It should then be possible to measure the sizes of infrared stars and possibly other infrared sources, such as Seyfert galaxies. With improved sensitivity one might eventually be able to resolve quasistellar sources. One can also measure proper motions or the rate of the earth's rotation—how well this can be done depends on properties of the atmosphere that are still not known.

One of the very common beliefs these days is that the stars are surrounded by dust clouds that produce most of the infrared radiation, Townes explained. The actual shape of the radiating region may not be spherical. Instead there may be a ring of clouds bigger than the star itself. "But we won't know until we measure it," he said.

Townes is now trying to raise money to build a pair of 60-inch telescopes, mounted on trailer trucks so that their separation can be varied and so that they can be moved to follow the good weather or even to the Southern Hemisphere. In actual use the telescopes would rest on concrete piers. The telescopes are of the Pfund type. In such a telescope light comes from the star to a plane mirror (see figure), which reflects it into a fixed parabola. The parabola then reflects the light through a small hole in the center of the flat mirror to a focal point beyond it. The focus would be fixed, a feature important for infrared work, Townes says, because one needs to install complex apparatus, such as the heterodyne detectors. Mobility would also allow complex new instrumentation to be installed on the telescopes at a convenient laboratory before they are taken to a remote observing site. The Pfund design minimizes the amount of infrared radiation from the telescope itself that reaches the detector.

The Berkeley telescopes would also be able to be pointed in an absolute fashion so that one can do observations in the daytime without locating the object first, thus enabling the experimenters to work the way radio astronomers do. The angular motion needed for the flat mirror will be more complicated than it would be with a Cassegrain-type telescope, but a modern computer can do the job simply, Townes said.

The parabolic mirrors would be 60 inches and the flat mirrors around 85 inches. Proposals have been submitted to NASA, NSF and to some private donors. The two telescopes would cost \$700 000. —GBL

Fine-structure components of Hα line resolved

Using high-resolution saturation spectroscopy, Theodore Hänsch, I. S. Shahin and Arthur Schawlow of Stanford University have been able to resolve for the first time single fine-structure components of the red Balmer line Hα of atomic hydrogen and to observe the Lamb shift directly in the optical absorption spectrum.[1]

Speaking at the Washington meeting of the American Physical Society in April, Hänsch said that his group was now working on an attempt to improve the measurement of the Rydberg constant. The group feels that one should be able to determine the constant to an accuracy of two parts in 10^8, an accuracy as good as that of the present standard of length.

The major problem in high-resolution spectroscopy is that the fine and hyperfine structure are obliterated by the Doppler effect. In the last few years people working on laser physics have found that the so-called "Lamb dip" gives you a way to get rid of Doppler broadening. The technique used by the Stanford group splits the output of a narrowband laser into two beams—a weak probe beam and a stronger, periodically blocked saturating beam. They are sent in nearly opposite directions through the hydrogen sample. If the laser frequency is tuned to an atomic resonance frequency, and if the laser bandwidth is sufficiently narrow, only those atoms with essentially zero velocity along the radiation axis can interact with both beams. Axial motion of the other atoms Doppler-shifts the resonance frequency up for one beam, down for the other. The saturating beam bleaches a path for the probe and decreases its absorption, and the changes in the probe intensity (caused by the inhomogeneous saturation) as a function of frequency show the spectrum lines with essentially their natural width.

For his laser, Hänsch developed[2] a pulsed tunable dye laser with a bandwidth of less than 10^{-3}Å. A passive confocal resonator further narrows the output by an additional factor of 40, to 10^{-4} Å. He uses a diffraction grating and a tilted Fabry-Perot interferometer as wavelength selectors in an optical cavity, which contains a beam-expanding telescope.

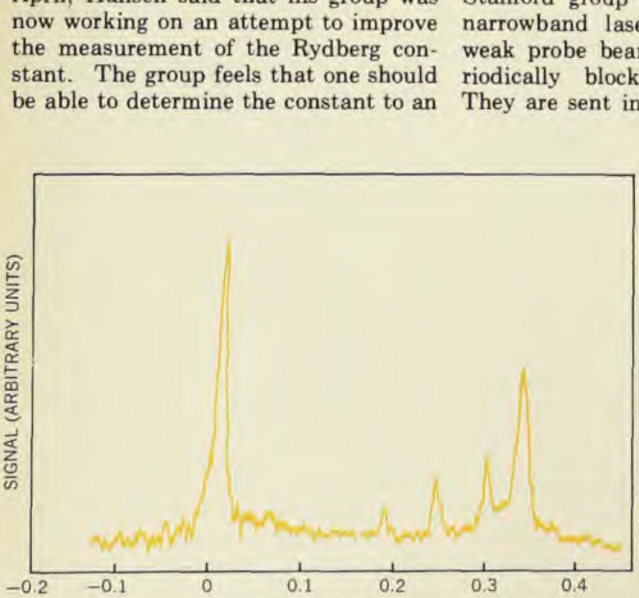
Because the Hα line is produced when a transition between the $n = 3$ and $n = 2$ states occurs, the experimenters had to populate the lower states with $n = 2$. This they did with a gas discharge.

The fine structure that the Stanford group observed agrees with theoretical expectations, both in frequency and relative intensity. The narrowest linewidth they observed is about 300 MHz for all resolved components; this they say represents a resolution of 5 parts in 10^7, about an order of magnitude narrower than the best previous value, which was obtained by conventional emission spectroscopy from a cooled deuterium discharge.

Schawlow enthusiastically summed up the prospects for high-resolution saturation spectroscopy: "For years we've had lasers that were good at certain particular wavelengths, but if you wanted to do fundamental things such as studying atomic wavelengths, you never had a laser at the right wavelength. Then when you began to have tunable lasers, they were so crude and broadband, you couldn't do any serious spectroscopy with them. But now we have them both. So now we can really begin to study with this enormously enhanced resolution the spectra of all kinds of atoms." —GBL

References

1. T. W. Hänsch, I. S. Shahin, A. L. Schawlow, Nature Phys. Sci. **235**, 63 (1972).
2. T. W. Hänsch, Appl. Opt. **11**, 895 (1972).



Saturation spectrum of Hα. Narrowest linewidth observed is about 300 MHz for all resolved components; this represents a resolution of 5 parts in 10^7.