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HIGH SPECTRAL PURITY, NARROW LINEWIDTH LASER TRANSMITTER FOR DIAL MEASUREMENTS

U.N. Singh
University of Maryland, Institute for Physical Science and Technology, College Park, Maryland 20742, U.S.A.

P.H. Flamant
Laboratoire de Meteorologie Dynamique du CNRS, Ecole polytechnique, 91128 Palaiseau, France

The use of the pulsed, oscillator-amplifier dye laser as a source of tunable coherent radiation for DIAL measurements is attractive because of its wide tunability, narrow spectral linewidth and high peak power. However, the multi-stage, high gain amplifiers, beside generating radiation within a narrow spectral bandwidth (a few picometers), also generate uncontrolled emission of a broad spectral nature (covering tens of nanometers) called amplified spontaneous emission (ASE). Thus the output radiation has two spectral components: (1) radiation within the required spectral bandwidth called signal radiation, and (2) radiation outside the required bandwidth called noise. The spectral purity can be defined as the percentage of signal radiation in the total output. The presence of ASE along with signal radiation is an unwanted interference in DIAL measurements.[1,2]

To minimize systematic errors associated with DIAL measurements, a narrow linewidth laser transmitter with a very high degree of spectral purity is needed.

A frequency-doubled Nd:YAG-pumped dye laser (Quantel 180C + Jobin Yvon HPHR) was used as a light source in our experiments. Rhodamine 6G and Carbazine 122 laser dyes were used for the generation of 580 nm and 720 nm wavelengths. A spectrometer (Spex 1800) in combination with an Optical Multichannel Analyzer (OMA) was used for spectral purity measurements. A multipass white cell with a path length of 150 meters was used along with a ratio meter (Lasers Precision, Inc. model Rj 7200) to study the influence of ASE on humidity measurements.[2]

With a Rhodamine 6G concentration of 4.5×10^{-4} M/L for the oscillator and 1.8×10^{-4} M/L for the amplifier, the peak of the frequency doubled Nd:YAG-pumped dye laser gain curve lies near 580 nm. Figure 1 illustrates the dependence of dye laser spectral purity on the oscillator energy, firstly, when emitted radiation is centered at the peak of the gain curve and secondly, when it is detuned.

With a Carbazine 122 concentration of 3.0×10^{-3} M/L and 1.25×10^{-3} M/L for oscillator and amplifier, respectively, Figure 2 shows the dye laser spectral purity dependence on oscillator energy.

Figure 3 shows the water vapor absorption line at 723.4734 nm recorded using a white cell of 150 meter path length. This linewidth was found to be 11.6 pm (FWHM), which is slightly higher than the value of 11.2 pm and 10.6 pm measured, respectively, by Wilkerson et al[3] and Grossmann et al.[4]

For small values of optical depth, a simple theoretical calculation predicts a linear variation of the White cell transmission with spectral purity: transmission approaches unity as spectral purity approaches zero, and becomes minimum when the spectral purity is high, i.e. approaches unity.

Figure 4 shows the transmission of the White cell as a function of spectral purity for the laser line centered at the peak of the water vapor absorption line at 723.4734 nm. The spectral purity at this laser output was varied in a known way by changing the orientation of the oscillator dye cell. Figure 4 clearly indicates the error involved in humidity measurements, if the emitted radiation from the laser transmitter does not have a high degree of spectral purity.

CONCLUSIONS

A laser transmission with very high degree of spectral purity has been described. ASE dependence on the oscillator energy and the detuning away from the gain curve center are demonstrated. The effects of both finite laser linewidth and spectral purity on humidity measurements are experimentally demonstrated.

References

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3. T.D. Wilkerson, G. Schwemmer, and B. Gentry, J. Quant Spectros. Radiat. Transfer 22, 315 (1979).

4. B. Grossmann, C. Cahen and J.L. Lesne, Proc Twelfth International Laser Radar Conference, Aix-en-Provence, France, August 13-17, 1984.

