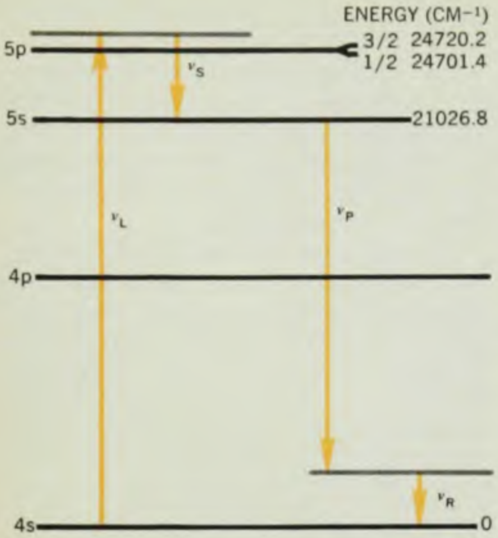

Four-wave parametric mixing in potassium. The waves ν_L, ν_S and ν_P beat together to create a polarization at $\nu_R = \nu_L - \nu_S - \nu_R$.

one of the ends of the crystal eliminates the cavity effect, and a superradiant spin-flip Raman laser, which is essentially a single-pass device, is produced. Nguyen is trying this arrangement now, using a pumping laser with enough intensity to produce enough single-path gain through the sample to build up intensity of the Raman-scattered light from spontaneous emission so that the device can be continuously tuned without mode hopping.

In principle the Bell technique should be applicable over a much wider range. Using two fixed-frequency carbon-dioxide lasers Patel and his collaborators had earlier shown that one could go from 2 cm^{-1} to 140 cm^{-1}. So Patel believes that with the new technique they should be able to tune in the range from 1 mm to 70 microns.

At MIT's National Magnet Laboratory R. L. Aggarwal, Benjamin Lax and their collaborators have demonstrated an infrared tunable source in the 5-micron region in which they combined a high-power spin-flip Raman laser with a 10.6-micron carbon-dioxide laser to produce the sum frequency. To bridge the far-infrared-microwave gap, they extended this general technique to produce the difference frequency. This was accomplished by a noncollinear technique of phase matching in gallium arsenide. The group reported their results in the 1 April issue of *Applied Physics Letters*.[5]

In more recent results reported at the March APS meeting in San Diego, the group produced step tuning using two carbon-dioxide lasers; they obtained 60 lines from 70 microns to 2 mm. Lax told us that it is evident that if one uses gratings for both carbon-dioxide lasers, it is possible to obtain 3000 lines between 70 microns and 1 cm.

In the present experiment one laser has 30 kW of peak power and the other 100 kW of peak power. The output observed was about 1 milliwatt at 100 microns; the MIT group had calculated that they would obtain 700 milliwatts. In work now in progress, the group is making a number of obvious engineering improvements that they expect will enhance the peak-power capability by two orders of magnitude and the repetition rate from three per second to at least ten per second. Using these improvements and a 1-kW spin-flip Raman laser that they had developed earlier, the group expects to obtain continuous tuning for the difference frequency.

At the March meeting the group also reported on a scheme to produce cw operation by employing a collinear phase-matching technique that takes advantage of a periodic variation of the refractive index.

Other groups. In the same issue of *Applied Physics Letters* that carried the MIT report was an article[6] by C. D. Decker and F. K. Tittel of Rice University on difference-frequency mixing between the output from a tunable narrow-linewidth ruby-pumped infrared dye laser and a Q-switched ruby laser in a proustite crystal. The Rice experimenters obtained peak infrared powers in the kilowatt range; they told us that their source was tunable from 3.20 to 6.47 microns. They believe that by using proustite crystals cut at a different angle to the optic axis, tunability from 6.47 to 13 microns should be possible.

In a more recent experiment, Decker and Tittel have used two independent dye lasers, mixing them in a proustite crystal and obtained tunability from 5.82 to 7.25 microns with peak powers in the 20–100-watt range. Provided appropriate nonlinear mixing crystals can be found, they say that this dual dye-laser frequency-mixing arrangement could generate radiation from 5 microns to greater than 100 microns.

At the March APS meeting, Patrick Yang, James Morris, Paul L. Richards and Yuen-Ron Shen of the University of California at Berkeley reported generation of continuously tunable far-infrared radiation over a factor of 20 in wavelength from 52 to 2000 microns. In these experiments the laser source was a one-dye-cell dual-beam dye laser. The laser cavity contains two diffraction gratings to tune, individually, two orthogonal polarizations of laser light that are spatially separated by a Glan-Thomson prism. This arrangement minimizes alignment and synchronization problems. Using a ruby-laser pump, the dye-laser output is 300 kW in each beam. Collinearly phase-matched far-infrared generation in room-temperature lithium niobate and zinc oxide yields about 5 milliwatts of far-infrared power from 52 to 800 microns. The power falls below 1 milliwatt at 2000 microns. These power levels are more than adequate for spectroscopy in the energy-starved far-infrared region of the electromagnetic spectrum, Richards said.

Tuning is achieved by rotating one of the laser gratings and simultaneously changing the angle of the nonlinear crystal. The tuning range can be extended to shorter wavelengths by using other nonlinear crystals. —GBL

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NBS offers 5 reference temperatures under 8 K

A superconductive device that provides five fixed-point reference temperatures near absolute zero has been developed at the National Bureau of Standards. The device, which will reproduce its transition temperatures within 1 millikelvin, is made from five high-purity elements—lead, indium, zinc and cadmium—and provides fixed points near 7.2 K, 3.4 K, 1.2 K, 0.8 K and 0.5 K.

Cylinders of the five elements are mounted in a threaded copper stud and enclosed by a mutual inductance coil set. The whole unit is about 1.5 cm in diameter and 4 cm long. In use, the copper stud is connected thermally to the thermometer to be calibrated or to the experimental chamber, and the four mutual-inductance coil leads are connected to a mutual-inductance bridge. The superconductive transitions can be easily monitored by mutual-inductance measurements, according to NBS. Called SRM 767, the device is available through the NBS Office of Standard Reference Materials for $250.00 each.

in brief

The first test experiments using the University Isotope Separator-Oak Ridge (UNISOR) were recently carried out with 100-MeV nitrogen ions on thin Nb^{93} foils mounted as part of the wall of the ion source. Recoil atoms were stopped in the ion source of the separator. Cadmium isotopes of mass 101 to 103 were definitely identified. When completed, a short tape-transport system will be attached to an extracted beam station for studies of still shorter-lived isotopes.