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We performed these experiments on a synchronously pumped Rhodamine 6G laser, which was operated in both conventional nearly-confocal configuration (point P_2 in Fig. 2), and in the new proposed configuration (point P_1 in Fig. 2). We found that the output power is the same in the two configurations. This is in agreement with the theoretical predictions, since the predicted spot sizes in the active dye are the same. To characterize the influence of MS on output power fluctuation, we measured the tilting angle $\bar{\sigma}_1$ of mirror M_1 that halves the output power as a function of the distance h of the gain jet from mirror M_4 for the two configurations (see Fig. 3). In both configurations we found an optimum position corresponding to the focal plane of mirror M_4; however, the MS is about 13 times lower in the new arrangement (P_1). To study the effects of MS on pulse duration stability, we measured the mode displacement, caused by mirror tilting, in the longer arm of the resonator, which usually contains the dispersion compensating prisms. The divergence of MS was clearly experimentally observed near P_2.

We believe that these results are a clear indication that the nearly-confocal configuration must always be avoided and that a more stable, less noisy configuration giving the same output power can be found. This configuration would be very difficult to find experimentally without the detailed stability analysis.

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9:30 am

CTuB6 Recent advances in the pulse shortening of copper bromide laser

Lei Zhu and Fucheng Lin*
Department of Physics, Fudan University, Shanghai, China

The Copper Bromide (CuBr) laser, characterized by high repetition rate, high average power, and output in visible spectral regions, has potential for research and applications in many fields. So far, there have been few investigations on the pulse shortening of CuBr laser, and no reporting on the ps CuBr laser. This lack of research stems from the CuBr laser being the "self-terminated" laser with a pulse duration of approximately 10–50 ns. Traditional modelocking techniques have failed to produce 100 percent modulated pulse trains or subnanosecond pulses because the typical gain duration of the CuBr laser represents only a few cavity roundtrip times. This short buildup time, combined with a moderate modulation index, results in incomplete mode-locking.

The following two methods were used for the first time to study pulse shortening of the CuBr laser both experimentally and theoretically.

1. The method of injection amplification
The output of the CuBr laser contains two spectral lines (511 nm and 578 nm) in the visible region, and the build-up time of 578 nm for laser oscillations is delayed about 10 ns compared with that of 511 nm. It is the delay time that permits the picosecond dye laser pulse[1] (generated from SCDL pumped by a CuBr laser) return back to the same CuBr gain medium to be amplified at 578 nm. Under proper conditions, nearly Fourier-transform limited pulses of 578 nm have been obtained with a pulsewidth of 113 ps, average power of 50 mW, and repetition rate at 11 KHz.

2. Generation of short pulses of the CuBr laser by quenching of resonator transients
The buildup of laser oscillations is faster in the low-Q value resonator than the high-Q value resonator which stored more energy. If the two resonators are established in the same part of the CuBr medium, the relaxation oscillations (except the first peak or falling part of the pulse) in the output of the low-Q resonator are quenched by the high-Q resonator. Short pulses are then generated. Experimentally, a single pulse with a pulsewidth of 2 ns was produced by quenching resonator transients using a relative small device of the CuBr laser. Its shot-to-shot pulse and stability are excellent. Theoretical treatment was made by introducing the rate equations with spatial dependence, which is different from that in SCDL. This was necessary because the pulse duration of the output is of the order of cavity roundtrip times. The theoretical results agree with the experiment very well.

Shanghai Institute of Optics and Fine Mechanics, Academia Sinica, Shanghai, China.

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9:45 am

CTuB7 Efficient frequency doubling of a self-starting additive-pulse mode-locked diode-pumped Nd:YAG laser

M. J. McCarthy, G. T. Maker, and D. C. Hanna
Optoelectronics Research Centre, Department of Physics, University of Southampton, Southampton S09 5NH, UK

The continuous wave mode-locked Nd:YAG laser is an important source of high power, short optical pulses. Operating at its fundamental wavelength or at higher harmonics, it is a convenient pump source for a range of ultrashort pulse laser systems.

The use of nonlinear-optical feedback from an external coupled cavity to enhance the mode-locking of actively mode-locked lasers can be described by a simple time domain theory called additive-pulse mode-locking (APM).[1] The extension of this technique to achieve self-starting APM has resulted in considerable advancement in the generation of ultrashort pulses from mode-locked solid-state lasers, and an overall simplification of such systems.[2-4]

Laser diodes have emerged as efficient, stable, and compact pump sources for solid-state lasers. Even with modest output powers from diode-pumped solid-state lasers, their excellent stability can be exploited to give shorter mode-locked pulse durations and enable very efficient nonlinear frequency conversion by using external resonant enhancement cavities.[5,6] The combination of diode pumping with self-starting APM and resonant second-harmonic generation (SHG) confirms the inherent stability of these schemes. Our results demonstrate the capability for high overall efficiency for such systems.

