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Calculation of the Stability of the Fiber Ring Laser with Liquid Crystal Polarization Controllers

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To date, with the ultra-short pulse lasers are used in many areas of science and technology, including information technology. The main task of creating such lasers is to provide output radiation with the shortest pulse duration. The shortest duration pulses achieved in fiber ring lasers with nonlinear rotating polarization modes, namely 20 fs. But in such lasers, there are a number of problems: stability of operation and tuning of the mode locking. This is due to the tuning of the mode-locked by rotating the wave plates in space manually. There are a number of papers in which the authors suggest using liquid crystal (LC) cells instead of wave plates, which are controlled by low-voltage voltage. But to solve a technical task, we need a theoretical solution. In this paper, we propose a method for calculating the stability of a fiber ring laser with LC cells by solving the nonlinear Ginzburg-Landau equation (1) and Oseen-Frank (2):

$$i\frac{\partial \tilde{F}(t,\varsigma)}{\partial \varsigma} = ig_1\tilde{F}(t,\varsigma) + (\frac{\beta_2}{2} + i\rho)\frac{\partial^2 \tilde{F}(t,\varsigma)}{\partial t^2} + (D_r + D_i)\tilde{F}(t,\varsigma)\left|\tilde{F}(t,\varsigma)\right|, \quad (1)$$

where β_2 is the coefficient of group velocity; g_1 is the linear gain; ρ is the spectral filtration; D_i is the nonlinear gain; D_r is the self-modulation factor; $\tilde{F}(t,\varsigma)$ is the complex field amplitude.

$$F = \int\left\{\frac{1}{2}K_{22}(\frac{d\theta}{dz})^2 - \frac{1}{2}\varepsilon_0\Delta\varepsilon E^2\sin^2(\theta)\right\}, \quad (2)$$

where K_{22} is the constant of elasticity; $\Delta\varepsilon$ is the dielectric anisotropy; $\theta(z)$ is the director inclination angle and E is the electric field.

These equations were solved using numerical methods: expansion with respect to physical quantities with a fast Fourier transform, methods for reducing the differential equation to a system of linear equations, and the method of Jones matrices. As a result of work, stability diagrams of a fiber ring laser were obtained, namely, the dependence of the pulse amplitude on the applied voltage on the LC cells. Calculations were carried out for a LC cell of planar execution.