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ЕРЕВАНСКИЙ ФИЗИЧЕСКИЙ ИНСТИТУТ
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A DIRECT MEASUREMENT OF THE NON-DIAGONAL COMPONENT OF THE TENSOR OF THE LINEAR PHOTOVOLTAIC EFFECT IN $LiNbO_3$:Fe CRYSTALS

ЦНИИатоминформ
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Ս.Ի. ԿԱՐԱԲԵԿՅԱՆ

ԳԱԼՑԻՆ ՖՈՏՈԳԱԼՎԱՆԱԿԱՆ ԷՖԵԿՏԻ ԹԵՆԶՈՐԻ ՈՉ ՀԵՂԱԳԻԾ ԲԱՂԱԴՐԻՉՆԵՐԻ ԱՆՄԻՋԱԿԱՆ ՉԱՓՈՒՄՆԵՐԸ $LiNbO_3$:Fe ԲՅՈՒՐԵՂՆԵՐՈՒՄ

Առաջին անգամ բերված են $LiNbO_3$:Fe բյուրեղներում ֆոտոգալվանական էֆեկտի թենզորի ոչ շեղագիծ բաղադրիչների անմիջական չափման արդյունքները: Բերված են թենզորի այդ բաղադրիչների անկյունային և սպեկտրալ կախումները, ինչպես նաև՝ դրանց քանակական արժեքը:

Երևանի ֆիզիկայի ինստիտուտ
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There arises a stationary current in crystals without a centre of inversion at their homogeneous lighting in the regime of short-circuited electrodes. According to the phenomenological theory [1] the expression of the photovoltaic (PV) current density has the form:

$$j_i = \beta^s_{inl} E_n E^*_l + i \beta^{as}_{il} [EE^*]_l ,$$

where E_n, E_l are the components of the light wave electric field, β^s_{inl} and β^{as}_{il} are the third-rank tensor and the second-rank pseudotensor components, respectively.

For the 3m-class crystals, to which $LiNbO_3$:Fe belongs, there are four independent components of the tensor of the linear photovoltaic effect (PVE) - β_{33}, β_{31}, β_{22} and β^s_{15}. Three of them, β_{33}, β_{31} and β_{22} have been measured earlier in Refs.[2,3]. The fourth component, β^s_{15} connected with the spatially oscillating currents, has been estimated by the holographic technique [4].

In this work the non-diagonal component β^s_{15} of the PVE tensor has been measured for the first time in $LiNbO_3$:Fe crystals. The method [3] used earlier for analogous measurements in $LiTaO_3$:Cu crystals has been used. The essence of the method is the following: if the XOY face of the crystal is exposed to light at an angle lying in the XOZ plane and polarized in the same plane (Fig.. then in this case only an

extraordinary wave will propagate in the crystal. Consequently, the photovoltaic current defined by the β^s_{15} component will no longer be a spatially oscillating one. The value of the photocurrent for the given geometry is defined by

$$j_x = \beta^s_{15} I^{(t)} \sin 2\alpha^{(t)}, \qquad (1)$$

where $I^{(t)}$ is the intensity of the light transmitted, $\alpha^{(t)}$ is the angle between the direction of propagation of the light transmitted and the normal to the XOY face. The intensity of the light transmitted is: $I^{(t)}=I(1-R_{\parallel})$, where $R_{\parallel}=tg^2(\alpha-\alpha^{(t)})/tg^2(\alpha+\alpha^{(t)})$ is the crystal reflectivity, I is the intensity of the incident light; $\alpha^{(t)}=\arg\sin((\sin\alpha)/n_e)$, where α is the angle formed by the incident light beam and the normal to the XOY face.

The experimental investigations were carried out on $LiNbO_3$:Fe crystals, 0.03% by weight, which had the form of a parallelepiped with the X:Y:Z sizes being 4.2:5.2:1.7 mm^3. The experimental layout was the same as in Ref.[3]. a ДКсЭл-1000 xenon lamp was used as a light source. The light was monochromated by means of a СФ-26 spectrophotometer. The contacts were made by the method of vacuum deposition of silver. The sample was fixed on the measuring head, which with the help of a remote control could be rotated in both XOZ and XOY planes independently. The head with the sample was placed in a shielded and heat-insulated vessel. The head was rotated in the XOZ plane to measure the angular dependence of the photovoltaic current j_x, which is defined by the β^s_{15} component. When measuring the spectral dependence of β^s_{15}, for each point of the spectrum we measured the change in the angular

dependence j_x (Fig.2a), according to the slope of which we determined the value of β^s_{15} by the formula (1). All the data obtained were corrected with regard to absorption and non-uniformity of the crystal lighting according to the technique reported in Ref.[3]. The PV current was measured by means of a B7-30 electrometer. The estimates of the β_{33}, β_{31}, β_{22} tensor components and their spectral dependences agreed to the known data [2,3]. Fig.2b shows the spectral dependence of the β^s_{15} component only for $LiNbO_3$:Fe, 0.03% by weight. The other components behave similarly.

