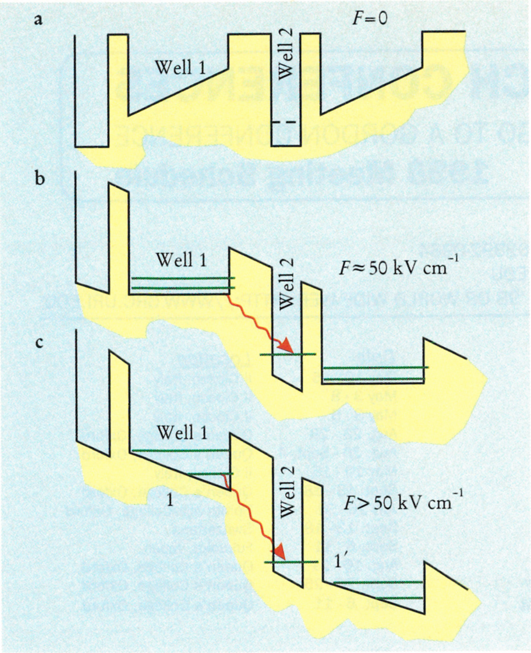

Energy levels in one stage of the quantum cascade laser for different values of electric field F. No photons are emitted (**a**) until the field is high enough (**b**) for electrons to go from the bottom level ($m = 1$) in well 1 to the bottom level ($m = 1'$) in well 2. Lasing occurs at stronger fields (**c**), when the potential in well 1 moves electrons closer to well 2. The barriers keep well 1 at a constant population level and well 2 empty. (Adapted from ref. 1)

a smaller percentage range. The researchers recently demonstrated this temperature tuning with a QC laser of the original design to which they had added distributed feedback to get single-mode lasing with 60 mW of power at 300 K.[2] In other work,[3] the same group made the active regions out of superlattices to produce a high-power pulsed QC laser at 8 μm.

Another type of QC laser is being designed to operate at shorter wavelengths, below 5 μm. In these shorter-wavelength QC lasers—developed by researchers at the University of Houston working with colleagues at Sandia National Laboratory and the Naval Research Laboratory—the electron transition occurs between the valence and conduction band rather than within the same subband.[4] Lasers of this design have operated at powers of nearly 500 mW, but so far they emit from both ends of the laser. Other researchers are also developing multiple quantum-well lasers in this observationally important region of the infrared.

Barbara Goss Levi

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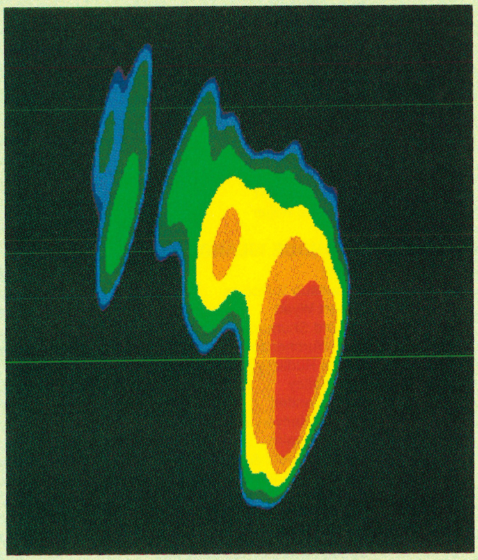
Radio Telescope in Space Maps Quasar Jet

What's remarkable about this radio image of quasar 1156+295 (shown in false-color form) is how it was obtained—using a radio telescope in space.



Radio waves are so long that high angular resolution can be achieved only with big telescopes—the bigger the better. Since the 1960s, radio astronomers have used interferometry to synthesize large apertures by combining signals from widely separated telescopes. Naturally, the largest aperture obtainable on the ground is Earth's diameter of 13 000 km.

Now, this terrestrial barrier has been breached by HALCA, a radio astronomy satellite launched by Japan's Institute of Space and Astronautical Science. In its elliptical orbit, HALCA ranges as far as 21 000 km from Earth's center, so that when it observes in conjunction with a ground-based telescope—in this case, the Very Long Baseline Array—a maximum baseline of 33 000 km is achieved, yielding a resolution of 0.3 milliarcseconds at an operating frequency of 5 GHz. That's enough to see things the size of 10 light-years at the quasar's distance of 6.5×10^9 light-years—a threefold improvement over ground-based arrays operating at the same frequency.

With its finer detail, this HALCA image (made at 1.6 GHz with 1 milliarcsec resolution) shows a jet of supersonic plasma shooting out from the heart of the quasar, which can be seen from the ground only at much higher frequencies. Moreover, because of the steeply falling energy dependence of its electron distribution, a jet like this one is much more prominent at low frequencies. The HALCA images, therefore, reveal smaller structures that are invisible in ground-based observations.

The achievement of the HALCA team lies not just in putting an 8-meter radio telescope on board a spacecraft. To obtain interference fringes, the team has succeeded in time-tagging the wavefronts arriving at the various telescopes with an accuracy of about 1 μs. For a rapidly moving space-based instrument whose precise frequency standard and high-data-rate recorders are actually on the ground, this is a remarkable technical accomplishment.

Still in its in-orbit checkout phase, HALCA (which stands for Highly Advanced Laboratory for Communications and Astronomy, and is meant to sound like *haruka*, the Japanese word for "distant") will embark on a full program of astronomical observations once calibrations are complete and regular, routine operations can be maintained.

Charles Day ■