ON FIRST ORDER COHERENCE OF THE RADIATION OF A DYE-LASER

By

L. VIZE, F. PINTÉR and L. GÁTI

Institute of Experimental Physics, Attila József University, Szeged

The first order (space) coherence of a pulse dye-laser with rhodamine 6G solved in ethanol as active material has been determined as a function of the energy of the lines (bands) of the spectrum of the laser pulse. The degrees of coherence first steeply increase, then slowly decrease.

Examining the coherence spectrum of a pulse dye-laser, it has been found that the half-width of the individual lines are 10^{-2} Å or smaller, while the degree of space coherence is nearly zero.

For characterizing the coherence of the electromagnetic radiation field (EMRF), correlation functions of different order [1—4] are used. If the EMRF is comparatively strong and of not too high frequency, the degree of coherence of the field, of first order according to GLAUBERS definition, can be determined from the intensity distribution of the interference pattern obtained with an interferometer of YOUNG-type (Y), with the formula [5—6]

$$|\gamma_{12}| = \frac{I_{\max} - I_{\min}}{I_{\max} + I_{\min}} \cdot \frac{I^{(1)}(Q) + I^{(2)}(Q)}{2\sqrt{I^{(1)}(Q)}\sqrt{I^{(2)}(Q)}}, \tag{1}$$

where $(I_{\max} - I_{\min})/(I_{\max} + I_{\min})$ is the visibility of the interference fringes; $I^{(1)}(Q)$ and $I^{(2)}(Q)$ are the light intensities which could be measured in the point Q of the screen on which the interference pattern is formed, if only one of the pinholes (1) and (2), respectively, were open.

Experimental arrangement and method of measurement

As the spectrum of the EMRF produced by the dye-laser (*DL*) under investigation consists of several hundreds of lines, in building up our arrangement we first had to determine the sequence of the Young-interferometer (*Y*) and of the spectrograph (*S*) of Steinheil -type. If this sequence is *DL*, *Y*, *S* and the straight line determined by the two pinholes of the Young-interferometer is parallel to the entrance slit of the spectrograph, then the narrow band cut out by the slit from the fringes perpendicular to the slit will be resolved by *S* according to wavelength. Such a system of fringes, a "coherence spectrum", is shown in Fig. 1.

A diagram of our arrangement is shown in Fig. 2. The cylindrical glass cell *C* containing the active dye solution was 10 cm long and of 0.8 cm inner diameter. L_1 and L_2 were Xe flash lamps type IFP—800, receiving the power supply from a

condensor of 10 μF capacity loaded to 4—6 kV. The resonator consisted of the mirrors M_1 of 500 cm curvature radius, and of the plane mirror M_2, with reflection coefficients of 70% and 99%, respectively. The pinholes of the interferometer Y, reflected by the glass plate G were photographed by the camera CA to give blackenings, from which the light intensities $I^{(1)}(Q)$ and $I^{(2)}(Q)$, respectively, could be determined. Y consisted of a thin aluminium plate with two pinholes of 0.002 cm diameter, the distance between their centres being 0.01 cm. The lengths l_1, l_2, l_3 were 40 cm, 100 cm, 15 cm, respectively; l_2 and l_3 were chosen on the basis of trial measurements. According to these, the visibility of the fringes did not show significant changes and increased only slightly with l_2 gradually decreasing down to 1 cm. As the intensity of the light of the flash lamps passing through M_2 had to be decreased, l_2 was chosen to 100 cm.

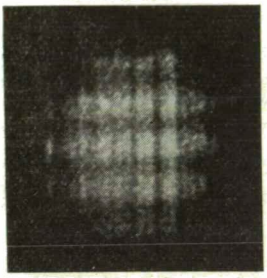

Fig. 1

An ORWO (Wolfen) film of 27 DIN sensitivity was used as detector and its blackening determined with a Zeiss photometer. To permit to conclude from the blackening to the intensity and the energy, the film was calibrated. The calibration was made with a lamp giving a flash commensurable with the half-width in time of the laser pulse.

