TEMPERATURE BEHAVIOUR OF OPTICAL BIREFRINGENCE OF CRYSTALS α-ZnP$_2$

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UDC 548.0, 535.5

Using the high-accuracy polarimetric techniques, the temperature dependences of optical birefringence (OBR) and dichroism of α-ZnP$_2$ crystals are studied in detail in the temperature range 290 – 460 K. The temperature oscillations of OBR originated from multiple light reflections are revealed. The dependence of OBR on the thermal prehistory of a sample and the temperature variation rate, together with a slight difference between the OBR curves under temperature reversal, are possibly associated with the manifestations of an incommensurately modulated superstructure in α-ZnP$_2$ crystals.

Introduction

For last decades, a permanent attention of researchers was paid to wide-band semiconductor crystals of zinc diphosphide [1 — 5]. Crystals of tetragonal modification α-ZnP$_2$ prove themselves as a rather promising material for quantum electronics [4]. Though the considerable OBR of α-ZnP$_2$ promotes the attainment of conditions for phase synchronism under a nonlinear transformation of the emission frequency [6], these crystals are not very efficient for the use in frequency transformers. However, they are used in nonlinear optics for the extension of laser impulses and the stabilization of the emission power [1, 7, 8].

Crystals α-ZnP$_2$ attract attention also by their unusual temperature evolution of the lattice parameters and heat expansion coefficient [2, 9] which allowed one to assume the presence of phase transitions. The structure studies on the base of the diffraction of X-rays and electrons and electron microscopy (see, e.g., [2, 10, 11]) testified to the existence of a long-period incommensurately modulated superstructure in α-ZnP$_2$ which was approximately referred to the so-called "interface" type [12]. Though the fact of the existence of complicated phase transitions (PT) in zinc diphosphide correlates, on the whole, with the results derived in experimental works [3, 13, 14], it was indicated in the survey [12] that the nature and type of a incommensurate (IC) modulation, temperature limits of the IC phase, and its manifestations in various physical properties require the additional clarification. In this aspect, actual are the studies of the temperature behaviour of optical parameters of the crystals which are characterized by a high sensitivity to structural changes. However, the available data are concerned with only the dispersion dependences [6, 15].

The goal of the present work is to study the temperature behaviour of OBR and such an associated phenomenon as optical dichroism of crystals α-ZnP$_2$ in detail and to elucidate the presence of phenomena related to the effect of IC modulation in these crystals.

1. Experimental Procedure

For measurements, we prepared an x-cut plate of $5.0 \times 5.5 \times 1.41$ mm and oriented it with optical methods. In view of a great absolute value of OBR Δn (according to data in [3, 6, 15], $\Delta n = n_o - n_e \simeq 0.15$, where n_o and n_e are, respectively, the refractive indices of ordinary and extraordinary waves), we gave a special attention to the plane-parallelism of the surfaces of a specimen which was not worse than $2 \cdot 10^{-4}$ radn. The latter allowed us to minimize the overfalls in the optical phase difference $\Delta = 2\pi l \Delta n / \lambda$ (where l is the specimen thickness and λ is the light wavelength in vacuum) over a cross section of the light beam and, therefore, to increase the accuracy of measurements (see [16]).

To measure the temperature variations in OBR, we used the Senarmon method. Semiconductor crystals in the region of transparency are characterized by great refractive indices (≈ 3.2 for α-ZnP$_2$ at 0.6 mm [6, 13, 15]). Therefore, the formula for the polarization azimuth χ_C of light measured in the frame of the above-mentioned method at the output of a compensator (a phase plate) should consider a possible influence of multiple reflections of light between the surfaces of a crystalline plate [16]:

$$\mathrm{tg}2\chi_\mathrm{C}=\frac{2(1+2\beta Re^{-\alpha l}\cos 2\varphi)\mathrm{tg}(\Delta/2)}{1-(1+4\beta Re^{-\alpha l}\cos 2\varphi)\mathrm{tg}^2(\Delta/2)}, \qquad (1)$$