Juxtaposing the results, one can notice that the spectrum of β^s_{15} correlates with those of β_{33}, β_{31} and β_{22}. All of them increase with the energy of the projectile photons, and at energies higher than 3eV there is observed a cutoff in all the curves. The presence of a small arm in the energy range from 2.8 to 3.2eV also is a characteristic of all the curves.

Issuing from the aforesaid, one can conclude that the nature of the centres determining the photovoltaic currents, which is connected with all the four components, is the same according to the results of measurements carried out in the energy range from 2.4 to 2.6eV for $LiNbO_3$:Fe (0.03% by weight), the ratios of the β_{31}, β_{22} and β^s_{15} components to the β_{33} component, which is the maximal one in that range, have the following values:

$B_{22}/\beta_{33}=(5\pm0.9)\cdot10^{-2}$; $\beta^s_{15}/\beta_{33}=(2\pm0.15)\cdot10^{-2}$; $\beta_{31}/\beta_{33}=0.9\pm0.03$.

In conclusion the author would like to express his gratitude to S.G.Odoulov for a stimulating conversation and for discussion of the results.

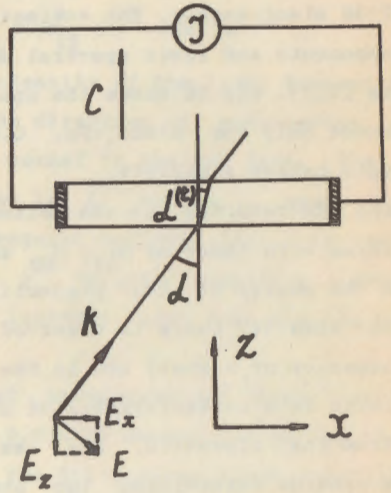

Fig.1 The scheme of measuring the photovoltaic current determined by the tensor component β^s_{15}.

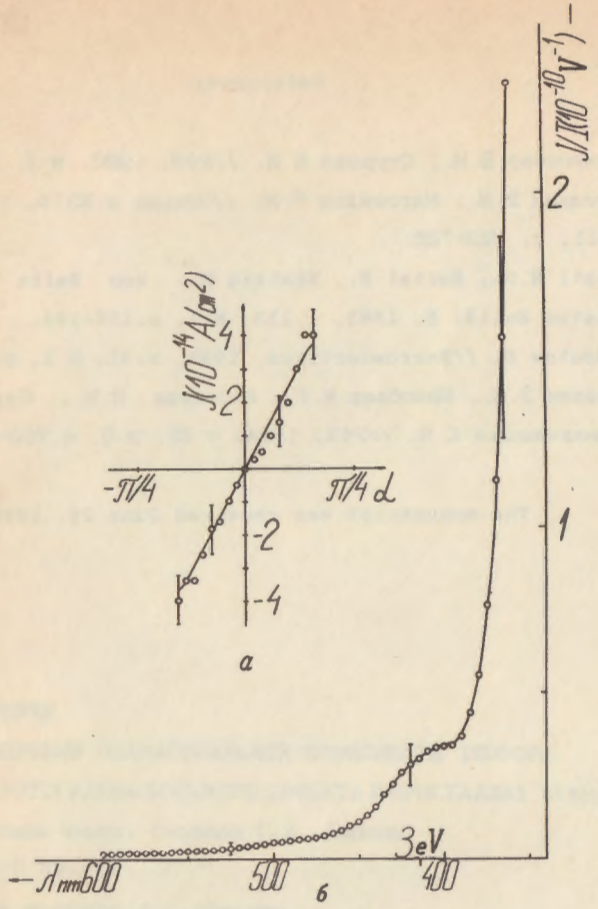

Fig.2 a) The angular dependence of the photovoltaic current density $j_x \cdot \lambda = 470$ nm.

b) The spectral dependence of the tensor component β^s_{15} for $LiNbO_3$:Fe.

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С.И. КАРАБЕКЯН

ПРЯМОЕ ИЗМЕРЕНИЕ НЕДИАГОНАЛЬНОЙ КОМПОНЕНТЫ ТЕНЗОРА ЛИНЕЙНОГО ФОТОГАЛЬВАНИЧЕСКОГО ЭФФЕКТА В КРИСТАЛЛАХ $LiNbO_3$:Fe

(на английском языке, перевод Г.А. Папяна)

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