Interferometric Mode Selector for a cw Dye Ring Laser

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A novel interferometric mode selector allows easy alignment and stable operation of a cw dye ring laser. Details of its function in multimode and single mode operation are described.

Interferometric devices based on Michelson-type resonator configurations have been proposed by Fox and Smith [1, 2] for mode selection in He-Ne-lasers. The concept of mode competition within two coupled cavities has recently been applied for reliable generation of single-mode emission of pulsed [3] and cw dye lasers [4, 5]. The additional cavity discriminates against unwanted longitudinal modes of the active cavity by allowing only common resonances of both cavities to oscillate. As has been shown by Rigrod [6], mode selection is most efficient, if the length difference of both cavities is as large as possible and coupled resonators of the "venier"-type of nearly equal optical length are avoided. Considering the advantages of cw dye ring lasers [7], the idea was found attractive to combine a ring laser configuration with a Michelson-type mode stabilisator as studied by Smith [8] in the case of a long He-Ne ring laser. In the optical schematic of Fig. 1 experimental details of the interferometrically stabilized cw dye ring laser are shown. The cavity consists of the two prisms P_1, P_2, the couple of concave mirrors M_1, M_2, a flat mirror M_4 and the roof-top prism P_3. The Ar^+-laser pump beam is tightly focused into a free-flowing dye sheet of a $3.5 \cdot 10^{-4}$ molar solution of rhodamine 6G in ethylene glycol using a symmetric mirror configuration to compensate for aberrations due to astigmatism and coma [7]. The Abbe Prisms P_1 and P_2, made from highly dispersive Schott SF 10 glass (dispersion at 590 nm $12.9 \cdot 10^{-5}\,\mathrm{nm}^{-1}$), can be rotated around a vertical axis for coarse tuning of the emission wavelength. Mirror M_4 serves as outcoupler of fixed transmission ($R = 96\%$) in the wavelength range 560 nm to 640 nm and mirror M_3, with a broadband dielectric coating, reflects back the clockwise traveling wave onto itself to accomplish self-stabilizing traveling wave operation of the ring laser. The prism P_3 has two functions: (i) after removal of the two auxiliary mirrors M_5 and M_6 the ring-shaped cavity can be easily closed to a ring laser by means of P_3 and (ii), it considerably narrows the emission bandwidth to approximately 1 GHz, where four longitudinal modes spaced by 230 MHz are simultaneously oscillating. The prism P_3 corresponds to an interferometer of 2.5 GHz free spectral range with low finesse. In order to maintain the ring laser properties of the cavity, a reflectivity of 40% has been chosen for the front surface of P_3. The optical path within P_3 represents the small, coupled cavity, which replaces the usually used external Fox-Smith mode selector [4, 5]. The prism is fabricated with interferometric precision avoiding thus a sophisticated alignment procedure, since this is done in the opticians workshop. By means of the etalon FPE I (solid quartz etalon of 2 mm thickness and 40% reflectivity) single-mode operation with a bandwidth less than 15 MHz can be achieved. Tilting FPE I, single mode jumps corresponding to the free spectral range of P_3 are observed. The single-mode emission can be tuned continuously with a second etalon FPE II (uncoated quartz etalon of 12 mm thickness). In the latter case, prism P_3 is used to stabilize the single mode emission and – by a simultaneous longitudinal translation as indicated in Fig. 1 – to suppress mode jumps by compensating for the

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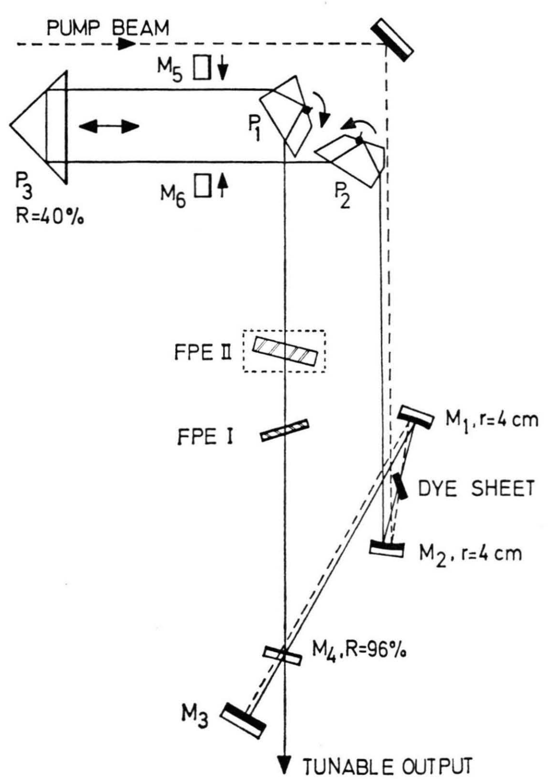

