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B. I. Stepanov. Lasers Based on Complex Organic Compounds. The prospects of the use of organic compounds of the dye type to generate radiation was reliably validated in 1964 by the staff of the BSSR Academy of Sciences Physics Institute. The principal distinctive features of the anticipated generation were predicted at the same time. The generation was experimentally realized in 1966[1]. As it turned out, the capacity for generation is a widespread property of complex molecules. At the BSSR Academy of Sciences Physics Institute alone about 350 generating compounds have been studied. The principal sources of energy loss and a number of relationships connecting the generation properties with the structure of the molecules are already known. This allows us to conduct a directed search for prospective molecules for the construction of lasers for different purposes. Knowing the optical characteristics of a solution, we can compute a priori the generation parameters (the efficiency, power, energy, frequency, and duration). Where they are comparable, the theoretical and experimental results practically coincide. By measuring the generation parameters, we can in principle obtain new information about the properties of the excited states of the most active substances.

Lasers based on organic compounds possess a number of specific distinctive features which make them widely applicable for the solution of the most diverse scientific and technological problems. Their main property is the possibility of producing radiation of any wavelength in the range 2400—11180 Å[2-4]. At the BSSR Academy of Sciences Physics Institute a device, called "Raduga" (Rainbow), has been developed which allows the realization of a smooth tuning of the laser radiation in the entire range of from 3600 to 10600 Å without having to replace the pumping source and the resonator elements[3]. Also of extreme importance is the possibility of controlling the spectral characteristics of the generation. The width of the spectrum generated by a given solution can be changed at the experimenter's will within the limits of six orders of magnitude—from 10^3 to 10^{-2}—10^{-3} Å[1,2,5]. To narrow the band one introduces into the resonator different strobing elements. The smooth tuning of the generation frequency is realized within the limits of the luminescence band (up to 1000 Å) by a simple rotation or shift of a strobing element. An operational frequency tuning with electronic control has also been accomplished, and this allows us to vary the frequency according to a prescribed law, even during the period of one generation pulse, and thereby insert necessary information into the radiation.

Also possible is the production of generation with diverse time characteristics. There are in many laboratories operational, ultranarrow ($\sim 10^{-11}$ sec) light-pulse generators based on dyes[2]. When pumped with a nitrogen laser, generation with a high pulse-repetition rate (50—100 Hz[6]) is easily realized. At the BSSR Academy of Sciences Physics Institute a tunable laser with a repetition rate of up to 50 Hz and with ordinary pumping by a pulse tube has been tested[7]. In the USA a steady generation has been accomplished with pumping by an argon laser[8].

Theoretical and experimental investigations have shown that when generators bases on the best dyes are excited by pulse tubes, their energy characteristics are close to the characteristics of solid-state lasers. The highest energy (>100 J) has for the present been obtained in the investigations[9].

The preparation of microgenerators in the form of films and fibers has been reported lately, and this is important for integral optics. Owing to the high amplification factor and the wide band, organic compounds are used as light amplifiers.

Generators based on organic compounds are already being quite extensively used: in laser spectroscopy, nonlinear optics, photochemistry and luminescence, in high-resolution spectroscopy in the probing of plasmas and the atmosphere, in holography, medicine, and biology, i.e., wherever we need to tune the frequency of the laser radiation and the action on a substance under the conditions of a one-photon or a many-photon resonance. The practical utilization of generators of this type will expand rapidly from now on.

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F. I. Fedorov. The Theory of the Optical Activity of Crystals. Optical activity is the most important manifestation of spatial dispersion, i.e., of the dependence of the permittivity tensor on the wave vector. Optical activity has for a long time been inseparably linked with the phenomenon of the rotation of the plane of polarization of linearly polarized light passing through a medium in an arbitrary direction (for active isotropic media and cubic crystals), or in the direction of the optical axes (for active uniaxial and biaxial crystals) with which another name, gyrotropy, is associated. On this basis, crystals of the planar classes of the intermediate syngonies, in which rotation of the polarization plane is impossible for any direction, belonged to the set of crystals which could not be optically active[1-4]. A different point of view was expounded in[5,6], and in[7] a plan for an experiment is proposed which allows the detection of the manifestation of optical activity in the planar crystals of the intermediate syngonies.

The electrodynamics of gyrotropic media is characterized by the following matter equations:

$$D_i = \varepsilon_{ik}E_k + \alpha_{ikl}\nabla_k E_l, \quad B_i = \mu_{ik}H_k + \beta_{ikl}\nabla_k H_l; \tag{1}$$

here the third-rank tensors α_{ikl} and β_{ikl} are responsible for the gyrotropy and, according to[5,6] (see also[8]), the nonvanishing of at least one of them is necessary and sufficient for the medium to be optically active. In the book[8] it was assumed that $\beta_{ikl} = 0$, and, on the basis of the symmetry principle for kinetic coefficients, α_{ikl} was found to obey the condition

$$\alpha_{ikl} = -\alpha_{lki} = e_{ilm}\alpha_{mk} \tag{2}$$

(e_{ilm} is the Levi-Civita symbol), as a result of which Eqs. (1) assume the form

$$\mathbf{D} = \varepsilon\mathbf{E} + [\alpha\nabla, \mathbf{E}], \quad \mathbf{B} = \mu\mathbf{H}. \tag{3}*$$

