High-power ultraviolet paraterphenyl-solution laser excited by the plasma focus of a magnetoplasma compressor

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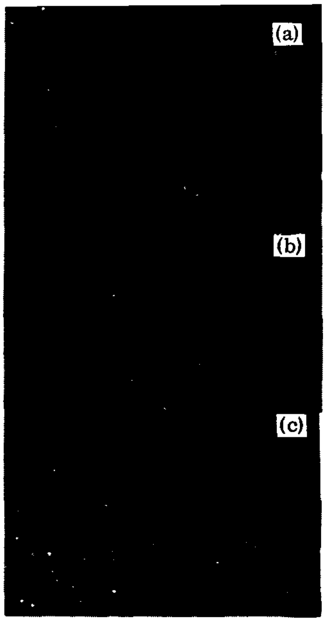
High-power ultraviolet laser action was obtained in the 339–345 nm range by exciting an ethanol solution of paraterphenyl with a plasma focus of a magnetoplasma compressor in a vacuum $\sim 10^{-6}$ Torr. At 1710 J energy input to the discharge, the lasing energy was 2.6 J and the generated power was 26 MW.

The need for having sufficiently powerful monochromatic radiation in the 200–400 nm, for example to realize many photochemical processes, to sound the sea and the upper layers of the atmosphere, or to investigate high-temperature plasma, has stimulated research on organic dye lasers operating in this frequency band.[1] Although paraterphenyl is the best compound for tunable lasers in the ultraviolet band (low excitation threshold, shortest generation wavelength in a nonselective resonator and sufficiently wide range of continuous tuning), the presently attained values of the generation ($\sim 10^{-3}$ J) and the radiation power (~ 40 kW)[2,3] with noncoherent excitation are patently insufficient. Owing to the presence of T-T absorption, appreciable energies can be obtained from organic dyes only with short pump pulses, the shaping of which in gas-discharge tubes or with exploding wires entails great technical difficulties, owing to the worsening of the matching of the discharge-circuit resistances.

The magnetoplasma compressor (MPC) of the erosion type seems to be at present the only device that creates, if the discharge plasma material is suitably chosen (metals, dielectrics, gases, and their combinations), conditions under which a stored electric energy 10^3–10^6 J is effectively converted into radiation of the required and sufficiently broad quantum-frequency range. In addition, the self-focusing of the plasma stream and, in contrast to MPC of the gas-discharge type,[4] the possibility of relatively simple control of the spectral and dynamic characteristics of the discharge, the high electric efficiency (up to 0.94) and the ~0.75 efficiency of utilization of the working medium, as well as the possibility of repeated operation, all these make the MPC of the erosion type a promising source of optical laser pumping.

In experiments with the apparatus described in[5], optimization of the shaping-circuit parameter and of the



Pulse oscillograms: a) MPC radiation in the 270—380 nm band (UFS-2 filter); b) luminescence; c) lasing of paraterphenyl solution in ethanol, $W_0 = 1875$ J. The time markers are spaced 0.1 μsec apart.

geometric, dynamic, and the energy characteristics of the plasma focus has made it possible to obtain, at a stored energy 1875 J, a 1710 J input into the discharge within a discharge pulse of ~1.2 μsec. The composition of the plasma-producing medium was selected to obtain a maximum of radiated energy in the region of high extinction coefficients of the solution, 210—390 nm.[6] The parameters of the optical pumping pulse can be assessed from the oscillograms shown in Figs. a and b. We see that the duration of the leading front (from 0.1 to 0.9 of the peak value) in the UV region in ~0.3 μsec.

The construction of a laser with continuously flowing active medium and liquid filter has a number of peculiarities due to the fact that the laser operates in a vacuum of $\sim 10^{-6}$ Torr, to the presence of magnetic fields $\sim 2\times 10^{4}$ Oe, and to the need for eliminating temperature gradients produced along the cell and leading to thermal optical stratification of the dye solution, etc.[1)]

The paraterphenyl solution was excited in a quartz cell 120 mm long and of 6 mm diameter, with the end faces parallel within 1′. The diffuse cylindrical reflector had a silicon-oxide coating. The resonator was made up of flat dielectric mirrors with reflectances $R'_{340} = 0.9$ and $R''_{340} = 0.75$; the concentration of the paraterphenyl solution in ethanol was $C = (9-15)\times 10^{-4}$ M. The lasing energy was measured with a three-layer bismuth bolometer and with an IKT-1M calorimeter. The wave forms of the pump and generation pulses were registered with an FEK-15 coaxial photocell with a separation condenser, and the width of the lasing spectrum was determined with an ISP-30 spectrograph. Figure c shows the temporal characteristics of the generated radiation. The half-width of the generation pulse was 0.1 μsec, and the width of the generation spectrum was 6 nm. A generation energy 2.6 J was reached as a laser efficiency 0.14% and an emission peak power 26 MW. By optimizing the generation regime and eliminating certain loss sources, the laser parameters can be greatly improved. At the present time we see no difficulties in principle hindering the development of similar laser systems with much higher energy. We note also that the MPC, owing to its characteristic features (operation in vacuum, strong magnetic fields $(2-5)\times 10^{-4}$ Oe, etc.) is a rather simple and effective system for the excitation of organic dye vapor lasers[7] and for the investigation of the kinetics of lasing in strong magnetic fields.[8]

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[1)]A detailed description of the laser construction has been submitted to the Journal "Pribory i tekhnika éksperimenta."

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