MATHEMATICS AND NATURAL SCIENCE

Proceedings of the Fifth International Scientific Conference – FMNS2013

12 - 16 June, 2013

Faculty of Mathematics and Natural Science

VOLUME 7

Fifth International Scientific Conference – FMNS2013

South-West University,

Faculty of Mathematics and Natural Science

12 – 16 June 2013

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Enhancing cooperation between Bulgaria and FYROM through developing Web Geo-Services

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***Abstract**: The cross-border cooperation between Bulgaria and FYROM should be fostered through developing new Web Geo-Services. They may contribute to economic growth by promoting the public access by using Geoportals and their tools. One of the prerequisite for cross-border compliant Geo-services is the implementation of INSPIRE Directive which can provides interoperable resources of spatial information. An overview of present state of its implementation in Bulgaria and the Republic of Macedonia is presented. Some important issues related to establishing the infrastructure for spatial information to support cross-border cooperation between two countries are discussed.*

***Keywords:** Web Geo-Service, INSPIRE Directive, cross-border cooperation, economic development.*

1. INTRODUCTION

Advanced web services and geoportals play an increasingly important role as intelligent platforms for geographic data mining, visualization, manipulation, analysis, and usage for scientific and practical applications [1]. Geoportals could provide semantics or automation of specific process of full exploiting functionality of the interdisciplinary geoinformation, i.e., data that has been processed and prepared to be useful in a particular context trough simple user interface for users in a specific application domain [2].

Spatial Data Infrastructure (SDI) as the INfrastructure for SPatial InfoRmation in Europe (INSPIRE; http://inspire.jrc.ec.europa.eu) require intelligence to orchestrate (automatically coordinate) web services that support Community environmental policies and activities which may have an impact on the environment. One basic prerequisites to be useful spatial information in a particular context is that the INSPIRE portals have to provide an interop-

erability of all data using multiple platforms, architecture, clients, developer environments, protocols, and encodings. Spatial information data relating to local, national, regional or global size is the basis of geosciences. All datasets have to be standardized and harmonized to simplify the integration of individual datasets to support their connectivity at different scales and for specific user groups, and to help resolving real social and environmental problems.

This paper deals with the issues related to the necessary conditions for creating Web Geo-services for the processing, analysis and verification of spatial data. Brief review of the INSPIRE Directive implementation in Bulgaria and the Republic of Macedonia is presented. Specific characteristics of the approaches to build the SDI taken by the responsible authorities and stakeholders in both countries are outlined, and some difficulties that should to overcome to realize intelligent Web Geo-portals are discussed.

2. IMPORTANCE OF DEVELOPING WEB GEO-SERVICES BASED ON INSPIRE DIRECTIVE

The European Commission (EC) has developed a roadmap for the implementation of the stages of the facilities with which the Member States must comply with the construction of national SDI. To enable SDI as a core infrastructure furthering economic development, social life, and environmental sustainability of a country or region, open and interoperable systems have to build, which sustain a security framework performance and scalability of the variety of geographic data bases. The INSPIRE Directive 2007/2/EC aims to build a SDI in the European Union allowing the exchange of interoperable spatial data in a harmonized rules among different levels of public administration and between the Community as well between government and the private sector. The European spatial data providers are expected to accomplish and disseminate their metadata records by 2013.

For the purpose the SDI to be independent from the technologies applied to create maps, it is necessary to use uniform qualifiers of maps, uniform requirements to the structure of metadata to provide data transformation in the Geography Markup Language (GML) uniform standard. The given specification contains a description of the application order of the GML standard and other international standards for the exchange of spatial data contained in the digital maps.

Essential tool in the development of the SDI development concept is a Geographic Information System (GIS) with proposed structured base of the geospatial data used for analysis, model validation, evaluation, and visualization of results. SDI makes data from several sources accessible to users of geodata, including the necessary access and distribution procedures.

Executive authorities, local, national or regional governments and organizations that administer spatial data related to their areas of responsibility, should publish their description (metadata) to provide a rapid assessment of the properties of the data resource. These requirements apply only to spatial data that are created by law or other legal document. Technical implementation of the requirements of Directive 2007/2/EC and the access to spatial data should be consistent with those published by the Community authorities' regulations, guidelines and specifications to ensure the achievement of interoperable spatial data and services at national and European level (http://inspire.jrc.ec.europa.eu).