where $R=[(n_o+n_e-2)/(n_o+n_e+2)]^2$ is the mean reflectivity of the surface, $\alpha=2\pi(\kappa_o+\kappa_e)/\lambda$ is the mean absorptance (κ_o and κ_e are, respectively, the extinction coefficients for ordinary and extraordinary waves), $\varphi=\pi l(n_o+n_e)/\lambda$, and $0\le\beta\le1$ is the parameter which is related to the damping of multibeam interference due to the scattering of light in the bulk and on the surfaces of a specimen or due to a violation of the specimen plane-parallelism. Because the calculation of the phase difference is forcedly carried out by the formula $\Delta\approx 2\chi_\mathrm{C}$ which is exact only under the absence of multiple reflections (for $\beta R\exp(-\alpha l)\to 0$), the temperature dependences $\Delta(T)$ can include, in the general case, an oscillatory component at the expense of changes in $\varphi(T)$.

The Senarmon method was realized on a universal zero-polarimeter [16—18] which ensured a limit accuracy of the measurements of azimuths up to $5\cdot10^{-4}$ deg. We determined the absolute value of OBR only at 293 K by the compensation method. Additional measurements in the optical systems PSA and PSCA on the same polarimeter allowed us to derive information on linear dichroism $\Delta\kappa=\kappa_e-\kappa_o$ by means of the calculation of the parameter (see [16, 17])

$$\sigma=\left(\frac{d\chi_\mathrm{S}}{d\theta}\right)^2+\left(\frac{d\varepsilon_\mathrm{S}}{d\theta}\right)^2-1\approx$$

$$\approx-\frac{4\pi l\Delta\kappa}{\lambda}-4\beta Re^{-\alpha l}\sin 2\varphi\sin\Delta, \qquad (2)$$

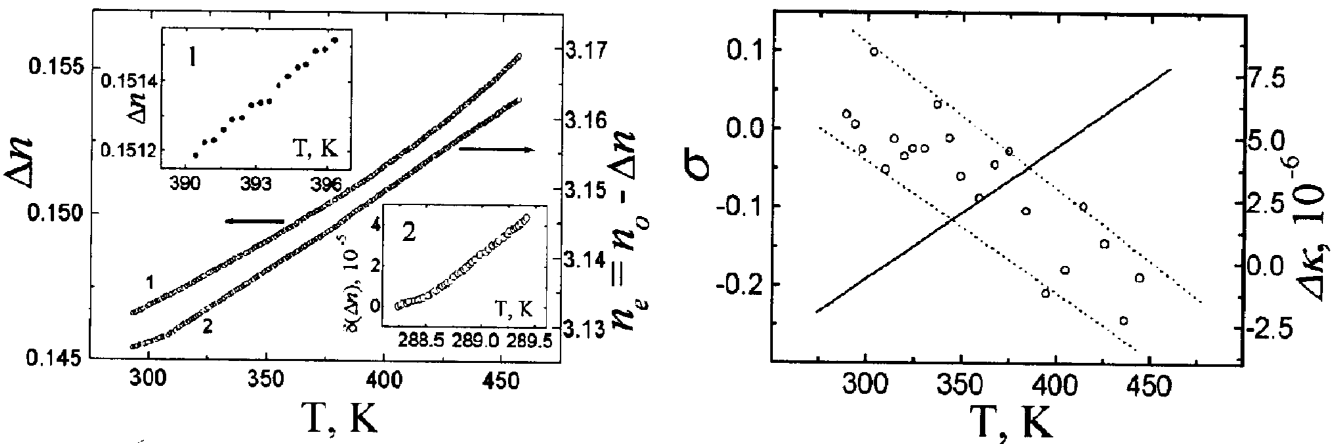
where $d\chi_\mathrm{S}/d\theta$ and $d\varepsilon_\mathrm{S}/d\theta$ are the slopes of the linear dependences of the azimuth χ_S and the ellipticity ε_S of light at the crystal output on the (small) azimuth θ of the incident light.

