Continuous dye laser yields tunable output

If you want to make an organic dye laser operate continuously, just mix the dye with a little soapy water. That recipe worked for Otis G. Peterson, Sam A. Tuccio and Benjamin B. Snavely of the Eastman Kodak Research Laboratories. Since the group reported making a cw laser (*Appl. Phys. Lett.* **17**, 245, 1970) it has managed to make it tunable in the range 5500–6500 Å and hopes soon to extend the work to other parts of the visible spectrum. Snavely says the dye laser should be tunable over the entire visible region. Although cw semiconductor lasers are tunable in the infrared, Snavely noted that the Kodak laser is the first cw tunable source in the visible range.

Tunable dye lasers have been made in the past but two problems had to be overcome to make them operate continuously. Lasing in organic dye molecules occurs because of the transitions within the numerous molecular singlet states, but the lasing is limited by losses associated with the accumulation of molecules in the molecular triplet state. Furthermore, optical inhomogeneities are produced by temperature gradients connected with the excitation. To overcome these problems one needs a medium that has a small change in refractive index with temperature—water. Because the dye used, rhodamine 6G, is not completely soluble in water the experimenters added a de-aggregating agent, a soaplike material (1.5% Triton-X100), that not only helps to dissolve the dye but also manages to quench the triplet state losses.

The Kodak group used an argon ion laser with 5145-Å output to pump a 4.5-mm transverse-flow hemispherical cavity filled with a 2.5×10^{-4} molar solution of the dye. Threshold power level is 60 mW and beyond that pump power the efficiency is 20%. The maximum power output obtained has been limited to about 55 mW by the intensity of the pump source. To make the cw output tunable the Kodak group put a dispersive element in the cavity, just as is done for pulsed dye lasers.

Some groups have suggested setting up a solar reflector and using the sun to pump a dye laser; the sunlight matches the band of rhodamine 6G.

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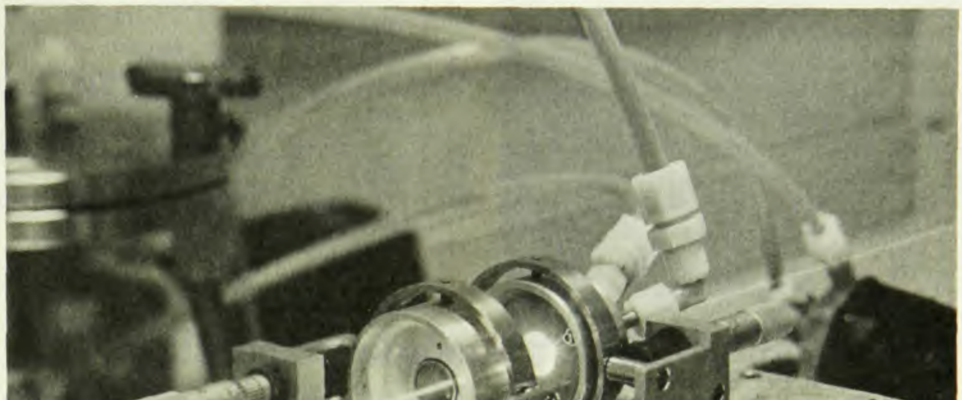

Continuous organic dye laser at Eastman Kodak Research Laboratories has been made tunable in the range 5500–6500 Å. Pump light of 5145 Å enters from left and is focused by condenser lens into dye-laser cavity. Topmost tube is dye outlet.

Polarized light from white-dwarf star

Circularly polarized light has been found[1] in a peculiar white dwarf star; the result suggests that its magnetic field is between 10 million and 100 million gauss, a value to be expected on theoretical grounds. Further observations show that with increasing wavelength the percentage circular polarization rises in the ultraviolet, drops somewhat and then rises sharply again in the infrared at 12 000 Å.[2,3] There is also a linear polarization, which is present in the uv, disappears at about 6000 Å, then reappears at about 8000 Å perpendicular to the first direction.[2,3,4]

When an ordinary star contracts the magnetic flux can be conserved, and the magnetic field strength increases inversely as the radius squared, as first pointed out by Lodewyk Woltjer.[5] Normal stars have surface magnetic fields ranging from about 1 gauss in the sun to 10^4 gauss in magnetic A stars. Collapse to a white dwarf reduces radius by about 100; so fields between 10^4 and 10^8 gauss might be expected. The same argument for neutron stars suggests fields of 10^{12} gauss.