The INSPIRE Directive sets the standards for discovery services and metadata, but does not oblige the EU countries to collect new geospatial data. The foundation of many of INSPIRE specifications is laid down on the Open Geospatial Consortium (www.opengeospatial.org) consensus standards and the International Organization for Standardization (www.iso.org) standards for geographic information. Regulations concerning authoring, publishing and sharing of geographic information was developed also to a certain extent.

Intelligent processing of the open data could produce valuable new findings and stimulate many applications from a wide range of areas, which are of a great interest to the society, generating completely new information of social relevance. The ability to understand the data and services across systems are facilitated through the intelligent SDIs [1]. Thus, the information retrieval, its integration and inference of new facts based on existing ones through automated geospatial web-services are significantly improved [3, 4]. Developing web geo-services is one possibility to foster the economic growth in the cross-border regions between European countries.

3. SPATIAL DATA INFRASTRUCTURES - CROSS-BORDER COLLABORATION INTEROPERABILITY AND FOSTERING ECONOMIC GROWTH

Successful positioning on Bulgaria and FYROM on the international geo-services market is possible after making the geospatial data from different sources accessible to the end-users, including the necessary access and distribution procedures. The development of SDI is a necessary prerequisite to provide the cross-border region with information needed to ensure sound decision support for the interoperability and fostering economic growth through prudent management of the limited resources. Both countries implementing the INSPIRE Directive requirements and recommendations will create conditions for mediation between the services provided lo-

cally at the national level and the EU-level usage. Data and services can be made available through INSPIRE network services following the guidelines provided in the INSPIRE documentation (http://inspire.jrc.ec.europa.eu).

Establishing a National SDI (NSDI) is a long-term process, which needs to be coordinating by an interdepartmental body as in other European countries, e.g., Germany, Netherland, UK, etc. In Bulgaria and FYROM a regulation for establishing such a body does not exists. Such institution can coordinate the activities of governmental departments not to multiply databases, information systems and technical infrastructure; elaborate a general and a technical projects of the National SDI; working out a metadata standard based on OGC and ISO/TC standards; monitor and coordinate activities of the local and national administration; cooperate and exchange information with other countries' and international organizations; maintain and update national SDI portals.

Strategic document adopted in 2010 for the Republic of Bulgaria, which reflecting the harmonization of the Directive in national legislation is the Law on access to spatial data for building the elements of the national infrastructure for spatial information [5]. Actually, Executive Agency "Electronic communication networks and information systems" (EAECNIS) at the Ministry of transport, information technology and communications of Bulgaria should to act as responsible body and to coordinate all activities concerning INSPIRE Directive implementation. During the last years this Agency repeatedly published on its website (www.esmis.government.bg) the goals, which include the national inherently obligations to implement requirements of the INSPIRE Directive trough building a national geoportal.

Till now there are several completed projects related to the development of SDI and usage of geospatial data for different purposes and end-users funded by EU Programs or other donors in which Bulgaria took part. EC supports INSPIRE implementation by EU programs and projects as most of the initiatives concern the geodata use within the field of environmental policy. Through all projects the involved parties aim to share knowledge within EU and to build interoperable applications on issues related to geospatial data, forming a position and balanced public policy that defends the interests of the states and citizens. The knowledge acquired and experience can provides significant input to a national framework that would aim to elaborate a vision of all activities in the field of geospatial data, which is a fundamental prerequisite to successful construction of the NSDI.

However, due to lack of Bulgarian strategy and an Action Plan of consecutive steps to meet the INSPIRE requirements and recommendations, the efforts remain scattered and undervalued. These circumstances lead to seriously lagging on the Directive implementation. A description of the role of the various stakeholders in the development and maintenance of the National

SDI, including their role in the coordination of tasks, in the provision of data and metadata, and in the management, development and hosting of services is still lacking. There are various reasons which determine the current situation. Part of these problems concerned clearly prescribed rights and responsibilities, lack of consistent legislation, fairness, clarity, state revenue, investments for the SDI construction. Other issues are related to security of spatial data and lack of public safety. But, all these problems should to be resolved on a national level by the Bulgarian coordination structure EAECNIS for the infrastructure for spatial information with participation of the government, academia, universities, NGOs, public institutions and stakeholders that are relevant to the NSDI strategy.