All studies were performed at the wavelength $\lambda=632.8$ nm of a single-mode laser LG-38 in the range from room temperature to 457 K. In temperature measurements, a copper-constantan thermocouple was in the direct thermal contact with a specimen. Its temperature was controlled automatically by supplying the amplified signal of unbalance from the other (controlling) thermocouple to the unit of control over the feeding unit of the thermostat furnace. As a result, the feeding of the furnace was proportional to the unbalance signal, which ensured a smooth (without "shocks") control over temperature. The accuracy of control ($\delta T_\mathrm{min}\simeq 0.02$ K) was typical of similar studies (see [19 — 22]. As a peculiarity of the thermostat, we mention the absence of optical windows. This allowed us to avoid the systematic errors of measurements related to the temperature-dependent OBR in windows which arises inevitably due to the thermal stresses in them [18].

Measurements by the Senarmon method were performed in the "quasistatic" mode (slow heating or cooling with the temperature change rates $\dot{T}=0.3\div65$ K/h), and the more difficult measurements of dichroism were carried out in the mode of a long-term (up to 0.5 h) stabilization of temperature. On the alternation of the modes of heating and cooling (temperature "reversal"), the specimen was held at the reversal point during 0.5 h in order to avoid the appearance of a temperature gradient. Though the potentialities of the experimental setup, in particular the accuracy of the reading units of polarizators, allowed us to register, in the general case, changes in OBR $\delta(\Delta n)_\mathrm{min}\simeq 7\cdot10^{-8}$, the resulting accuracy was approximately $\delta(\Delta n)_\mathrm{min}\simeq 2\cdot10^{-6}$ and depended, in particular, on the variations in temperature and the thermal coefficient $d(\Delta n)/dT$ (see below). Such a value of $\delta(\Delta n)_\mathrm{min}$ corresponds to the level of high-accuracy measurements of OBR aimed at the study of fine effects of the influence of a PT and an IC structure in crystals [19 — 22], perhaps yielding to the accuracy attained in [23, 24] at the expense of, first of all, the temperature control, being better by the order of magnitude. We calculated the temperature changes in OBR for a constant thickness of the specimen, which introduced the interpretation error to be less than 2% in view of the data [9] for the heat expansion coefficient of α-ZnP$_2$.

2. Results

Fig. 1,*a* (curve *1*) shows the temperature dependence of OBR of crystals α-ZnP$_2$ measured in the mode of fast heating. Curve *2* corresponds to the dependence $n_e(T)$ which is first obtained in view of the value of OBR and the data on $n_o(T)$ taken from work [13]. OBR increases with temperature and is accompanied by a slight growth



a

b

Fig. 1. *a* — temperature dependences of OBR Δn (curve *1*) in the heating mode ($\dot{T} = 65$ K/h) and the refractive index n_e (curve *2*) of crystals α-ZnP$_2$. On the inserts: *1* — temperature changes in the relative value of OBR $\delta(\Delta n)(T)$ at the vicinity of 289 K ($\dot{T} = 0.8$ K/h); *2* — a fragment of the dependence of $\Delta n(T)$ on the greater scale. *b* — temperature dependences of the polarimetric parameter σ (points) and dichroism $\Delta\kappa$ (solid line) of crystals α-ZnP$_2$. The dotted lines define the amplitude of oscillations $\sigma(T)$ (see the text)

in the thermal coefficient $d(\Delta n)/dT$ in the high-temperature region, whereas the averaged value $\langle d(\Delta n)/dT\rangle \approx 5.4 \cdot 10^{-5}$ K^{-1}. Such a behaviour agrees, on the whole, with the data in [3, 6], though the absolute value and the slope of the temperature-dependent plot correlate better with the result $\langle d(\Delta n)/dT\rangle \approx 5 \cdot 10^{-5}$ K^{-1} [6]. We note that the accuracy of measurements in [3] was only $\delta(\Delta n)_{\min} \approx 10^{-4}$ (the temperature stabilization accuracy was ±0.3 K), the thoroughness of the data derived was less by one order than that in this work, and the influence of the thermal OBR occurring in the thermostat windows on the final results cannot be excluded.

