DENSITOMETRIC EVALUTION OF INTERFERENCE PATTERNS DUE TO COHERENT LIGHT ON THE BASE OF CALIBRATION CURVES DETERMINED WITH INCOHERENT LIGHT

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The calibration of ORWO NP 27 (Wolfen) films was performed with spontaneous or induced luminescence light emission of an alcoholic rhodamine 6G solution excited by a flash lamp. The shape of the blackening curves measured with both methods proved to be the same within the error of measurement.

Introduction

The first order spatial coherence of a dye laser excited by a flash lamp was determined with the aid of an interferometer of Young type [1], by photographing the interference pattern and calculating the visibility from the densitometric data obtained.

One of the central problems of our measurements was the calibration of the ORWO NP 27 film used.

During our work the question emerged whether the blackening of the film depends on the coherence properties of the incident light, *i.e.* whether the blackening curve produced by incoherent light can be used for evaluating the interference pattern obtained with coherent laser light.

Some publications concerning this problem, both theoretical and experimental, are available in literature.

ROSENBLUM [2] summarized the state of knowledge concerning the functioning of photoemulsions and the photon statistics of laser and thermal light. On this basis, completed with some suppositions on the photoemulsions, he calculated the shape of the blackening curve. According to his calculations the steepness of the blackening curve should be less for thermal light than for laser light, if the time of exposition is less than or equal to the coherence time. This difference between the densities can be attributed to the fundamental difference between the photon statistics of laser and thermal light, respectively.

Prior to the publications of ROSENBLUM's paper, AUSSENEG and KREINER [3] published experimental results concerning the problem. Studying red-sensitive and orthochromatic plates, they found the sensibility for rubin-laser ($\lambda = 6943$ Å; half-width 10^{-7} sec) to be higher than in the case of excitation by thermal source.

POLOVTSEVA *et al.* [4] determined the blackening curves of some photographic plates for quasithermal and thermal light. They found differences both in the gradation and in the inertia of the plates.

As these theoretical and experimental investigations did not give a satisfactory and unequivocal solution of the problem, we found necessary to perform further measurements seeming important from our point of view, for determining the blackening curve both with laser light and with thermal light.

Methods of measurement

Our aim was to compare the shape of the non-linear part pertaining to low intensities of the blackening curves of the film used in our studies in the case of illumination with coherent and with incoherent light. (The part pertaining to higher blackening was not necessary, as such blackenings did not occur during our investigations.) As a light detector of sufficient sensitivity and accuracy, theoretically independent of coherence, was not available, the dependence on coherence of the inertia of the photographic plates could not be studied. This, however, does not imply a problem because in order to calculate the visibility it is sufficient to know the ratio of the intensities, and for determining this ratio it is not necessary to know the position of the blackening curve along the energy axis.

Homogeneous illumination of the grey filter of seven grades was obtained by the arrangement seen in Fig. 1a.

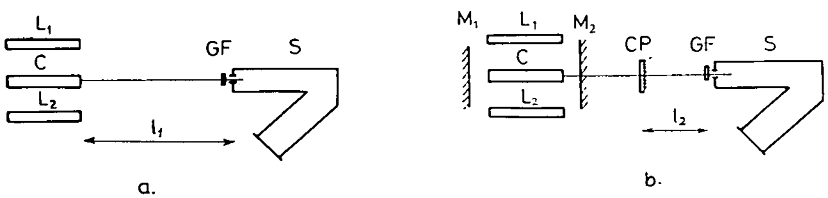

Fig. 1. L_1, L_2: flash lamps; *C*: cuvette; M_1, M_2: mirrors; *CP*: clouded plexiglass plate; *GF*: grey filter; *S*: spectrograph.

Incoherent light was produced by spontaneous luminescence of an active dyestuff solution (rhodamine 6G in ethanol) in a cylindrical cuvette of 10 cm length and 0.8 cm inner diameter. Excitation of the dye-solution was produced by two xenon flash-lamps type IFP—800, L_1 and L_2. The end-windows of the cuvette were not parallel within an accuracy of 1′; the intensity of the exciting light was low enough to secure the thermal character of the luminescence.

