OPTIC GENERATION IN SOLUTIONS OF COMPLEX MOLECULES

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Submitted 15 December 1966
ZhETF Pis'ma 5, No. 5, 144-148, 1 March 1967

The effect of the vibrational structure of the working levels on the generation properties were considered in [1-4]. A detailed calculation, carried out in [4,5], proved the feasibility of generation within the framework of two electron-vibrational levels, which are characteristic of a large number of dyes and other complex molecules.* It was proposed in [7] to pump such compounds with a ruby laser operating in the giant-pulse mode. The same reference reports a study of the optical characteristics of phthalocyanines of different metals, which made it possible to determine the concrete experimental conditions needed to obtain their generation.

In this communication we describe optical generation observed experimentally at room temperature in solutions of four compounds: magnesium phthalocyanine in quinoline, free phthalocyanine in sulfuric acid, cryptocyanine in methyl alcohol, and the dye methylene blue in sulfuric acid. Figure 1 shows the absorption and luminescence spectra of these compounds and delineates the generation regions.

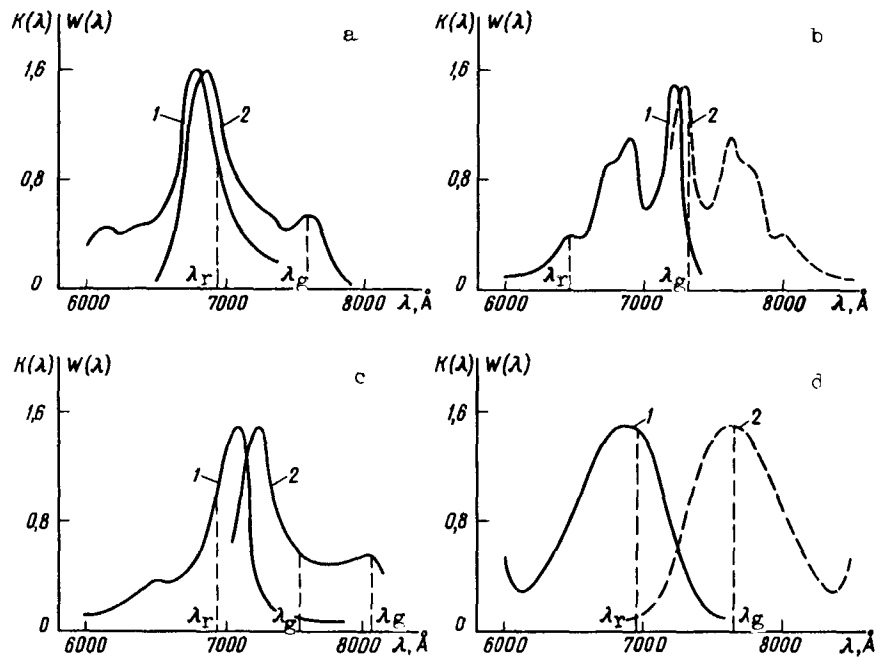

Fig. 1. Absorption (1) and luminescence (2) spectra: a - Mg phthalocyanine in quinoline, b - phthalocyanine in sulfuric acid, c - cryptocyanine in methyl alcohol, d - methylene blue in sulfuric acid: ——— measured, - - - assumed (owing to the extremely low quantum yield of the luminescence of free phthalocyanine and methylene blue, their spectra could not be registered even when excited with a ruby laser). Wavelengths: λ_r - ruby laser, λ_g - generation of solutions.

The generation conditions consisted in the following. A solution of active substance was placed in a rectangular cell 6 mm thick with plane-parallel precision-finished walls. In accordance with the calculation in [7], the concentration of the substances was taken in all cases to be approximately $5 \times 10^{16} - 10^{17}$ cm^{-3}. The cell was placed between plane-parallel dielectric mirrors having reflection coefficients from 50 to 99% in the region $\lambda \approx 7600$ Å. In some experiments, the reflecting coatings were deposited on the outer faces of the cell. The excitation was with the aid of a ruby laser in a direction perpendicular to the direction in which the generation of the solution was observed (Fig. 2). The ruby laser operated in the single-pulse mode, producing in each flash one pulse of 30 - 40 nsec duration, with energy 1.5 J. A part of the pulse energy, equal to 0.5 J, with a relatively uniform energy distribution over the section, was separated to excite the solution. Under these conditions, generation was observed in all the tested compounds. The generated emission had a divergence of 5×10^{-4} rad. The wavelengths and the spectral widths of the generated lines are listed in the table for each of the substances.