According to [3], anomalous changes in OBR — $(1 \div 2) \cdot 10^{-4}$ occur at temperatures of approximately 310 and 380 K. The authors of work [3] related them to a PT. As distinct from those data, we did not registered the breaks or jumps of OBR which could be uniquely associated with a PT despite the fact that the mentioned anomalous changes observed in [3] exceed considerably the error of our experiments. The same concerns the narrower temperature ranges and the considerably less rates $\dot{T}$ (see below), though we paid a considerable attention to just the vicinities of temperatures of 308 and 380 K, where the anomalies of lattice parameters [2] and the breaks of dn_o/dT [13] were registered earlier. At the same time, the data derived in the vicinity of 288.6 K (Fig. 1,*a*, insert *1*), where the thermooptical coefficient changes from $2.0 \cdot 10^{-5}$ to $4.4 \cdot 10^{-5}$ K^{-1}, incline to the conclusion as for the presence of a first-order phase transition.

An important peculiarity of the behaviour of the OBR of α-ZnP$_2$, which is characteristic of the entire temperature range under study, is almost periodic oscillations with the period $\Delta T \simeq 0.7$ K and with the amplitudes of approximately $2.0 \cdot 10^{-5}$ and $1.8 \cdot 10^{-5}$, respectively, for the regions of low and high temperatures in Fig. 1,*a* (see insert *2*). It is natural to connect this peculiarity with the phenomenon of multiple reflections of light in the specimen rather than with a PT (see also the results for dichroism). The relevant estimates by formula (1), the data on refractive indices [6, 13], and the data [25] on the absorptance ($\exp(-\alpha l) \simeq 0.25$) lead to the coincidence of the theoretical and experimental values of the amplitude of oscillations if we take a quite real value $\beta \approx 0.4$ for the scattering correction. According to (1), the period of oscillations is defined by the expression

$$\Delta T \approx \frac{\lambda}{l[\gamma(n_o + n_e) + d(n_o + n_e)/dT]}, \tag{3}$$

where γ is the linear expansion coefficient. Whence on the basis of results in [9, 13], we get $\Delta T \approx 0.73$ K which is also quite close to the experimental value.

Fig. 1,*b* represents the polarimetric parameter σ vs temperature. In view of formula (1), it should be defined by the temperature dependence of dichroism $\Delta\kappa(T)$ and by oscillations due to multiple reflections of light. On

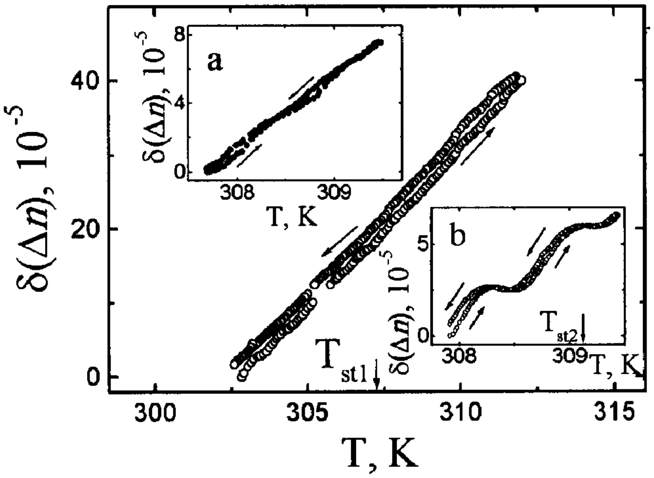


Fig. 2. Dependence of OBR of α-ZnP$_2$ under the temperature reversal for the region of low temperatures and $\dot{T} = 8.6$ K/h ($\Delta T_{\rm hys} \approx 0.5$ K). On inserts *a, b*: the same dependences under conditions of different thermal prehistories of the specimen (see the text) and for $\dot{T} = 0.9$ K/h ($\Delta T_{\rm hys} \approx 0.1$ K) and $\dot{T} = 1.0$ K/h ($\Delta T_{\rm hys} \approx 0.1$ K), respectively. The temperatures $T_{\rm st1} \approx 307.3$ K and $T_{\rm st2} \approx 309.1$ K are stabilized, the times of stabilization are $t_{\rm st1} = 13$ h and $t_{\rm st2} = 15$ h