For calculating γ on the basis of Eq. (1), our field must be quasimonochromatic. As the condition of quasimonochromaticity consists in the mean half-width $\Delta\nu$ of the beam being much less than its mean frequency $\bar{\nu}$ and the spectrum of the DL consisting of separate lines, a series of degrees of coherence according to frequency ν can be associated with each pulse. The dispersion of the spectrograph used was 12 Å/mm and 2 Å/mm, respectively, in the spectral range employed. The width of the spectrum photographed from the laser pulse was about 20 Å. The photometer used enabled us to divide this interval of 20 Å into about 20 or 1000 parts, respectively, the halfwidth of each band being less than 1 Å or 0.02 Å, respectively. Thus a series of the degree of coherence, ordered according to wavelength, could be coordinated to each pulse.

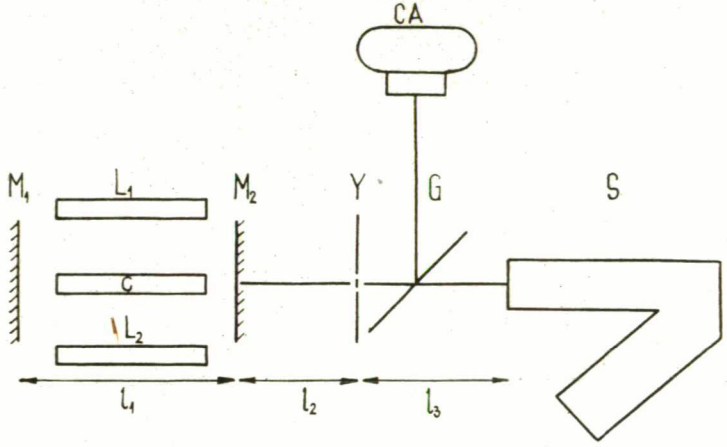

Fig. 2

Results of measurements

Using the arrangement and method described, we determined the coherence spectra of the EMRF produced by our dye-laser in the axis of the laser beams. As active dye, different concentrations of rhodamine 6 G solved in ethanol were used, with 6% acetic acid added.

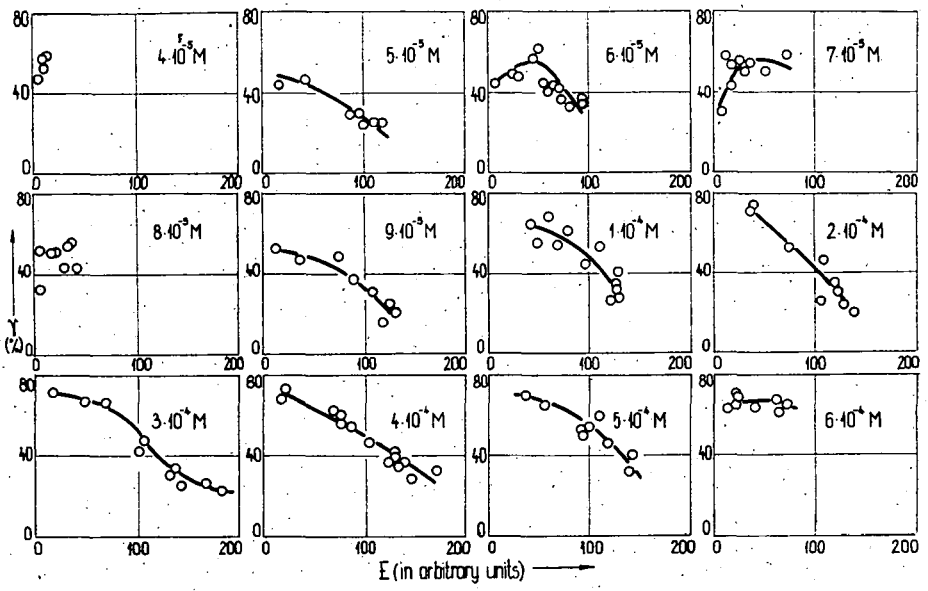

Fig. 3

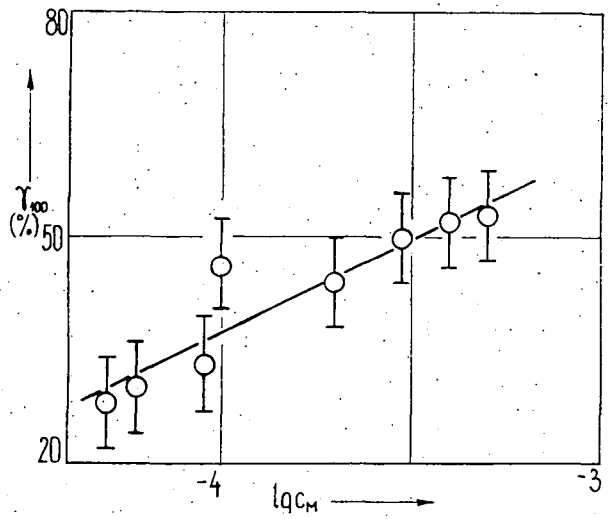

Fig. 4

Arranging the degrees of coherence for the same concentration according to the band energies, the curves shown in Fig. 3 are obtained. According to our measurements, the dependence of γ on the band energy E for a given concentration is described by a function steeply increasing in the range of small energies, then monotonously decrasing after a not too sharp maximum.