As the decay-time of the dye-solution was in the nsec range, the changes in intensity of the luminescence followed with good accuracy the changes in intensity of the flash pulses, which were of μsec-order. The axis of the cylindrical cuvette was coincident with the optical axis of the Steinheil spectrograph *S* of stigmatic image. In our measurements, the distance l_1 was 100 cm; according to our experience, the illumination of the grey filter was homogeneous in this case.

In order to perform the calibration with a laser, the arrangement described was modified by placing the cylindrical cuvette in an optical resonator consisting of the mirrors M_1 and M_2 (Fig. 1b) and by raising the exciting energy above the threshold energy of the laser.

Homogeneous illumination and decreased intensity of the illuminating light was achieved by placing a clouded plexiglass plate *CP* at a distance $l_2 = 50$ cm from the grey filter. The grey filter was calibrated for 590 nm wavelength, corresponding to the wavelength of the laser light.

Results of measurements

We made photographs of the graded grey filter on ORWO NP 27 film with coherent and incoherent light using the arrangements described above. To secure the identity of the conditions of development, all photographs were developed at the same time in a developer FORTE 22, consisting of methol 5 g, sulphite (anhydrous) 100 g, water *ad* 1000 ml. The time of development was 12 minutes, the temperature of the developer 18.0±0.2 °C; fixation lasted 15 minutes. With regard to the circumstance that our grey filter, despite its seven grades, decreased the light intensity only by 1.5 orders of magnitude, the wide range of light intensities necessary for obtaining different blackenings was produced by changing the pumping energy. The developed films were evaluated using a semiautomatic Zeiss densitometer.

The blackening curves were obtained by plotting the $\bar{D}$ values of the blackening compared with that of the background, as a function of the transmissions of the grey filter. The shape of the blackening curves obtained with spontaneous and with induced emission, respectively, were compared by fitting both curves at the point where the error of measurements was comparatively the smallest (point *A* in Fig. 2).

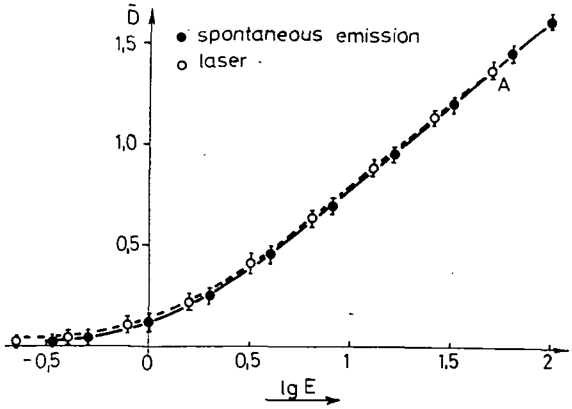

Fig. 2

It can be seen from the figure that the shape of both curves is identical within the errors of measurements.

As it is only necessary to know the ratios of the light intensities for determining the visibility and, irrespective of an additive constant, this ratio is unequivocally determined by the course of the blackening curves; therefore the results of our experimental research mean that, in the case of the light sources investigated, the degree of visibility is independent of the circumstance whether the blackening curve of the film was determined whith spontaneous or induced luminescence.

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О ДЕНСИТОМЕТРИЧЕСКОЙ ОБРАБОТКЕ ИНТЕРФЕРЕНЦИОННОЙ КАРТИНЫ КОГЕРЕНТНОГО СВЕТА С ПОМОЩЬЮ ГРАДУИРОВОЧНОЙ КРИВОЙ, ПОЛУЧЕННОЙ НЕКОГЕРЕНТНЫМ СВЕТОМ

Л. Визе, Ф. Пинтер, Л. Гати, Й. Юнг

Определена градуировка пленки ORWO NP 27 (Wolfen) с помощью спонтанного и вынужденного излучения раствора родамина 6Ж в этиловом спирте при возбуждении импульсными лампами. Кривые почернения, снятые этими двумя методами, в пределах ошибки измерения, совпадают.