Last year Roger Angel and John Landstreet of Columbia University started looking for the Zeeman effect in hydrogen lines from DA dwarfs (which show Balmer absorption lines), but found none down to a level of about 10^4 gauss. Meanwhile James C. Kemp[6] (University of Oregon) developed a theory that said that in a strong magnetic field a plasma that is not a true blackbody would yield circularly polarized emission. By looking at continuum dwarf stars it might be possible to see the circular polarization. Sure enough, when Kemp and John Swedlund looked at such a star, GRW 70°8247, they found the circular polarization. It was then quickly confirmed by Landstreet and Angel.

Since then the observations have been refined and extended to longer wavelengths by Kemp and Swedlund, by Angel and Landstreet and by Thomas Gehrels (University of Arizona). If a normal star were to contract to white-dwarf radii without loss of angular momentum, then one would expect periods of minutes. But Angel and Landstreet find no variation either in the polarization or in the intensity for time scales from 24 sec to a few days.

So far the peculiar dwarf continues to be unique. Angel and Landstreet have looked at six other continuum dwarfs, one DA dwarf and one DBP dwarf, and found no circular polarization within a 0.1% accuracy.

Recently Kemp[7] has suggested that the very striking rise in circular polarization at 12 000 Å could be caused by cyclotron resonance in a field of 10^8 gauss. —GBL

References

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4. T. Gehrels, to be published.
5. L. Woltjer, Astrophys. J. **140**, 1309 (1964).
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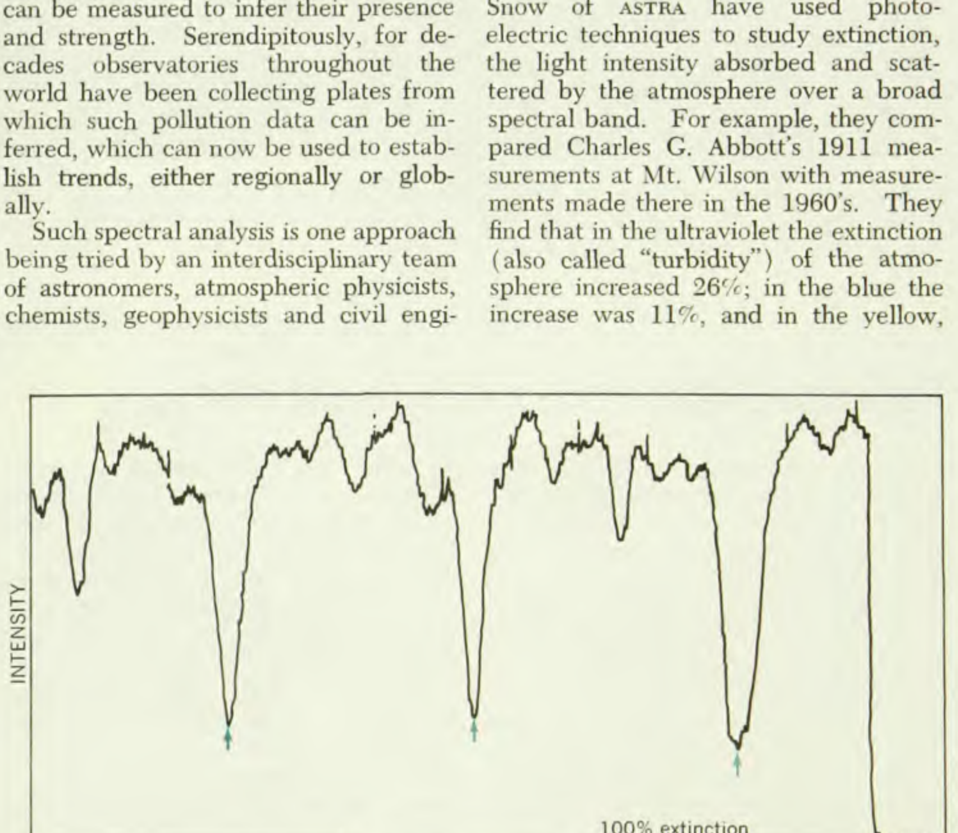
ASTRA project monitors atmospheric pollution

