with the interference of the additional waves. The latter alternate with somewhat larger intervals than the reflection maxima. This effect is due to absorption of one of the two waves in the crystal, namely the wave corresponding to the exciton propagation. Lines with N = 3 - 8 are observed in the emission spectra.

Analogous singularities in the reflection, transmission, and emission spectra were observed by us also in thin CdS crystals near the resonances A (n = 1), B (n = 1), and A (n = 2).

Thus, investigation of interference phenomena in ultrathin crystals reveal the size quantization of optical-exciton states and the additional waves. This makes it possible to trace the dispersion of the refractive index with allowance for the optical-exciton interaction and spatial dispersion.

[1] M. S. Brodin and S. I. Pekar, Zh. Eksp. Teor. Fiz. 38, 74 and 1910 (1960) [Sov. Phys.-JETP 11, 55 and 1373 (1960)].
[2] V. M. Agranovich and V. L. Ginzburg, Kristallooptika s uchetom prostranstvennoi dispersii i teoriya eksitonov (Spatial Dispersion in Crystal Optics and the Theory of Excitons), Nauka, 1965 [Wiley, 1966].
[3] S. I. Pekar, Zh. Eksp. Teor. Fiz. 34, 1176 (1958) [Sov. Phys.-JETP 7, 813 (1958)].
[4] R. G. Wheeler and I. O. Dimmock, Phys. Rev. 125, 1805 (1962).

FEASIBILITY OF A SUPERSENSITIVE LASER METER FOR ARTIFICIAL ANISOTROPY AND FARADAY ROTATION OF THE PLANE OF POLARIZATION

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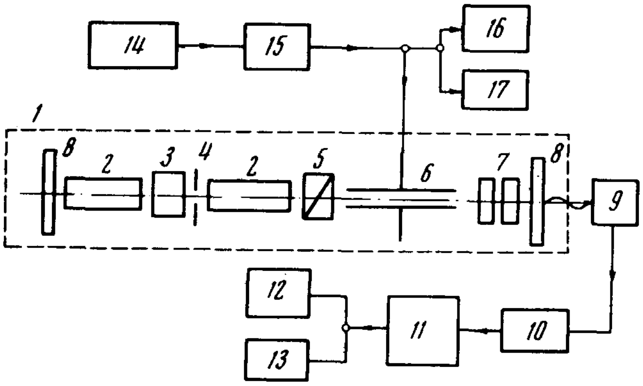
It is shown that the use of single-frequency solid-state laser of stable frequency and stable emission power make possible measurements of an induced anisotropy up to (10^{-10} - 10^{-11}) and of optical activity up to 10^{-6} - 10^{-7} second of angle.



Experimental setup for the measurement of the anisotropy induced in air by an electric field: 1 — YAG:Nd$^+$ laser, 2 — active rods, 3 — 90° polarization rotator, 4 — diaphragm, 5 — polarizer, 6 — air capacitor, 7 — phase plate with adjustable anisotropy, 8 — resonator mirrors, 9 — photodiode, 10 — bandpass filter, 11 — measuring amplifier, 12,13,16,17 — instruments for monitoring the waveform and level of the signal, 14 — sound generator, 15 — power amplifier.

An investigation of the emission kinetics of high-stability solid-state lasers has shown [1, 2] that such lasers have high sensitivity to resonator-loss modulation at the frequency ω_r of the relaxation oscillations. The radiation-modulation coefficient m_r can be determined in this case by solving the nonstationary rate equations, and at small perturbations of the single-mode generation in a four-level system we have

$$m_r = \frac{\Delta\sigma c \tau}{2 L_r n} \qquad (1)$$

where $\Delta\sigma$ is the amplitude of the resonator-loss modulation per double pass, c is the speed of light, L_r is the optical length of the resonator, n is the excess of pump over threshold, and τ is the lifetime of the excited level.