Fig. 1. Optical schematic of cw dye ring laser.

optical wavelength difference produced by the rotation of FPE II. Using a preliminary laboratory setup, 10 mW output power in multimode operation and 2 mW in single mode operation were observed at 350 mW Ar^+-laser input power. This relatively low efficiency is attributed to non-optimized outcoupling and imperfections as to flatness and angular precision of the home made roof-top interferometer prism. In both cases multimode and single-mode operation, the longterm variations in bandwidth did not exceed a few Megahertz.

The combination of the prism mode selector with an electrically driven etalon FPE I can lead to interesting applications, where narrowband laser radiation at discrete wavelengths is needed, e. g. in multiwavelength holography.

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Berichtigung

F. Scappini, H. Mäder, and J. Sheridan, "Investigation of the Internal Rotation in Propargyl Mercaptan by Microwave Spectrum Analysis", Z. Naturforsch. **28a**, 77 [1973].

Page 80, Table 3 should be read:

Transition	0^+ Observed frequency	0^+ Calculated frequency	0^- Observed frequency	0^- Calculated frequency	Observed Splitting $(\nu_{0^+}-\nu_{0^-})$	Calculated Splitting $(\nu_{0^+}-\nu_{0^-})$
$1_{01}-0_{00}$	5 803.180	5 803.134	5 802.829	5 802.713	0.351	0.421
$1_{11}-0_{00}$	25 104.853	25 105.010	25 103.544	25 103.679	1.309	1.331
$1_{10}-1_{01}$	19 589.860	19 589.970	19 588.750	19 588.521	1.110	1.449
$2_{11}-1_{10}$	11 894.976	11 894.226	11 893.944	11 893.658	1.032	0.568
$2_{12}-1_{11}$	11 317.920	11 318.146	11 318.220	11 318.645	−0.300	−0.499
$2_{02}-1_{01}$	11 603.184	11 603.031	11 602.272	11 602.201	0.912	0.830
$2_{12}-1_{01}$	30 619.893	30 620.023	30 618.498	30 619.611	1.395	0.412
$2_{11}-2_{02}$	19 881.740	19 881.166	19 880.540	19 879.978	1.200	1.188
$3_{21}-2_{20}$	17 423.489	17 422.466	17 422.251	17 421.377	1.238	1.089
$3_{22}-2_{21}$	17 410.731	17 409.881	17 409.489	17 408.791	1.242	1.090
$3_{12}-2_{11}$	17 838.834	17 838.196	17 840.139	17 838.899	−1.305	−0.703
$3_{03}-2_{02}$	17 396.655	17 396.456	17 395.395	17 395.239	1.260	1.217
$3_{13}-2_{02}$	35 992.663	35 991.737	35 995.309	35 994.435	−2.646	−2.698
$3_{12}-3_{03}$	20 324.019	20 322.905	20 325.100	20 323.638	−1.081	−0.733
$4_{22}-3_{21}$	23 243.592	23 242.332	23 241.864	23 240.848	1.728	1.484
$4_{23}-3_{22}$	23 211.636	23 210.888	23 210.040	23 209.421	1.596	1.467
$4_{04}-3_{03}$	23 180.376	23 180.189	23 178.780	23 178.613	1.596	1.576
$4_{13}-4_{04}$	20 920.314	20 919.802	20 927.538	20 926.998	−7.224	−7.196
$5_{05}-4_{04}$	28 951.208	28 951.048	28 949.236	28 949.146	1.972	1.902
$6_{33}-5_{32}$	34 841.238	34 837.794	34 840.133	34 835.563	1.105	2.231
$6_{34}-5_{33}$	34 838.754	34 836.611	34 837.667	34 834.473	1.087	2.138
$6_{06}-5_{05}$	34 705.942	34 705.943	34 703.737	34 703.747	2.205	2.196

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