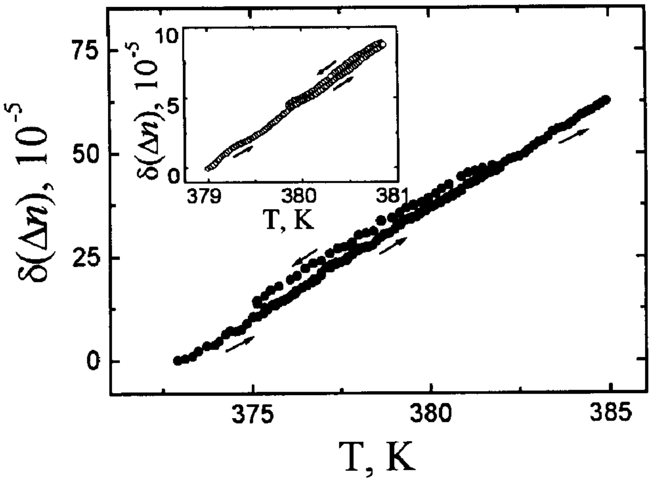


Fig. 3. Dependence of the OBR of α-ZnP$_2$ under the temperature reversal for the region of high temperatures and $\dot{T} = 15.0$ K/h ($\Delta T_{\rm hys} \approx 0.8$ K). On the insert: the same dependence for a different thermal prehistory of the specimen (see the text) and $\dot{T} = 2.5$ K/h ($\Delta T_{\rm hys} \approx 0.1$ K)

the basis of the value of $d(\Delta n)/dT$ derived by us and the data in [9, 13], we conclude that the studied temperature range includes about 20 periods of $\sin\Delta(T)$ and 120 periods of $\sin 2\varphi(T)$. Therefore, the data of Fig. 1,*b* correspond to namely oscillations which are not separated in temperature rather than to the dispersion of points. This is confirmed by the comparison of the experimental value of the amplitude, ($A \approx 0.070$), with the theoretical result, ($A = 4\beta R \exp(-\alpha l)$), which leads to $\beta \approx 0.3$, being in agreement with the data on OBR. By using (2) and the value $\langle\sigma\rangle$ averaged over oscillations, we get the approximate dependence $\Delta\kappa(T)$ (the solid line in Fig. 1,*b*).

To verify the hypothesis on the influence of an IC superstructure on optical properties, we carried out the complex of studies of the OBR of zinc diphosphide, including a change in the rate $\dot{T}$, the alternation of the cycles of heating and cooling of the specimen, the long-term holding of it in certain temperature ranges, and its annealing in the high-temperature region. Some results are presented in Figs. 2 and 3. It is established that the features of the temperature behaviour of OBR depend considerably on the thermal prehistory of the specimen. For example, annealing during $5-10$ hours at $T > 430$ K leads typically to a decrease in the amplitude of oscillations. Moreover, the relative changes in OBR, $\delta(\Delta n)(T)$, vs temperature reveal only a slight periodic nonmonotonicity (see Fig. 2 and Fig. 3 (the insert)). The data presented in Fig. 1,*a* (insert *1*) also correspond to similar conditions of experiment. At the same time, a long-term holding of the crystal in the temperature range which will be used in the subsequent experiment causes the "amplification" of oscillations (see Fig. 2 (insert *b*) and Fig. 3). Both the period and the maximum ($\sim 2 \cdot 10^{-5}$ under optimum conditions) amplitude of oscillations almost do not depend on $\dot{T}$ (compare the data in Fig. 1,*a* (insert *1*), Fig. 2 (insert *b*), and Fig. 3).

