SYMMETRY OF TENSORS AND OPTICAL PROPERTIES OF DIRECTIONS IN MAGNETICAL CRYSTALS

Girgel S.S., Demidova T.V.

Gomel State University

Syrotin and Shaskolskaya [1], Zheludev [2] have introduced the concept of optical properties of directions (OPD) in crystals. OPD are polarizable characteristics and birefringeces of own plane monochromatic waves in these directions.

We use Maxwell equations for plane monochromatic waves and material equations [3] for vectors of electromagnetic field $\underline{E}$, $\underline{D}$, $\underline{B}$, $\underline{H}$ to description of optical properties of crystals.

$$\underline{E} = \varepsilon^{-1}\underline{D} + \alpha\underline{H},\quad \underline{B} = \mu\underline{H} + \beta\underline{E}, \qquad (1)$$

These equations describe various types of anisotropy, gyrotropy and absorption of linear media. As for transparent media

$$\varepsilon = \varepsilon^{+},\ \mu = \mu^{+},\ \alpha = -\beta^{+}, \qquad (2)$$

sign "+" means Ermit's conjugate.

According to Maxwell equations and (1) we may obtain the wave equation [4].

$$\hat{M}\underline{D} = [I(\varepsilon^{-1} + \alpha\underline{n}\,\underline{n}\alpha^{+} - 1/n^{2})I + 1/n(I\alpha\underline{n}^{\times} - \underline{n}^{\times}\alpha^{+}I)]\underline{D} = 0 \qquad (3)$$

where $I=-\underline{n}^{\times}\underline{n}^{\times}$, $\mu=1$, $\underline{n}^{\times}$ - antisymmetrical tensor of second rank which is dual to vector of wave normal $\underline{n}$ ($\underline{n}^{2}=1$). Symmetry of matrix $\hat{M}$ defines symmetry of OPD along $\underline{n}$ selected.

It is possible to choose parts in material tensors ε^{-1} and α. These parts answer for various optical effects.

$$\varepsilon^{-1} = \chi + i\underline{G}^{\times},\quad \alpha = i\alpha_{oa} + \alpha_{me}, \qquad (4)$$

where χ is symmetrical i-tensor of second rank describing linear birefrigence, $\underline{G}$ - vector of magnetical gyration, characterizing Faraday's effect. Tensor α_{oa} - axial nonsymmetry i-tensor of second rank, defining natural optical activity, α_{me} - axial nonsymmetric c-tensor of the second rank describing magnetoelectrical effect.

c-tensor of the second rank describing magnetoelectrical effect.

It is not necessary to solve (3) for qualitative analyses of symmetry OPD.

That is why N may be subdivided to items and be looked for their symmetry. Every item corresponds to definite optical effect.

We released research all classes of magnetical symmetry so that should know availability those optical effects along different crystallographic directions.

For example we gave the tables of optical properties of cubic and unaxial crystals. In tables signs "+" or "-" correspond to the presence or the absence of the effects, which are interesting for us.

REFERENCES

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Table 1

OPD in cubic crystals
$\underline{n}$-arbitrary

Classes	BR	MEE	OA	FE
432, 23	–	+	+	–
m3'm, m3m, m3m', m'3m, $\bar{4}$3'm', $\bar{4}$3m, m3', m3	–	–	–	–
$\bar{4}$3m', m'3, m'3m'	–	+	–	–
43'2, 4'32, 23'	–	–	+	–

Table 2

OPD in unaxial crystals
$\underline{n}\underline{c} \neq 0$; $[\underline{n}\underline{c}] \neq 0$

Classes	BR	MEE	OA	FE
$\bar{4}$, 4, 6, $\bar{4}$2'm', 42'2', 62'2, 32', 3, $\bar{6}$	+	+	+	+
6/m'mm, 6/m'm'm', 4/m'm'm', 4/m'mm, 4'/m'mm', 4mm, 6mm, 3m, 4mm', $\bar{6}$'m2', $\bar{3}$'m, 4/m', 6/m', 4'/m', $\bar{6}$', $\bar{3}$', $\bar{6}$'m'2, $\bar{3}$'m'	+	+	–	–
$\bar{4}$2m, $\bar{4}$'2'm, $\bar{4}$'2m', $\bar{4}$', 4', 3', 4'22 422, 622, 32	+	+	+	–
4m'm, 6m'm', 3m'	+	+	–	+
6/mmm1', 6/mmm, 6'/mmm', 6'/m'mm' 4/mmm1', 4/mmm, 4'/mmm', 4mm1', 6mm1', 3'm, $\bar{6}$m21', $\bar{6}$m2, $\bar{6}$'mm', $\bar{3}$'m1', $\bar{3}$m, 6/m1', 6'/m, 6'/m', 4/m1', 4'/m, $\bar{6}$1', $\bar{3}$1'	+	–	–	–
$\bar{4}$2m1', 4221', 6221', 3'2, 6'22', $\bar{4}$1', 41' 61', 6'	+	–	+	–
4/m, 6/m, 6/mm'm', 4/mm'm', $\bar{6}$m'2', $\bar{3}$, $\bar{3}$m'	+	–	–	+