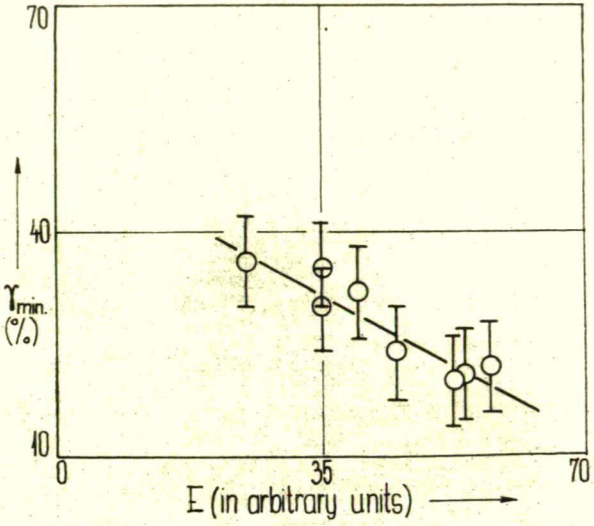

Fig. 5

γ_{100} as a function of concentration is plotted in Fig. 4, where γ_{100} is the degree of coherence pertaining to 100 units of band energy. The degrees of coherence of the decreasing sections pertaining to constant band energies show a monotonous increase as a function of concentration in the given concentration range.

In Fig. 5 γ_{min} as a function of the total energy of the pulse is shown, here γ_{min} is the minimum of the degree of coherence for the given concentration. The minima of the degree of coherence of the same decreasing range decrease monotonously when plotted as a function of the total energy of the laser beam.

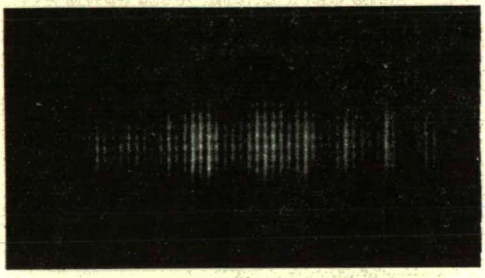

Fig. 6

Fig. 6 shows the coherence spectrum of a dye-laser, measured with a spectrograph of 2 Å/mm dispersion. The halfwidths of lines are about 10^{-2} Å, the degree of coherence is nearly zero at intensive lines, thus the low degree of coherence can not be attributed to the line-width.

Further measurements in this fields are in course.

References

[1] *Glauber, R. J.:* Phys. Rev. **130**, 2529 (1963).
[2] *Glauber, R. J.:* Phys. Rev. **131**, 2766 (1963).
[3] *Wolf, E.:* Nuovo Cimento **12**, 884 (1954).
[4] *Wolf, E.:* Proceedings of the Symposium on Optical Masers (John Wiley & Sons, Inc., New York, 1963).
[5] *Mandel, L., E. Wolf:* Rev. Mod. Phys. **37**, 231 (1965).
[6] *Born, M., E. Wolf:* Principles of Optics (Pergamon Press, 1959, p. 503).

О КОГЕРЕНТНОСТИ ПЕРВОГО РОДА ИЗЛУЧЕНИЯ ЛАЗЕРА НА КРАСИТЕЛЕ

Л. Визе, Ф. Пинтер и Л. Гати

Определена зависимость когерентности (пространственной) первого рода излучения импульсного лазера на красителе родамин 6Ж в этиловом спирте от энергии отдельных линий (полос) в спектре излучения. С ростом энергии полос, степень когерентности сначала быстро увеличивается, а затем медленно уменьшается. Из спектра когерентности получилась, что полуширина отдельных линий порядка 10^{-2} Å или меньше, в то же время степень пространственной когерентности приблизительно равна нулю.