On cyclic changes in temperature, the OBR curves of crystals α-ZnP$_2$ which correspond to the modes of heating and cooling do not coincide, which can be interpreted as a hysteresis behaviour (see Figs. 2 and 3). The careful analysis shows that the mean temperature distance between the curves of heating and cooling (or the "hysteresis width") $\Delta T_{\rm hys}$ decreases at first with $\dot{T}$ ($\Delta T_{\rm hys} \simeq 0.6$ K at $\dot{T} \approx 10$ K/h and $\Delta T_{\rm hys} \approx 0.1$ K at $\dot{T} \approx 1$ K/h, as seen in Fig. 2). It is important that the parameter $\Delta T_{\rm hys}$ remains practically constant in the interval $\dot{T} \simeq 0.3 \div 2.5$ K/h. Thus, the values $\Delta T_{\rm hys}$ derived at large $\dot{T}$ are apparently overstated, most likely at the expense of the influence of a temperature inhomogeneity in the specimen bulk despite its small size. Then the more real values of $\Delta T_{\rm hys}$ must correspond to the rates of at most $\dot{T} \approx 2$ K/h. The temperature distance between the curves of heating and cooling is insignificant under these conditions ($\Delta T_{\rm hys} \approx 5\delta T_{\rm min}$). Moreover, the difference $\Delta n_{\rm hys}$ between the values of OBR at the same temperatures is approximately $5.5\times \times 10^{-6}$, i.e., $\Delta n_{\rm hys} \approx 3\delta(\Delta n)_{\rm min}$ (see Fig. 2 (inserts *a*, *b*) and Fig. 3 (the insert)). These facts keep us from the flat assertion as for the thermal hysteresis in OBR (see the discussion below).

We note that the temperature studies of the refractive index n_o of crystals α-ZnP$_2$ [14] which were performed at $\dot{T} = 12$ K/h on a specimen with a comparable or larger volume (see the procedure in [13]) revealed a hysteresis and found $\Delta T_{\rm hys} \approx 6$ K. In view of the above-presented, this value seems to be overstated, though the quantitative characteristics of a hysteresis can be essentially different for different specimens at the expense of different concentrations of structural defects (see [23] and the discussion below). Under the repeated heating, the curve $n_o(T)$ [14] touched the initial curve of heating only at a sole point, which was inerpreted in [14] as a manifestation of optical "memory". Contrary to those results, both curves of the repeated heating $\delta(\Delta n)(T)$ in Fig. 3 and its insert reproduce the initial curve within to the accuracy of the experiment. At last, just this character of thermal hysteresis is inherent in modulated phases and is observed in all IC crystals (see, e.g., [21 — 23]. It is possible that the specific character of hysteresis of $n_o(T)$ which was registered in [14] was caused by the insufficient accuracy of measurements and certain drawbacks of the temperature control system.

With the purpose to reveal a "true" effect of thermal "memory" [23, 26] in crystals of α-ZnP$_2$, we held the specimen prior to separate experiments at fixed (stabilized) temperatures $T_{\rm st}$ during $t_{\rm st} = 5 \div 15$ h (see Fig. 2 and its insert *b*). On the following passage of temperatures $T_{\rm st}$, we found no anomalies in the dependences $\delta(\Delta n)(T)$. Thus, the observation of the phenomenon is difficult, and our experiments cannot give an unambiguous answer as for its presence in α-ZnP$_2$. We may assume that defects and admixtures in a crystal, whose ordering in the potential field of an IC modulation induces the "memory", possess a quite high mobility. Due to the latter, they "forget" the stabilized phase of the modulation for the time interval between the termination of the stabilization of temperature and the beginning of the next experiment (approximately $2 - 4$ h).

3. Discussions and Conclusions

The increments in the refractive index n_e, OBR, and the dichroism of crystals α-ZnP$_2$ with temperature which are found in this work are explained by narrowing the forbidden zone and by approaching the adsorption edge to the working wavelength. We assume that the changes in $n_e(T)$ are connected with the temperature changes in the forbidden zone width $E_g(T)$ by the relation [27]

$$n_e^4 E_g = C, \tag{4}$$

where C is the Moss constant. In view of the insignificance of the anisotropy of E_g for the polarizations of ordinary and extraordinary waves on the working wavelength (see the results in [1, 25]), we can neglect it in the rough calculation of the Moss constant. By using the values $E_g \approx 2.18$ eV [13, 25, 28] and $n_e = 3,1268$ at temperature $T = 293$ K, we get $C \approx 208$ eV^{-1}. Then, by using Eq. (4), we can estimate the temperature evolution of $E_g(T)$. We also note that the corrected data on $n_o(T)$ and $n_e(T)$ can be useful in the calculations of the temperature stability of phase synchronism in nonlinear crystals α-ZnP$_2$.

