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Abstract

Full Text

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S. D. KAITMAZOV, I. K. KRASYUK, P. P. PASHININ,
Academician A. M. PROKHOROV

CHARACTERISTICS OF AN OPTICAL QUANTUM GENERATOR OPERATING IN THE MODE-LOCKING REGIME

Optical quantum generators operating in the mode-locking regime make it possible, in principle, to obtain light pulses of extremely short duration, determined by the spectral width of the line of the active substance. In particular, for lasers based on doped crystals and glasses it is possible to generate pulses of picosecond duration with peak power exceeding 10^9 W. The realization of such generators poses in a new way a number of problems in the study of the interaction of intense coherent radiation with matter. In this connection there arises the need for accurate measurement of the parameters of powerful light pulses of picosecond duration. Oscillographic and electron-optical apparatus cannot be used, since they have insufficient time resolution.

Fig. 1. Schematic of the experimental setup.
K_1 —cell with saturable filter, A —neodymium-doped glass rod, K_2 —cell with rhodamine 6G

Recently, a number of authors ([1,2]) have used a method for measuring the duration of ultrashort light pulses which is essentially an extension of the coincidence method ([3]) to the optical range, where it allows durations down to 10^{-14} sec to be determined.

This article presents the results of measurements of pulse duration for mode-locked generators based on ruby and neodymium glass. The scheme of the experimental setup with the neodymium OQG is shown in Fig. 1. The OQG resonator of length $L = 2$ m was formed by two plane-parallel mirrors with reflection coefficients $R_1 = 98\%$ and $R_2 = 50\%$. The active element made of neodymium glass of type KGSS-7, 240 mm long and 15 mm in diameter, had

Fig. 2. Photographs of the luminous trace of the laser beam in a cuvette with Rhodamine 6G. Bright points correspond to the place where the pulses collide. a –mode selection is eliminated; b –selection is present at two surfaces of the output mirror. The total length of the beam in the photograph is 8 cm

Figure 2: Fig. 2. Photographs of the luminous trace of the laser beam in a cuvette with Rhodamine 6G. Bright points correspond to the place where the pulses collide. a –mode selection is eliminated; b –selection is present at two surfaces of the output mirror. The total length of the beam in the photograph is 8 cm

its ends cut at the Brewster angle. Mode locking was carried out by means of a liquid saturable filter based on a solution of polymethine dye in nitrobenzene with absorption coefficient 0.5. The cell with the filter, 3 mm thick, was tilted at the Brewster angle.

For measuring the duration, the most convenient of the methods mentioned above was used—the method of "collision"of light pulses in a medium luminescing under two-photon excitation. The output signal of the OQG is divided by the semitransparent mirror R_3 into two light beams of equal intensity. By means of mirrors R_4 and R_5, the beams are directed exactly toward one another inside a cell with a solution of rhodamine 6G in ethyl alcohol. Since the luminescence intensity under two-photon excitation is proportional to the square of the photon density, at the place of "collision" of the pulses in the cell, where the photon density at that instant doubles, the luminescence intensity sharply increases. The size of this brighter ob-

Fig. 2. Photographs of the luminous trace of the laser beam in a cuvette with Rhodamine 6G. Bright points correspond to the place where the pulses collide. **a** –mode selection is eliminated; **b** –selection is present at two surfaces of the output mirror. The total length of the beam in the photograph is 8 cm.

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parts is equal to the distance that light travels during the duration of the pulse.

The experimental results showed that the output radiation of the neodymium-glass laser consists of a train of pulses, each pulse having a base duration $\Delta t = 1.5 \cdot 10^{-12}$ sec, with a spacing between pulses of 13 nsec. Simultaneous measurement of the radiation spectrum width gave the value $\Delta\nu = 35$ cm^{-1} (at the base). It should be noted that, in order to obtain the indicated temporal characteristics of the laser output signal, it is necessary carefully to eliminate all possible causes of selection of the longitudinal modes of oscillation of the resonator. If selective elements are present in the resonator, the radiation spectrum becomes impoverished [4], and additional pulses appear in the output signal with a repetition frequency characteristic of the selecting element (Fig. 2b).

Measurement of the energy of the laser output radiation gave a value of $0.6 \div 0.7$

J. Since this energy is distributed over a train usually containing about 10 pulses, the average energy in one short pulse is $0.06 \div 0.07$ J. If it is assumed that the duration of the individual pulses of this train varies only insignificantly, the peak power in the short pulses of the given generator can be estimated. Taking the pulse duration at half-height to be $7 \cdot 10^{-13}$ sec, we obtain for the peak power in a pulse the value $P \simeq 10^{11}$ W.

The indicated method was also used to measure the duration of pulses of a mode-locked ruby laser. In this case the basic layout of the setup differed from that shown in Fig. 1 only in that the laser resonator was a ring system consisting of three mirrors. More detailed data on the laser parameters are given in (5). As in the case of the neodymium generator, the measuring cell was filled with rhodamine 6G solution, since special measurements confirmed the quadratic dependence in it of the luminescence intensity on the radiation flux power at the ruby wavelength. The pulse duration at the base obtained in this case was $\Delta t = 2.4 \cdot 10^{-11}$ sec, which agrees with measurements previously carried out by another method (5). An estimate of the peak power gives the value $P = 1.2 \cdot 10^9$ W.

In conclusion, it should be emphasized that the results of this work confirm the possibility of obtaining, with the aid of mode-locked generators, ultrashort pulses of high peak power and of measuring their parameters with sufficient accuracy.

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P. N. Lebedev Physical Institute
Academy of Sciences of the USSR

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