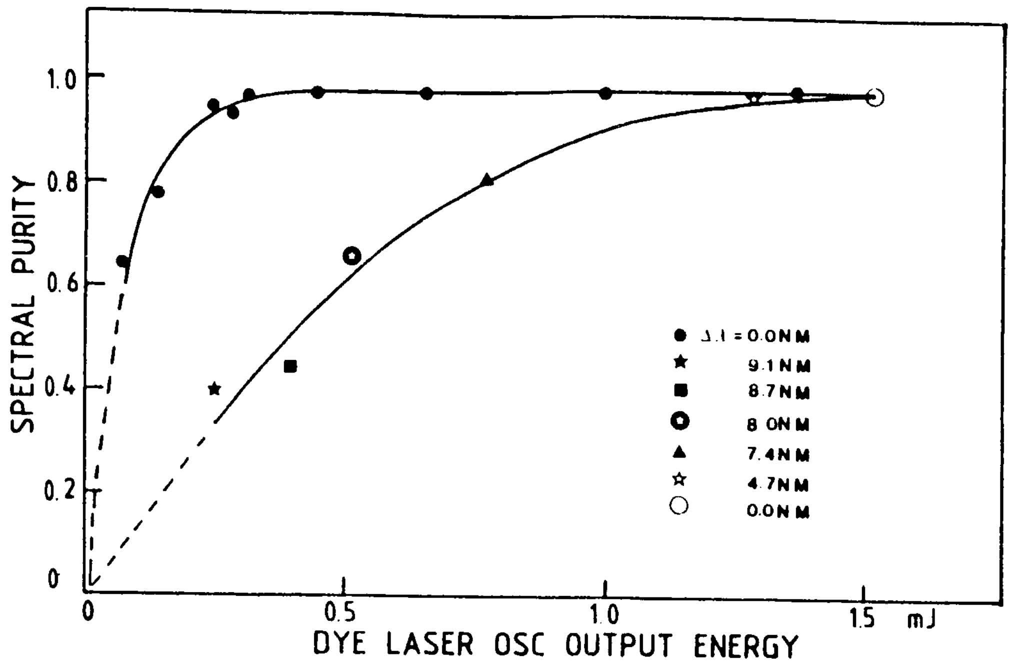

Figure 1 Spectral purity as a function of oscillator output energy and detuning from the center of the gain curve (580 nm).

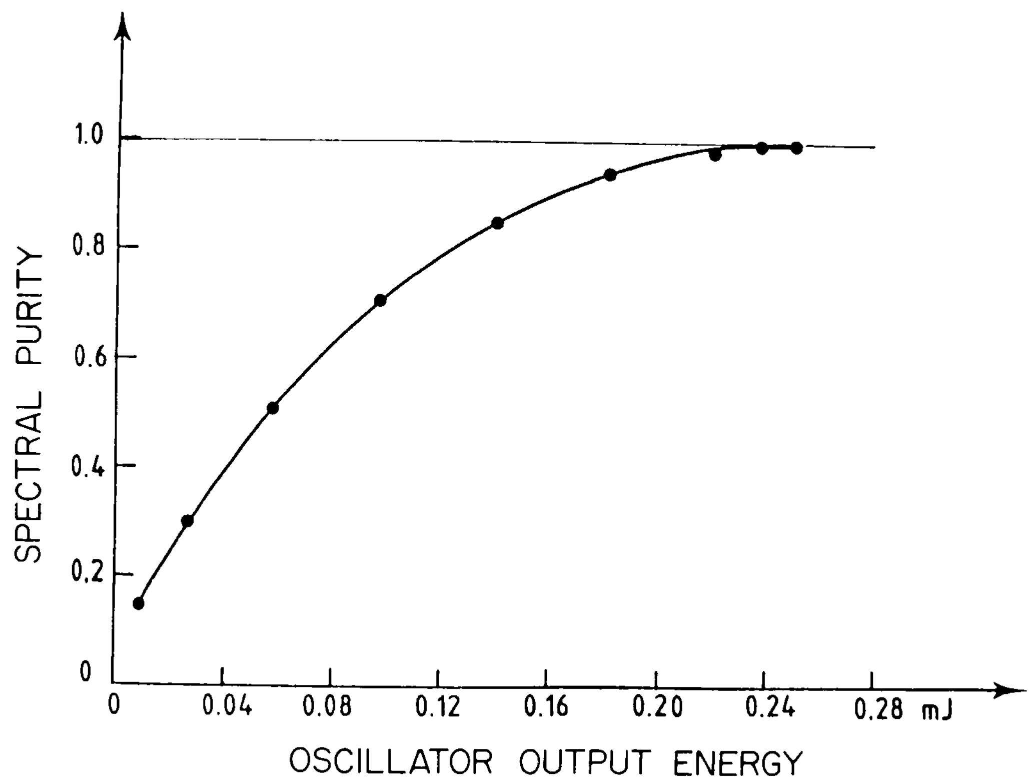

Figure 2 Spectral purity <u>versus</u> oscillator output energy at 724 nm.