We dwell now upon the questions as for PT and the IC modulation in zinc diphosphide. By thermodynamic theory, the possible manifestations of PT in OBR are reduced to "breaks" (changes in the thermal coefficient) under a second-order PT and to finite "jumps" under a first-order PT. Besides the point $T = 288.6$ K, such peculiarities were not registered in the studied temperature range despite the fact that we eliminated the sources of systematic errors, and the ratio of the range of variations in OBR to the experimental accuracy was at least 5000 : 1. At last, work [2] did not reveal a "classical" PT "IC — initial phase" or "IC — ordered phase", whereas the temperature limits for the existence of the IC phase were not reliably established. The numerous singular temperature points registered in [2] correspond to a specific "PT" which occur inside the IC phase. In these "PT", the period (phase) of the IC modulation changes firstly, and the soliton-like structure is reconstructed. Such slight structural reconstructions remind a first-order PT, but their manifestations in optical properties are difficult to be observed and depend, due to a finite mobility of the soliton system and its interaction with the system of defects, on the temperature change rate and the concentration of structural defects in a specimen [21 — 24, 29]. It is quite probable that, with our $\dot{T}$, we cannot register changes in the modulation phase of the type of steps of the "devil stairs" (in crystals of quartz, such jumps are revealed in OBR at $\dot{T} < 0.02$ K/h [24], in Sn$_2$P$_2$Se$_6$ — at $\dot{T} < 0.4$ K/h [21], and in (N(CH$_3$)$_4$)$_2$FeCl$_4$ — at $\dot{T} < 1.5$ K/h [22]). The above-presented results incline to the thought that, in the range $\dot{T} = 0.3 \div 65$ K/h, no "viscous interaction" (see [29, 24]) of solitons and defects in α-ZnP$_2$ is present. At last, the "domelike" form of the anomalies in OBR revealed in [3] at 310 and 380 K casts doubt on their connection with PT.

Since the mean distance between the curves of OBR registered under the temperature reversal for small $\dot{T}$ is only by 3—5 times more than the experimental error, the results of this work can be insufficient for the reliable confirmation of the existence of a thermal hysteresis of optical characteristics of crystals α-ZnP$_2$. In this aspect, the most reliable are the results of recent studies of the optical activity of α-ZnP$_2$ [30]. According to them, the parameter $\Delta T_{\rm hys} \approx 0.15$ K, and the difference $\Delta\rho_{\rm hys}$ between values of the specific turn angle of the polarization plane on the branches of heating anf cooling equals about 0.3 deg/mm, which exceeds the experimental error by more than one order in magnitude. It is also useful to compare out results for α-ZnP$_2$ with those for other crystals. For example, for Sn$_2$P$_2$Se$_6$, $\Delta T_{\rm hys} \approx 0.6$ K (at $\dot{T} = 0.4 \div 3$ K/h) [21], for (N(CH$_3$)$_4$)$_2$FeCl$_4$ $\Delta T_{\rm hys} \approx 0.5$ K ($\dot{T} = 5.7$ K/h) [22]. In addition, works [23, 24] derived the rather small values $\Delta T_{\rm hys} \approx 0.01 \div 0.2$ K ($\dot{T} = 0.1$ K/h) which strongly depended on the perfection of the specimens of quartz crystals and on the concentration of defects in them. Thus, we can state that, under similar conditions of experiments and similar levels of accuracy, we observed the behaviour of OBR in α-ZnP$_2$ under a temperature reversal which had the characteristics analogous to those of other IC crystals. However, in order to eventually clarify the presence of the thermal hysteresis in OBR, it is necessary to carry out additional studies with the uniquely accurate control over temperature reached, e.g., in [23, 24].

