PARAMETRIC GENERATION OF ULTRASHORT PULSES OF TUNABLE-FREQUENCY RADIATION

K.P. Burneika, M.V. Ignatavichus, V.I. Kabelka, A.S. Piskarskas, and A.Yu. Stabinis
Vilnius State University
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1. We report the results of an experiment aimed at developing a parametric generator of ultrashort light pulses with a smoothly tunable frequency in the range 0.72 - 1.2 μ and with a radiation power density not less than 100 MW/cm². The pumping was with the second harmonic of a mode-locked neodymium laser. By focusing the pump in a KDP crystal, the attained energy efficiency of the parametric conversion was ∿1% per pass through the KDP crystal.

The presently-known parametric light generators (PLG) emit mainly pulses of nanosecond duration or else operate in the cw mode [1]. Methods for generating picosecond pulses of tunable radiation by synchronizing the modes of the PLG resonator or by using a pre-shaped sequence of ultrashort pump pulses were proposed in [2]. The second method was realized experimentally in the present investigation.

2. The experimental setup is shown in Fig. 1. A neodymium-glass laser emitted a train of 20 - 25 ultrashort pulses of 5 - 6 nsec duration. The laser rasonator was mode-locked with a phototropic plate shutter, which results in a much higher stability and reproducibility of the radiation parameters than with liquid shutters. The second harmonic of the radiation was excited in the crystal KDP-1 4 cm long, cut to produce the interaction $o_1 o_1 - e_2$. After cutting off the fundamental radiation with filters, the second harmonic was focused with a lens (f = 500 nm) into crystal KDP-2 of length 6 cm, cut at the Brewster angle to eliminate any possible feedback. The interaction realized in the crystal KDP-2 was $e_H - o_c e_x$. The characteristics of the parametric superluminescence (PSL) excited in the crystal were measured with a broadband photoregistration system and with spectrographs DFS-8 and ISP-51 with electron-optical converters.

3. When the threshold density of the pump power entering the lens exceeded 500 MW/cm², the infrared receivers registered the onset of intense PSL radiation whose energy reached 10^{-3} at 10% above threshold. The PSL spectra obtained with an ISP-51 spectrograph at different deviations from the degenerate regime

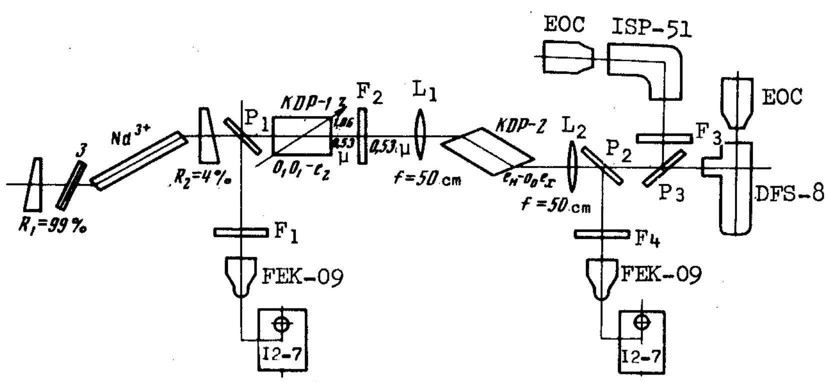
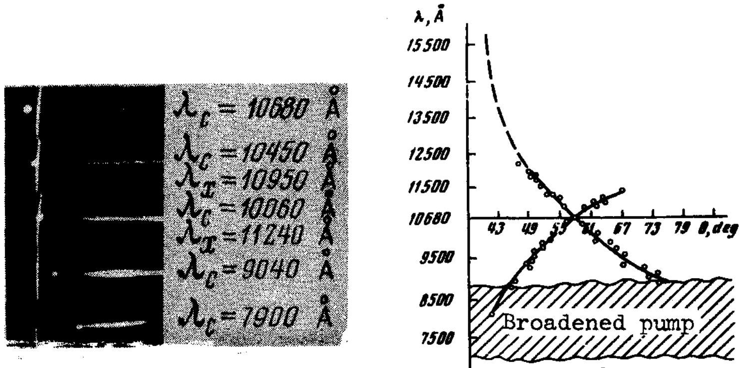


Fig. 1. Block diagram of experimental setup: R_1, R_2 - laser resonator mirrors, 3 - plate shutter, P_1, P_2, P_3 - glass plates, F_1, F_3, F_4 - KS-13 filters, F_2 - SZD-21 filters, L_1, L_2 - lenses, EOP - electron-optical converter.



a b

Fig. 2. a) Spectrograms of parametric superluminescence and of the additional glow at different angles of rotation of the KDP crystal, b) tuning curve of parametric superluminescence in a KDP crystal.

are shown in Fig. 2. The sharp spectral lines on all frames correspond to the reference emission lines of the PRK-4 lamp. The points, whose positions change relative to the reference lines, represent the signal and idling PSL waves. An identification of the broad spectral band on the right side of the spectrograms has shown that it corresponds to a pump radiation that is broadened in frequency as a result of the PM - FM process that occurs in the case of electronic self-focusing in the KDP crystal. The band of the frequency-broadened pump extends from 0.87 to 0.35 μ. The presence of self-focusing is evidenced by the clearly pronounced threshold for the appearance of the pump-spectrum broadening, and also by the accompanying sharp increase of the PSL intensity. An analysis of the PSL spectrograms shows that the signal wave increases in intensity as the wavelengths shorten from 0.87 to 0.78 μ, although the idling wave falls in this case into the region of total absorption of the KDP crystal. Figure 2b shows the PSL tuning curves, which indicate that in the present experiment the PSL can be tuned up to 0.78 μ in the visible region, while the idling wave reaches in this case 1.65 μ. It is known that the KDP crystal begins to absorb strongly near 1.2 μ, a fact that had heretofore limited the PSL tuning range to 0.95 - 1.2 μ. Such a strong broadening of the tuning range can apparently be attributed to the presence of self-focusing, which, first, increases sharply the pump intensity and, second, leads to the appearance of a frequency-broadened pump band, the long-wave edge of which plays the role of the intense priming signal of the PSL. Qualitative estimates based on the results of measuring the PSL energy near the degenerate regime show that the total gain in the self-focusing channel is 10^{17}, and the pump intensity reaches 10^{12} W/cm^2 in the pre-breakdown state of the crystal. The last figure agrees with measurements of the threshold of the radiative breakdown of a KDP crystal in a field of ultrashort pulses [3].

In conclusion, the authors consider it their pleasant duty to thank S.A. Akhmanov for valuable discussions and constant interest in the work.

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