This feature can be used, in particular, to measure very small values of artificial anisotropy and Faraday rotation of the polarization plane. On the other hand, it becomes possible to measure the optical constants that characterize these phenomena.

Let us determine the sensitivity of a laser polarimeter making use of this feature, using as an example the measurement of the anisotropy induced in air by an electric field. The diagram of such a polarimeter is shown in the figure. A polarizer and a Kerr cell were placed in the laser resonator in such a way that the field intensity vector in the cell made an angle of $\pi/4$ with the plane of the oscillations of the electric vector passed by the polarizer. An additional phase shift in plate 7 increased the sensitivity of the circuit. The phase shift produced by plate 7 was calibrated against the losses introduced in the resonator. An alternating voltage of frequency $\omega_r/2$ was applied to the air capacitor, thereby modulating the resonator losses at a frequency ω_r. The amplitude $\Delta\sigma$ in this circuit is equal to

$$\Delta\sigma = 0{,}64\pi B d E^2 = 0{,}64\pi \frac{(\kappa\ell - \kappa_o)d}{\lambda},$$

where d is the length of the air capacitor, λ is the generation wavelength, B is the Kerr constant, E is the field intensity in the capacitor, κ_e and κ_o are the refractive indices for the waves polarized parallel and perpendicular to $\overline{E}$. The numerical coefficient is determined by the losses introduced by the phase plate 7 and was equal to 0.64 under the conditions of the experiment.

By substituting (2) in (1) we can obtain an expression for the sensitivity of the measurement method

$$\frac{\kappa_e - \kappa_o}{\lambda} d = \frac{m_r L_r n}{0{,}32\pi c \tau}.$$

Using the corresponding numerical values L_r = 72 cm, n = 1.15, c = 3×10^{10} cm/sec, τ = 2×10^{-4} sec, m_r = 10^{-3} (laser-emission noise level at the frequency ω_r), and d = 13 cm, we obtain

$$(\kappa_e - \kappa_o)d = 1{,}4\cdot10^{-8}\lambda. \tag{4}$$

The use of a synchronous detector in the measurement circuit increases the sensitivity by two or three orders of magnitude more. It can thus be assumed that if one longitudinal mode is generated and the emission frequency is stabilized there is a realistic possibility of measuring artificial anisotropy up to $(\kappa_e - \kappa_o)d = (10^{-10} - 10^{-11})\lambda$. An analogous estimate for the measurement of the optical activity yields a sensitivity $\phi \sim 10^{-6} - 10^{-7}$ second of angle in the measurement of the angle of rotation of the polarization plane by a magnetic field. The sensitivity of the photoelectric polarimeters previously employed for these purposes is lower by approximately five orders of magnitude.

The sensitivity of the method was verified with the setup illustrated in the figure by measuring the Kerr constant B of air. The measured value of the Kerr constant at 5 = 30°C, λ = 1.06 μ, E = 4×10^3 V/cm was $(1.1 \pm 0.5)\times10^{-11}$ cgs esu. The value of B given in [3] for nitrogen and λ = 0.564 μ is 4×10^{-11} cgs esu. The sensitivity of the experimental setup without using synchronous detection agreed with the value given by (4).

The high sensitivity of the method can permit investigation, in gases, of such phenomena as in the inverse Zeeman effect in weak absorption lines, using the Faraday rotation of the polarization plane, and for the development of new methods for frequency stabilization of solid-state lasers.

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[1] G. N. Vinokurov, N. M. Galaktionova, V. F. Egorova, A. A. Mak, B. M. Sedov, and Ya. I. Khanin, Zh. Eksp. Teor. Fiz. 60, 489 (1971) [Sov. Phys.-JETP 33, 262 (1971)].
[2] N. M. Galaktionova, V. V. Gershun, A. A. Mak, and A. P. Khyuppenen, Abstracts of Papers at 2nd Internat. Conf. on Lasers and Their Applications, Dresden, 1973.
[3] G. S. Landsberg, Optika (Optics), GITTL, 1940.