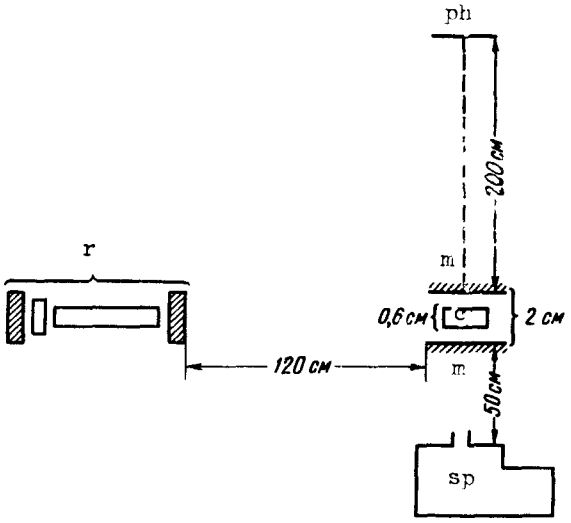

Fig. 2. Apparatus used to observe generation: r - ruby laser, c - cell with solution, m - mirrors, ph - photographic plate, sp - spectrograph (ISP-51).

The generation spectrum of cryptocyanine revealed at large mirror reflection coefficients the simultaneous presence of two lines, the one with the longer wavelength (λ = 8085 Å) being much more intense

T a b l e

Substance	Luminescence quantum yield, %	Luminescence spectrum width, Å	Generation wavelength, Å	Generation spectrum width, Å
Magnesium phthalocyanine in quinoline	80	1250	7590	10
Phthalocyanine in sulfuric acid	$\lesssim$ 0.001	1100	8634 7555	10 40
Cryptocyanine in methyl alcohol	$\approx$0.2	1200	8085	40
Methylene blue in sulfuric acid	$\lesssim$ 0.001	1100	8350	40

than that with the shorter wavelength (λ = 7555 Å). When the reflection coefficient of the mirrors was decreased, the intensity ratio changed in favor of the short-wave line, the long-wave line disappearing completely at coefficients R_1 = 99% and R_2 = 50%. A shift of the short-wave generation line towards the luminescence maximum, by 49 Å, was observed simultaneously. This change in frequency is in good agreement with the theoretical notions [4,5,7]. The emission generated by the solution of free phthalocyanine should include, in accordance with the calculation, a second generation line with λ = 9400 Å. No such line was registered because we did not have the required photographic material at our disposal.

The ratio of the energy generated by the solution to the energy of the exciting flux was 10% for cryptocyanine and methylene blue. Actually, the coefficient of conversion of the exciting energy of the ruby laser into energy generated by the solution is much higher, since the ruby emission was not effectively absorbed by the solution under our experimental conditions.

The effect described here offers experimental proof of the feasibility of obtaining generation with the aid of various complex organic compounds possessing broad absorption and emission bands. It turns out here that substances with exceedingly low luminescence quantum yields can be used for generation. At the same time, the experimental data show that complex molecules can be used for effective conversion of ruby-laser emission into coherent emission at long wavelengths. By varying the solvent, the concentration of the active medium, and the mirror reflection coefficients, the compounds used in this investigation can provide a large number of generation lines in the interval from 7000 to 10 000 Å.

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[3] B. I. Stepanov and A. N. Rubinov, ZhPS (J. Appl. Spectr.) 4, 222 (1966).

[4] Metody rascheta opticheskikh kvantovykh generatorov (Methods of Laser Design), B. I. Stepanov, editor, v. 1, Nauka i tekhnika, Minsk, 1966.

[5] A. N. Rubinov, Candidate's Dissertation, Minsk, 1965.

[6] A. P. Ivanov, Opt. i spektr. 8, 352 (1960).

[7] B. I. Stepanov, A. N. Rubinov, and V. A. Mostovnikov, ZhPS (cf. [3]) 6, No. 3 (1967).

* The possibility of obtaining gain in the systems was demonstrated by A. P. Ivanov [6].

PRODUCTION OF FOURIER HOLOGRAMS WITH THE AID OF A PULSED RUBY LASER

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Submitted 20 December 1966
ZhETF Pis'ma 5, No. 5, 148-150, 1 March 1967

The use of powerful ruby lasers with short emission pulses for holography uncovers a possibility of investigating very fast processes. There are already published reports [1,2]