Optica Applicata VIII/4, 1978

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Faraday effect of some dielectric crystals by phenomenological approach**

The electro-magnetic susceptibility tensor component χ_{ijk}^{em} has been determined for eleven crystals belonging to the four symmetry classes $\bar{4}2m$, $3m$, 6 and 23. Their Verdet constants have been determined for two wavelengths: $\lambda_1 = 632.8$ nm and $\lambda_2 = 694.3$ nm. The respective refraction indices are obtained from dispersion equations.

The electric polarization, induced in a dielectric medium by a simultaneous action of electric and magnetic fields, is given by the equation

$$P_i(\boldsymbol{r}, t) = \chi_{ijk}^{em} E_j(\boldsymbol{r}, t) H_k(\boldsymbol{r}, t), \tag{1}$$

where χ_{ijk}^{em} is the electromagnetic susceptibility pseudotensor. Assuming that the light wave propagates in the medium along its optical axis, parallel to the z-axis of coordinate system, we have:

$$n_+ - n_- = -\frac{4\pi}{n} \chi_{ijk}^{em} H_z(0), \tag{2}$$

where H_z — magnetic DC field strength acting on the medium, n_+ and n_- — refractive indices of the right- and lefthanded sense of circular polarization of light, respectively, propagating in the medium, n — refractive index of the medium in the absence of a magnetic field.

Eq. (2) describes linear Faraday effect and by the definition of the Verdet constant V [1, 9] we obtain

$$V = -\frac{4\pi^2}{n\lambda} \chi_{xyz}^{em}(\omega, 0), \tag{3}$$

while analizing the tensor components χ_{ijk}^{em} for all crystallographical classes KIELICH [1] have determined the nonzero and mutually independent ones.

The aim of this paper is to determine the numerical values of the xyz-component of χ_{ijk}^{em} for eleven crystals belonging to the four symmetry classes:

Values of refractive indices, Verdet constant, and tensor components χ_{xyz}^{em} Table 1

Crystal	Crystallographical class	Refractive index n		Verdet constant along the optical axis direction V [deg/mT]		Value of the tensor $\chi_{xyz}^{em} \times 10^{13}$ e.s.u. component		References
		λ_1	λ_2	λ_1	λ_2	λ_1	λ_2	
KDP	42 m	1.5073	1.5050	204	174	86	80	[5]
ADP		1.5277	1.5193	234	192	100	90	[5]
DKDP		1.5044	1.5026	238	197	100	91	[6]
KDA		1.5663	1.5610	394	327	173	157	[6]
DKDA		1.5597	1.5566	408	339	178	162	[6]
ADA		1.5743	1.5710	406	337	179	163	[6]
$LiJO_3$	6	1.8866	1.8784	981*	799*	518	461	
$LiNbO_3$	3 m	2.2911	2.2765	71	49	46	34	[7]
$LiTaO_3$		2.1772	2.1658	86	64	55	43	[7]
$NaClO_3$	23	1.5136	1.5115	266	209	113	97	[8]
$NaBrO_3$		1.6015	1.5859	383*	347*	176	169	

* From Becquerel's formula [9], on the assumption of magnetic anomaly $\gamma = 0.6$

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** Part of this work was carried out under the Research Project MR. I. 4. IV. 4.

$\bar{4}2m$, $3m$ 6 and 23. Accordingly, by carrying out the measurements of the Faraday effect at 21°C and using the values available in the literature we have determined Verdet constant for two wavelengths: $\lambda_1 = 632.8$ and $\lambda_2 = 694.3$ nm. The values of Verdet constant obtained are given in table 1.

From the dispersion equations we have calculated refractive index n from the following crystals: KDP, ADP [2], $LiNbO_3$ [3], $NaClO_3$ and $NaBrO_3$ [4]. For the other crystals listed in table 1 n has been calculated from the semi-empirical formula of Sellmeier

$$n^2-1 = \frac{S_0\lambda^2}{\lambda^2-\lambda_0^2} = S_0\left(1+\frac{\lambda_0^2}{2}\right), \qquad (4$$

where S_0 and λ_0^2 are quantities determined graphically from eq. 4. Table 2 gives the values S_0 and λ_0^2

Table 2

Values of the coefficient S_0 and λ_0^2 in Sellmeier equation

Crystals	S_0	λ_0^2 [μm^2]	References
DKDP	1.232	0.01008	[10]
KDA	1.407	0.01167	[11, 12]
DKDA	1.378	0.0155	[12]
ADA	1.420	0.0159	[13]
$LiTaO_3$	3.447	0.0340	[14]
$LiJO_3$	2.388	0.0268	[15]

for the crystals studied. The data given in table 2 and the eq. 3 were used to calculate the tensor components χ^{em}_{xyz}. The numerical values obtained are presented in table 1, they are necessary for evaluations of the order of magnitude of higher order nonlinear optical effects in dielectric crystals [1, 16].

Эффект Фарадея в диэлектрических кристаллах, рассматриваемый феноменологически

Вычислено значение составляющей псевдотензора электромагнитной восприимчивости χ^{em}_{iik} для одиннадцати кристаллов, относящихся к четырем классам симметрии: $\bar{4}2m$, $3m$, 6, и 23. Приведены значения постоянной Верде этих кристаллов для двух длин световой волны λ — 632, 8 нм и λ_2 — 694,3 нм. Значения коэффициентов светопреломления определены из дисперсионных уравнений.

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Received, April 27, 1978