levels. These investigations enable one to study the interactions of nucleons with strange baryons in nuclear matter. Last fall experimenters were surprised to discover the first hypernuclei with Σ rather than Λ hyperons. The remarkable stability of these unexpected hypernuclear states requires further study.

▸ Antiprotons. In the past few years experiments have suggested but by no means confirmed the existence of a number of proton–antiproton resonances with masses near 2 GeV. These states (if they exist) are thought to be bound states of two quarks and two antiquarks. The Committee thinks it of great importance to confirm the existence of such "baryonium" states and to determine their properties, for a better understanding of the quark nature of the nuclear force at small distances. This will require intense new antiproton beams.

▸ Giant resonances. Two new "giant resonances," indicating simple vibrational modes of the nucleus as a whole, have been detected recently by inelastic scattering experiments. The giant monopole resonance, seen only in heavier nuclei, is a "breathing" mode, in which the nucleus expands and contracts radially. This lets one measure the compressibility of the various nuclei, adding a new parameter of nuclear matter for testing theories of nuclear structure.

▸ Unified theories. Nuclei show promise as "microscopic laboratories," to test theories of elementary-particle interactions, especially the Weinberg–Salam theory that unifies the weak and electromagnetic forces. An important recent result has been the verification of relationships between nuclear gamma emission and beta decay predicted by that theory. By investigating the scattering of polarized electrons off selected nuclei, it should be possible to determine the spin