On the whole, all totality of the data on the dependence of OBR on the prehistory of a specimen, the temperature change rate, and the temperature reversal and the data presented in [30] incline us to the conclusion as for the influence of the IC structure on the optical properties of α-ZnP$_2$. Most likely, the discussed phenomena are caused [23, 26, 29] by the interaction of solitons with point-like structural defects, in particular with admixtures (first of all, by elements of the 3rd group for α-ZnP$_2$ [5]), vacancies, ions in interstices, etc. As known, hysteresis phenomena are defined by the influence of immovable defects or defects with low mobility. Since the values $\Delta T_{\rm hys}$ derived by us are rather small, we infer that the concentration of defects of this type in our specimen must be low.

The multiple reflections of light under OBR in zinc diphosphide which were observed by us are a consequence of both a great value of reflectivity of the crystal and the measures realized for the enhancement of sensitivity and accuracy in polarimetric measurements (first of all, we mean the nonscattering plane-parallel surfaces of the specimen; see Section "Experimental procedure"). As the new results, we emphasize the observation of the phenomenon in the temperature (not spectral) dependences of optical parameters and the considerable variations (up to 100% and more), which are dependent on the thermal history, in the amplitude of oscillations of OBR. Because the relative changes in the coefficients R and α in (1) caused by the last factor cannot be considerable, we assume that the decisive role can be again played by the influence of the interaction of the IC structure with defects on the scattering parameter β. This scattering of light occurs in the crystal bulk. Its intensity is low but is sufficient to weaken the rays which pass through the specimen many times. These conclusions are mediately confirmed also by a slight decrease in the sensitivity of polarimetric measurements, which happens under a weakening of the multibeam interference. The physical mechanisms of these phenomena require a separate investigation.

Finally, the absence of the observed effect of optical "memory" in zinc diphosphide cannot be generally considered as a fact which contradicts the presence of the influence of the IC modulation on optical parameters. Indeed, the effect is caused by the influence of defects which have the relatively great coefficients of diffusion and reorient themselves in the IC potential field periodic along the z axis [26]. In the case of crystals α-ZnP$_2$, these defects are, possibly, ions Zn^{2+}. As known [31], their mobility in the direction of the IC modulation axis, z, is extremely high and exceeds the relevant value for the perpendicular direction by three orders in magnitude. Just such a quasione-dimensional conduction hampers the registration of the effect of optical "memory". Instead of this, as a distinctive "memory", we can consider the dependence of the manifestation of multiple reflections of light on the thermal history of the specimen.

Thus, the studies carried out in this work allow us to determine the exact temperature behaviour of OBR and, in view of this, that of the refractive index $n_e(T)$. We revealed the slight oscillations of OBR occurring due to multiple reflections of light and elucidated the behaviour of dichroism. The specificity of the temperature dependences of OBR which is found in this work can be related, on the whole, to the influence of the IC modulation, whereas the question about the presence of hysteresis of OBR in crystals α-ZnP$_2$ requires the further investigations.

The author expresses his sincere thanks to members of the staff of Kyiv Tank College for the grown crystals, Senior sci. res. S. A. Sveleba for the specimens, Prof. I. I. Polovynko for the fruitful discussion, and O. A. Bevz for the help in the experiment.

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Received 09.04.02,
revised version — 26.06.03.
Translated from Ukrainian by V.V.Kukhtin

ТЕМПЕРАТУРНА ПОВЕДІНКА ОПТИЧНОГО ДВОПРОМЕНЕЗАЛОМЛЕННЯ КРИСТАЛІВ α-ZnP$_2$

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Резюме

За допомогою високоточних поляриметричних методів детально досліджено температурні залежності двопроменезаломлення (ДПЗ) та дихроїзму кристалів α-ZnP$_2$ у діапазоні температур 290−460 К. Виявлено температурні осциляції ДПЗ, що пояснюються багатократними відбиваннями світла в зразку. Залежність ДПЗ від термічної передісторії зразка та швидкості зміни температури, а також слабкі відмінності в кривих ДПЗ при реверсі температури, можливо, пов'язані з проявами несумірно модульованої надструктури в кристалах α-ZnP$_2$.