Figure 1 shows a schematic diagram of the self-starting APM diode-pumped Nd:YAG laser. The laser was pumped by a single 1-W diode laser array. The 10-mm length Nd:YAG rod was high-reflection coated at 1064 nm and high transmission at the pump wavelength on one end, and Brewster-angled on the other. The plane output coupler had a transmission of 17%. The nonlinear coupled cavity was formed by a 65% reflectivity beamsplitter and an 85-cm length of single mode fiber. The retroreflector was mounted on a PZT for interferometric cavity length stabilization. The Nd:YAG laser produced a stable train of 2.0-ps pulses at 125-MHz repetition rate. The average output power from the laser was 110 mW.

This output was spatially mode-matched int a ring resonant enhancement cavity, shown schematically in Fig. 2. The plane input couple was 20% transmitting, and all the other mirror were high reflecting at 1064 nm. The SHG element was a 3-mm-long $MgO:LiNbO_3$ crystal which was heated to 116.2 °C for 90° phas matching of 1064-nm radiation and placed at th intracavity focus between the two curved mirrors. The enhancement cavity was locked to peak of its transmission for the mode-locke laser output using the FM sideband lockin technique.[6] When locked, the enhancement ca ity produced 63 mW of average power at 53 nm in bandwidth-limited pulses of 2.0-ps d ration. This corresponds to an overall energ conversion efficiency from 1064 nm to useab 532 nm of 56%. The second-harmonic peak pow was approximately 240 W.

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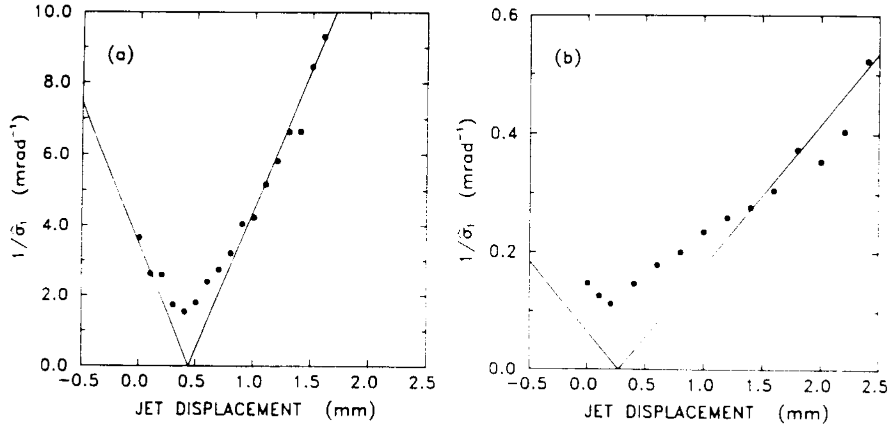
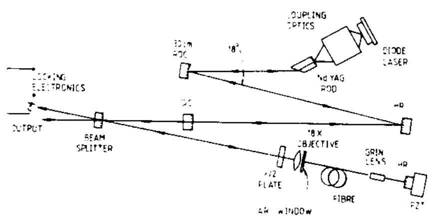
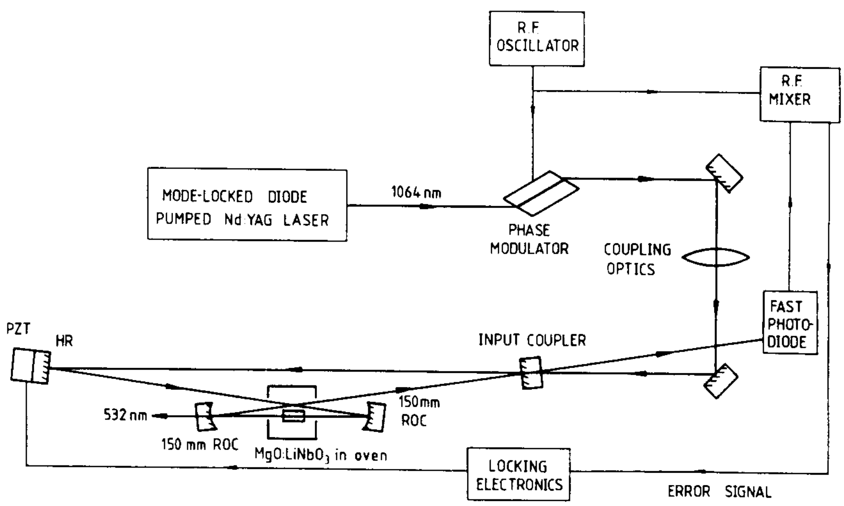


CTuB5 Fig. 3. Reciprocal of the tilting angle $\hat{\sigma}_1$ of mirror M_1 that halves the output power as function of the gain jet position inside the folding for z_1 = 100.40 nm (a) and z_1 = 109.82 m (b). The distance z_2 is 50 mm. The origin of the displacement was arbitrarily chosen. The solid line is a theoretical fitting.



CTuB7 Fig. 1. Schematic diagram of the self-starting APM Nd:YAG laser.



CTuB7 Fig. 2. Schematic diagram of the resonant enhancement cavity and locking electronics.