HIGH-INTENSITY ELECTRON ACCELERATOR at Cornell. Marx generator (right) erects a 700-kV pulse in about 300 nanosec. Then Blumlein transmission line (left) is charged to 500 kV in about 1 microsec and the energy is discharged.

in the direction of the beam, the beam can propagate without neutralization of the self magnetic field and even without electric neutralization.

Each of these propagation modes has been observed, for example by J. C. Ingraham and L. Bradley at EG & G; T. G. Roberts and Willard H. Bennett[4] of North Carolina State University, and J. Bzura, Fleischmann and Linke at Cornell.

The technology for such beams involves well known components. High voltage is usually produced by Marx generators or a Van de Graaff accelerator. A transmission line (Blumlein) is charged to high voltage and used to form a pulse of 0.25–5 MV for 20–100 nanosec. The voltage is applied to a low-impedance field-emission diode that features a thin-foil anode. Accelerated electrons pass through the anode into the drift tube that usually has a metallic-surface conductor, which may carry all or part of the return current (depending on the conductivity of the gas in the drift tube). J. Charles Martin of the UK Atomic Energy Authority has done pioneering work on these techniques.

Experiments with high-current electron beams in the US are taking place at Physics International Co, San Leandro, Calif.; Ion Physics Corp; Sandia Corp, Albuquerque, N. M.; Naval Research Laboratory, and Cornell. At the Lebedev Institute in Moscow, a program devoted to this problem is directed by Matvich S. Rabinovich.

Now that relativistic-electron beams with such large electron density (10^{11}–10^{12} cm^{-3}) and energy flux are available, one of the most interesting physics applications is the prospect for relatively inexpensive ion accelerators. Various methods for picking up or accelerating ions have been proposed.

- Cerenkov radiation of plasma waves: In the frame of reference where electrons are stationary, ions should radiate plasma waves and decelerate; therefore in the laboratory frame ions should accelerate. This mechanism was proposed by V. I. Veksler.[5] Veksler's theory has been applied to data of Nablo and his collaborators by John M. Wachtel of the Defense Atomic Support Agency and Bernard J. Eastlund of AEC.[6]
- Rostoker[7] has pointed out that when the electron beam goes through a neutral gas there must be a space-charge region at the front where the beam has not yet been neutralized. This region constitutes a potential well for ions, and ions produced at the bottom of the well will be accelerated.
- G. A. Askariyan of the Lebedev Institute suggests that if a plasmoid (a ball of plasma) carrying a current is placed in the path of the beam, the beam electrons will be reflected by the magnetic field of the plasmoid, thus accelerating the plasmoid.[8]
- An electron beam, without neutralization, in a constant guide field should have a constant density. In a method proposed by L. Kovrizhnykh of the Lebedev Institute, the electron density can be increased locally by increasing the strength of the guide field locally; this would produce a potential well for ions. Then the ions can be accelerated with a local concentration of the guide field produced by a traveling magnetic-field wave.

Nablo has reported[9] ion currents of the order of 100 amperes for about 5 nanosec when an electron beam of about 50 000 amperes is injected into a neutral gas. He observed ion energies about ten times the electron energy.

So far there are insufficient data to identify the acceleration mechanism and estimate the ultimate capability, but the chances look good that high-current relativistic electron beams will lead to economic and versatile ion accelerators.