Astronomy, a field for which few have claimed relevance, is now becoming relevant to a pressing problem, atmospheric pollution. It turns out that those pesky atmospheric contaminants that have been annoying astronomers looking at the sun and other stars, have been leaving tell-tale lines on spectra, which can be measured to infer their presence and strength. Serendipitously, for decades observatories throughout the world have been collecting plates from which such pollution data can be inferred, which can now be used to establish trends, either regionally or globally.

Such spectral analysis is one approach being tried by an interdisciplinary team of astronomers, atmospheric physicists, chemists, geophysicists and civil engineers, who are organizing Project ASTRA (Astronomical and Space Techniques for Research on the Atmosphere) at the University of Washington. They are also doing atmospheric extinction measurements and studying the aerosol component of the atmosphere of the earth.

Paul Hodge, E. Mannery and T. P. Snow of ASTRA have used photoelectric techniques to study extinction, the light intensity absorbed and scattered by the atmosphere over a broad spectral band. For example, they compared Charles G. Abbott's 1911 measurements at Mt. Wilson with measurements made there in the 1960's. They find that in the ultraviolet the extinction (also called "turbidity") of the atmosphere increased 26%; in the blue the increase was 11%, and in the yellow, 10%.



Spectrum of atmospheric carbon monoxide in the infrared solar spectrum (after M. Migeotte, L. Nevin, J. Swensson, Infrared Solar Atlas, Memoirs de Societes vol. Hors Série Nr. 1, 1956). Carbon-monoxide absorption lines are indicated in color.

Another ASTRA group, Robert J. Charlson, William M. Porch and Lawrence F. Radke recently reported (*Science* **170**, 315, 1970) light-scattering measurements at Point Barrow, Alaska and Mount Olympus, Wash. to determine that a background level of atmospheric aerosols (particulates) does exist.

By using calibrated high-dispersion astronomical spectra one can do a curve-of-growth analysis to determine the amount of a particular pollutant that is between the source and observer. Hodge told us that although the sun's spectrum can give us information on lines caused by atmospheric contaminants, it is not an ideal light source because it has many absorption lines of its own throughout the optical region. On the other hand very hot, rapidly rotating stars, whose spectra have only broad hydrogen and helium lines, offer a smooth continuum to display the polluting absorption lines. Using these stars instead of the sun would, however, require relatively large telescopes to collect enough light to detect trace pollutants.

Molecules identified so far in solar spectrograms include CO_2, C^{13}, O^{16}_2, CH_4, N_2O, CO, SO_2 and possibly NO_2. By looking at old spectra Hodge feels that pollutant trends can be established for these molecules, particularly when they have lines in the visible range and near infrared. One contaminant of particular interest is carbon dioxide. Two years ago Reed Bryson suggested that the abundance of CO_2 in the atmosphere had increased by about 13% per decade, suggesting that by the year 2000 or so we'd all be in serious trouble. It might be possible to check this trend over recent decades by looking at existing infrared data in observatory archives. Hodge feels that many other of the 5000 or so suspected atmospheric pollutants would probably be recognizable and measurable by setting up in a large city a telescope and spectrograph and using high-temperature stars as background sources. —GBL

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Snavely feels that the cw dye laser is presently the most attractive high-intensity tunable light source for the visible region of the spectrum. The parametric oscillator remains attractive as a tunable source for the infrared, however. In the visible region, where both devices operate, the dye laser appears to have an advantage by virtue of its simplicity, Snavely says.

High-sensitivity spectroscopy is the most immediate application for the dye