In[5] this problem is considered from other angles. The restrictions on the tensors α_{ikl} and β_{ikl} are derived from the requirement that from the constitutive equations (1) and the Maxwell equations

$$\operatorname{rot}\mathbf{E} = -c^{-1}\dot{\mathbf{B}}, \quad \operatorname{div}\mathbf{B} = 0, \tag{4a}$$

$$\operatorname{rot}\mathbf{H} = c^{-1}\dot{\mathbf{D}}, \quad \operatorname{div}\mathbf{D} = 0 \tag{4b}$$

should follow the energy conservation law in the usual form

$$\operatorname{div}\mathbf{S} + \dot{w} = 0, \tag{5}$$

where **S** is the energy current density vector and w is the energy density. The condition (2) is again obtained for the activity tensor, on account of which (1) assumes the form

$$\mathbf{D} = \varepsilon\mathbf{E} + [\alpha\nabla, \mathbf{E}], \quad \mathbf{B} = \mu\mathbf{H} + [\beta\nabla, \mathbf{H}]; \tag{6}$$

in this case

$$\mathbf{S} = \frac{c}{4\pi}[\mathbf{EH}] - \frac{1}{8\pi}(\tilde{\alpha}[\mathbf{E}\dot{\mathbf{E}}] + \tilde{\beta}[\mathbf{H}\dot{\mathbf{H}}]), \quad w = \frac{1}{8\pi}(\mathbf{ED} + \mathbf{HB}), \tag{7}$$

where $\tilde{\alpha}_{ik} = \alpha_{ki}$. The role of the vector **S** in electrodynamics is well known; therefore the new expression (7) (it differs from the standard expression $c[\mathbf{E}\times\mathbf{H}]/4\pi$), obtained for it in[5], is of definite interest. Note that the energy relations are not considered in[8] at all, while the expression (7) for $\beta = 0$ is used in the book[9]. In[10] the method expounded in[5] is applied to the case of moving optically active media.

It subsequently becomes clear, however, that the relations (6) and (7) together with the standard boundary conditions (continuity at the boundary of the tangential components of **E** and **H** and the normal components of **D** and **B**) do not guarantee energy-flux balance when light is reflected and refracted at the boundary of a gyrotropic medium[1)].

Thus arose the necessity to change either the relations (6) and (7), or the boundary conditions, or both. Hence it is clear that we encounter in the theory of gyrotropic media a number of fundamental problems connected with the generalization of the basic electrodynamic relations.

A more detailed investigation shows that for the constitutive equations (1) the energy conservation law in the form (5) can be satisfied in more than one way. For this purpose the relations (1) were used in their original form in[5]. At the same time, we can, by decomposing the tensors α_{ikl} and β_{ikl} into their symmetric and antisymmetric parts with respect to the indices kl, separate out the curl operation and use the Maxwell equations (4) in (1). By applying such procedure to Eqs. (1) and (4), the authors of[11] obtained the relations[2)]

$$\mathbf{D} = \varepsilon(\mathbf{E} + \alpha\operatorname{rot}\mathbf{E}), \quad \mathbf{B} = \mu(\mathbf{H} + \tilde{\alpha}\operatorname{rot}\mathbf{H}), \tag{8}$$

for the case when the energy conservation law (5) in which

$$\mathbf{S} = (c/4\pi)[\mathbf{EH}], \quad w = (1/8\pi)(\mathbf{D}\varepsilon^{-1}\mathbf{D} + \mathbf{B}\mu^{-1}\mathbf{B}). \tag{9}$$

is fulfilled. In this case the energy-flux balance for light incident at the boundary of a gyrotropic medium is fulfilled when the standard boundary conditions

$$[\mathbf{E}_1 - \mathbf{E}_2, \mathbf{n}] = 0, \quad (\mathbf{B}_1 - \mathbf{B}_2)\mathbf{n} = 0, \tag{10}$$

$$[\mathbf{H}_1 - \mathbf{H}_2, \mathbf{n}] = 0, \quad (\mathbf{D}_1 - \mathbf{D}_2)\mathbf{n} = 0, \tag{11}$$

where **n** is the normal to the interface, are used.

In the constitutive equations (8), as in (3), the gyrotropy properties are determined in the most general case of a crystal of arbitrary symmetry by the single tensor α, i.e., by nine parameters. It was shown in[13] that a mutual correspondence can be established between the formulas (3) and (8), at least up to terms of first order in the small quantities α.

In this connection let us emphasize particularly the known fact that the Maxwell equations (4) alone certainly cannot uniquely determine the vectors **E**, **B**, **H**, and **D**. Indeed, it is easy to see that the vectors

$$\mathbf{E}' = \mathbf{E} + c^{-1}\dot{\mathbf{P}}, \quad \mathbf{B}' = \mathbf{B} - \operatorname{rot}\mathbf{P}, \quad \mathbf{H}' = \mathbf{H} + c^{-1}\dot{\mathbf{Q}}, \quad \mathbf{D}' = \mathbf{D} + \operatorname{rot}\mathbf{Q} \tag{12}$$

*$[\alpha\nabla, \mathbf{E}] \equiv \alpha\nabla \times \mathbf{E}$.

1)Naturally, this difficulty pertains in full measure to the theory expounded in the book [9], since the latter is based on the relations (6) and (7).

2)Similar results were obtained simultaneously and independently by a more complicated method in [12].