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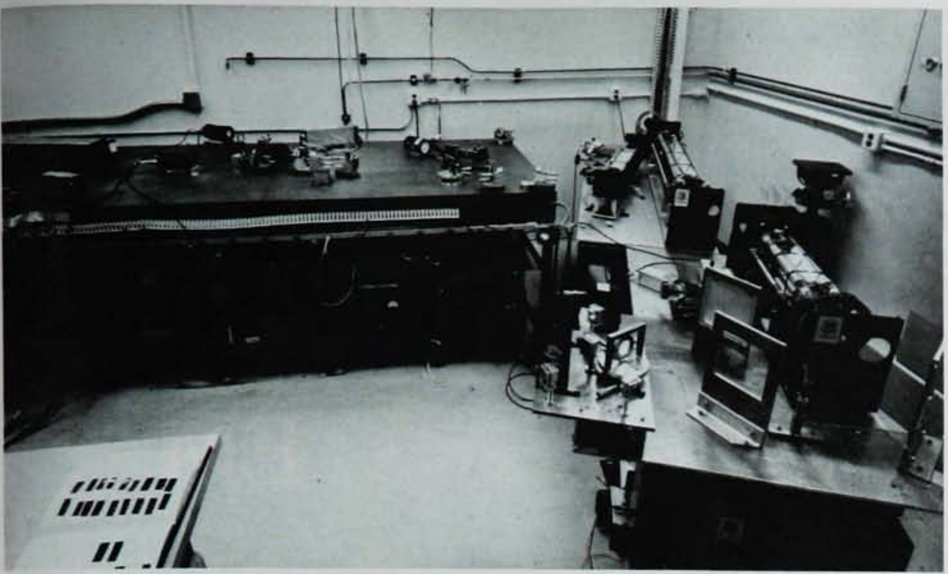
Sandia Operates Picosecond Laser at 50-Joule Output

A laser that emits 50 joules in about 2 picoseconds is now running at Sandia Laboratories in Albuquerque. Its basic input is the train of pulses from a mode-locked neodymium-doped glass laser. Garth Gobeli, Eric Jones, Paul Peercy and James Bushnell hope to use the short high-energy pulse to produce among other things thermonuclear reactions.

The laser has five neodymium-doped glass rods—a small oscillator rod and four amplifier rods ranging from 53 to 105 cm long. The oscillator generates a train of ultra-short light pulses, one of which is selected and amplified. (The final three amplifier stages were built by American Optical Co. to Sandia specifications.) Overall gain is 50 000 to 150 000, with the final stage operating in the gain-saturated mode.

(*cont.*, p. 63)



SANDIA LASER has emitted 50 joules in about 2 picosec. Overall gain is 50 000 to 150 000. The mode-locked neodymium-doped glass laser has four amplifier rods. Table at left is 4 meters long; two tables at right are 3 meters long.

The total light-path length through the laser is about 18 meters from the 100% reflector of the oscillator to the output face of the last laser rod. The pulse length is measured by a two-photon fluorescence system.

The laser has a beam divergence (quoted by American Optical) of 1 milliradian and an output diameter of 3.8 cm.

In the fusion experiments, the Sandia group hopes to generate thermonuclear neutrons by focusing the laser on a solid LiD or Li_2DT surface. Gobeli says that with a nanosecond pulse striking a solid target, the front surface evaporates so fast that the resultant plasma, formed in front of the target, shields it from some fraction of the incident energy; so one is uncertain how much energy is actually deposited. With picosecond pulses, however, one can be fairly certain that the energy is deposited in the target. The longer pulses are good for making lots of plasma, but at Sandia the emphasis will be placed on producing neutrons, Jones explains.

Nikolai Basov and his group at the Lebedev Institute (PHYSICS TODAY, November, page 57) have done similar experiments with solid lithium deuteride and believe they have observed thermonuclear neutrons. The group is now rebuilding its laser.

The Sandia experimenters also plan to use their laser for studying radiation damage, attempting to observe photon-photon and electron-photon scattering, producing precisely variable shock waves and studying their effects on materials.

Vela Pulsar Slows, Speeds Up, And Then Slows Down Again

If some observers were surprised to find pulsars slowing down, they must have been utterly astonished to learn that the pulsar in the Vela remnant (PSR 0833-45) apparently sped up between 24 February and 3 March, and then slowed down again. Paul Reichly and George S. Downs of the Jet Propulsion Laboratory (International Astronomical Union circular no. 2140) report that during the seven-day interval the pulsar period decreased by 134 nanosec and then resumed its former rate of increase.

So astronomers have one new puzzlement about pulsars.

IN BRIEF

The University of Bochum in West Germany has ordered a 9-MeV tandem accelerator from Radiation Dynamics, Inc., at a cost of just over $1 million. The research program on nuclear structure will be directed by D. Kamke.

A 2-MeV Van de Graaff accelerator has been passed from Illinois Institute of Technology to De Paul University last summer. It will be used for undergraduate and graduate teaching and research projects under the general direction of Thomas Stinchcomb, chairman of the De Paul physics department. □