ratory experiments, Anthony Pirri and Peter Nebolsine used helium, which was struck by radiation from four TEA carbon-dioxide lasers, producing 10 J each, fired sequentially at intervals of 10–100 microseconds. As the experimenters approach shorter times between pulses, they expect to run into an acoustic-valve limitation. Experiments so far were done at ambient pressure, and have generated a specific impulse of more than 900 seconds.

New experiments will be done in a vacuum chamber and are expected to improve the specific impulse 25%. In the future, Physical Sciences plans to experiment with various expellants, optimize the collector/nozzle, increase the energy and reduce the pulse repetition rate. They also plan to study the effect of varying the angle of incidence between the nozzle axis and the optical axis of the laser beam.

Weiss envisions the Physical Sciences system as useful for moving from low earth to high earth orbit or producing a ground-based high launch-rate system that could raise 2 tons at a time—"a conveyor belt to the sky." The laser would need 1 MJ/pulse, with 350 pulses/sec for a 2-ton payload and would generate 20 000 pounds of thrust.

NASA supports research at Physical Sciences using cw lasers for operation outside the atmosphere. In this work Physical Sciences has been studying absorption through a laser window. They have considered using hydrogen as an expellant, alone or with various seed materials, such as sodium or cesium. In another approach, discussed by Pirri and Weiss, one introduces air from a hypersonic inlet, and pulses the laser in the Physical Sciences system studied for DARPA.

In experiments being done by Lewis Research Center, a cw carbon-dioxide laser heats hydrogen plasma on the subsonic side of the nozzle, the gas flowing in the same direction as the laser. The absorption wave is supported by the laser. The objective is to heat hydrogen to 15 000–20 000 K.

The NASA program concentrates on orbit-to-orbit propulsion. A cw laser transmitter energized by the Sun might be located at 500-km orbital altitude. The laser would transmit energy to a rocket. Because the rocket is so far from Earth gravity, the thrust required to launch a 5000-pound payload would be only 50–100 pounds. In the NASA concept, a laser would strike a 1–2-meter mirror on the rocket. The beam would be focussed and used to heat hydrogen. The energy conversion could involve inverse bremsstrahlung or excitation of vibrational levels of molecules.

Besides supporting Physical Sciences, NASA has funded Rocketdyne Division of Rockwell International. They have built a tiny thruster whose throat is the size of a hypodermic needle. The thruster will be tested at Lewis Research Center. Lockheed is doing a systems study to see how laser propulsion from orbit to orbit compares to a conventional chemical system. So far, NASA's Carl Schwenk and Frank Stephenson feel that the laser approach looks reasonably promising.

The Lebedev Institute is considering[1] a solid-propellant (such as graphite) cw laser jet engine. If the propellant is heated to too high a temperature, a breakdown wave is produced. To avoid this, one must heat below the threshold, and according to Reilly, this limits the effective specific impulse to about 600 seconds. In addition, Lebedev is also considering a laser air-breathing jet engine similar to that of Kantrowitz and Rosa. —GBL

Reference

1. F. V. Bunkin, A. M. Prokhorov, Sov. Phys. Uspekhi **19**, 561 (1977).

Electron storage ring from Cornell synchrotron?

If Congress approves President Carter's science budget, Cornell University will proceed with plans to convert the Wilson Laboratory synchrotron facility into an electron storage ring. The President's budget includes an NSF request for funds to build the storage ring (known as CESR); design and prototype stages are already well advanced. The storage ring is to be housed in the synchrotron tunnel, and—in a novel injection scheme—the synchrotron itself injects electrons into the ring. Maximum design luminosity is $10^{32}/\mathrm{cm}^2\mathrm{sec}$ at about 8 GeV, so that the efficient operating range for CESR lies between that of existing storage rings (SPEAR at Stanford and DORIS at DESY) and the PETRA and PEP rings now under construction. Both SPEAR and DORIS have maximum beam energies of about 4 GeV, whereas PEP and PETRA are to have maximum luminosity at energies of about 15 GeV. In the range 4 GeV–8 GeV, the CESR design calls for four times the luminosity of the higher-energy rings. This is a particularly important consideration because, in storage rings, all experimental areas must operate at the same energy at any one time, and colliding-beam experiments can take several months, even at high luminosities.

To keep costs down, the plans call for developing only one of the two interaction regions as a major experimental area, at least at first. This area will be in the present South Experimental Hall. A group of some 40 physicists from the University of Rochester, Cornell, Harvard, Rutgers, Syracuse and Vanderbilt Universities are busily designing a general magnetic detector with maximum flexibility. "We're trying to use the previous experience of SPEAR and DORIS as a guide in designing the detector," commented Maury Tigner, director of operations at the Laboratory, in our conversations with him.

As Tigner explained to us, the magnet will be a solenoid—superconducting if possible—with a 2.0-meter inner diameter and a length of 3.2 meters. Within the coil, experimenters will be able to observe charged-particle trajectories and detect photons at small angles. Outside the coil, shower counters will measure photons, and a combination of time-of-flight, dE/dx and Cerenkov counters will identify particles. Surrounding all these detectors will be a thick shield of iron interleaved with muon detectors. The goal is to be prepared to measure electron-positron annihilation cross sections, hadronic and leptonic decay of new particles and monoenergetic photons, as well as to identify particles over a wide momentum range, since the onset of new phenomena in this unexplored energy range will presumably be accompanied by changes in particle composition. (A few smaller experiments will also be possible in the limited space of the North interaction area. Anyone interested in proposing experiments for this area should write to Boyce McDaniel, director of the Laboratory.)

The technique known as "vernier phase-space compression," developed at Cornell, will allow rapid injection of electrons and positrons directly from the synchrotron. Positrons in 60-bunch trains are injected from the linac into the synchrotron, accelerated to 8 GeV, extracted from the synchrotron in a single turn and injected into the storage ring. This process is repeated and the bunches stacked one atop the other within the ring. To coalesce these bunches into a single bunch, vernier compression comes into play. In brief, this technique exploits the existence of a planned size difference equal to one bunch space, between the synchrotron and storage-ring circumferences. The positron bunches are reintroduced into the synchrotron one at a time. Because of the circumference difference, the bunch in the synchrotron catches up with its mates in the storage ring. When the bunch has caught up with the others, it is reinjected into the storage ring, where it merges with one of the bunches there. By this means, all bunches can be coalesced into one within two seconds. The linac for CESR will consist of the original Cornell linac along with components from the dismantled Cambridge Electron Accelerator. With the initial rf power the storage ring will have a maximum energy per beam of 8 GeV, with the option to increase energy to 10 GeV with additional rf power. If funds are approved by this fall, Tigner told us, the turn-on date is scheduled to be October 1979. —MSR □