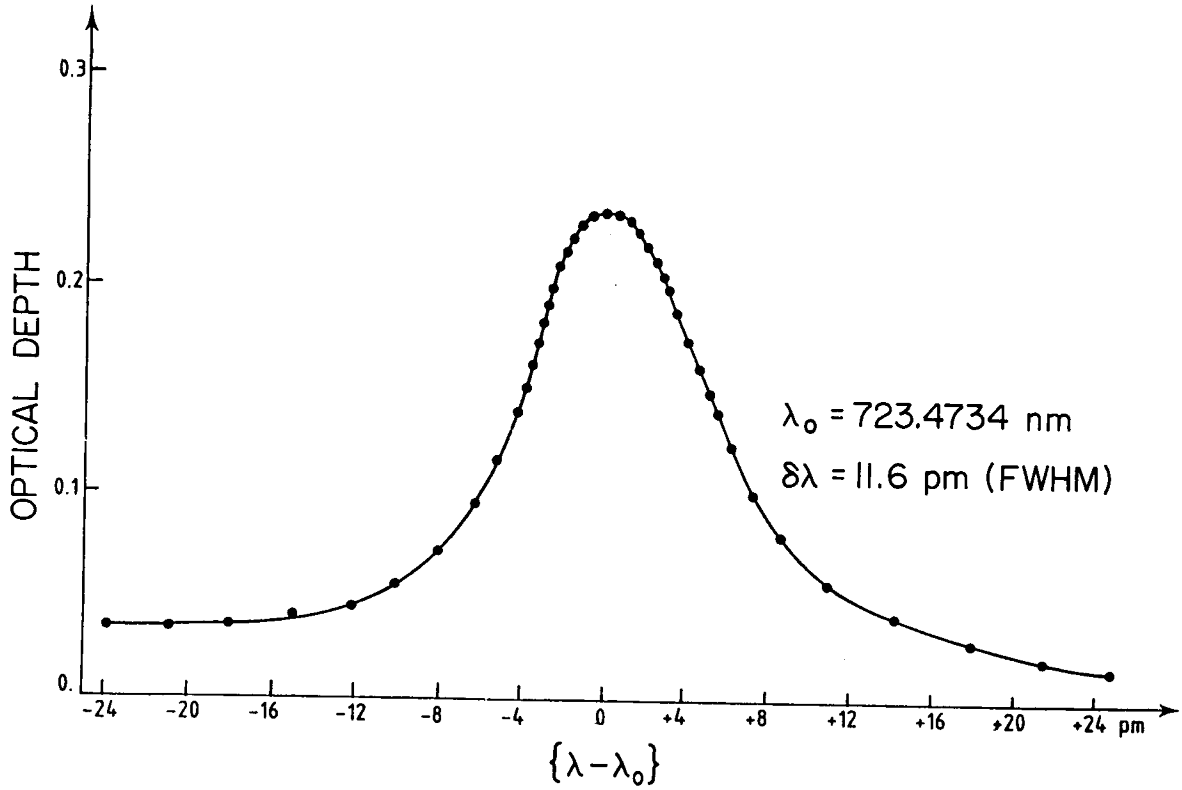

Figure 3 Water vapor absorption spectrum at 723.4734 nm obtained with pulsed dye laser.

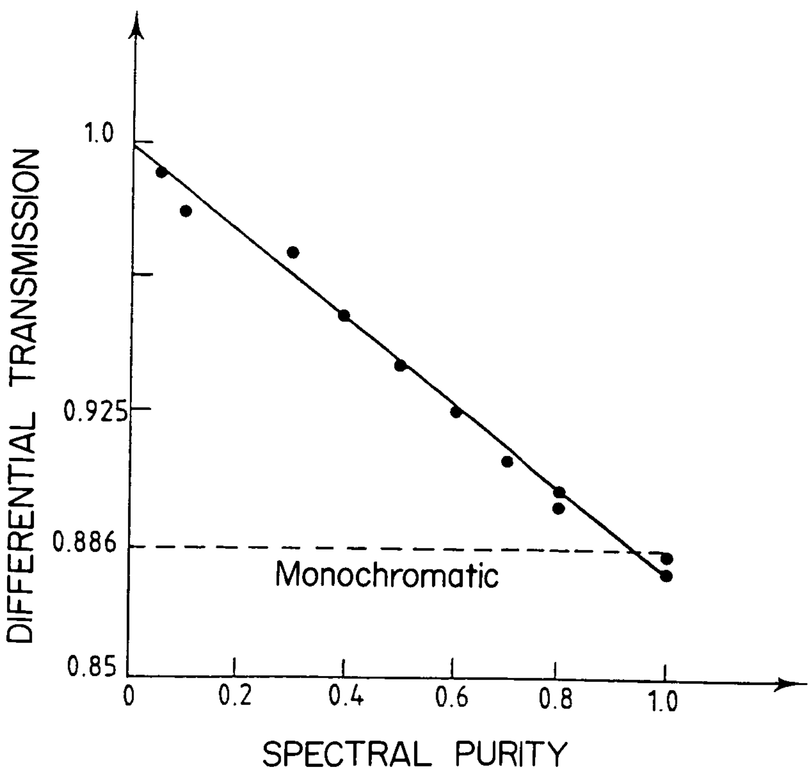

Figure 4 Differential transmission of the white cell at 723.4734 nm <u>versus</u> spectral purity.