First beginning of NSDI of Macedonia is a Strategic plan of SAGW for the period 2007-2010, where NSDI for the first time was recognized as project to be powered in Macedonia based on European INSPIRE directive. As result of the strategic plan, in 2008 a special chapter for NSDI within the Law for Real estate cadastre has been added [6].

Agency for real estate cadastre of Macedonia is the responsible institution for establishing Macedonian NSDI, as a set of activities that enable quality collection, administration, sharing and use of geo-referenced spatial data. Macedonia's NSDI vision statement is to facilitate the access, sharing, use and distribution of standardized spatial data/services in an efficient, effective and harmonized way in order to fulfil the needs of the private/ public sectors as well as citizens, contributing to economic growth and sustainable development of the country. In other side, Macedonia's NSDI mission statement is to establish a technological, institutional, legal and administrative framework for inter-organizational collaboration that will support e-Government, integrate geo-information from different sources, be in line with INSPIRE Directive (www.katastar.gov.mk, April 2012). Till now, the national coordinative body for NSDI developing has already defined: Strategic mission and vision, Business case, Governance structures, Legal framework, Interoperability infrastructure, Outreach and capacity building, Implementation roadmap, and NSDI strategy.

On March 2012, the NSDI strategy for the Republic of Macedonia has been promoted for public and published in the web site of the responsible institution (www.katastar.gov.mk). The strategy goes through the costs and benefits of creating a NSDI and then lists the main areas in which work will be needed in order to implement such an infrastructure. The objectives of the NSDI Strategy include the way of spatial data transformation to share within Macedonia so it can underpin the social and economic development to the benefit of all. An incremental and sustainable implementation path is needed so stakeholders move from the current state of scattered and un-

connected collections of spatial data to an integrated and harmonized infrastructure for sharing spatial data. The institutional framework defined in the strategy includes the elements that make up the governance and organizational aspects, which will help to the various individuals and groups of people for organizing in order to manage the NSDI and make it happen, by taking into consideration the skills, competencies and knowledge that those will need. The implementing of the Macedonian NSDI will be governed by: Responsible Minister, NSDI council (19 key stakeholders), NSDI committee (management unit), and Working groups (4 working groups). Based on the roadmap which was defined in the NSDI strategy, implementation of NSDI was planned to be realized within next four years.

4. CONCLUSIONS

The geospatial data bases were developed worldwide over the past several decades primarily to support the economic and social activities. Bulgaria and FYROM have achieved some results in developing an integrated NSDI, but more efforts are needed to overcome the obstacles to meet the INSPIRE Directive requirements and recommendations. Nevertheless, the physical, computational, and organizational data infrastructures developed now support a wide range of applications. A user-friendly, easily expandable web-GIS geospatial system could serve as the basic tool for the data base visualization, interpretation and analysis for numerous potential groups and various end-users and beneficiaries. Thus, through developing new Web Geo-Services cross-border cooperation between two countries can be fostered. The subject of another publication will be an analysis of all completed steps in this direction so far by Bulgarian and Macedonian institutions, which are the main producers of spatial data and have participated actively in the NSDI development. The necessary activities related to building the interoperable Web Geo-services across platforms, applications, and programming languages will be also discussed. NSDI can provide significant benefits to the EU community, allowing for expanding the range of activities and innovations that can be explored for potential future applications.

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DIFFRACTION AND INTERFERENCE FROM THE LIQUID CRYSTAL LAYERS AND NONLINEAR ELECTRO-OPTICAL EFFECTS UPON INTENSIVE ELECTRICAL FIELDS

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ABSTRACT

Liquid crystal (LC) systems are of importance for electrically switchable and tunable phase grating, optical switchers
utilizing Diffraction and LC devices for control of both intensity and spatial distribution of the passed or reflected light. The efficiency of the coherent light Diffraction by LC layers can be surely enhanced by a proper choice of the polymer and LC components, having greater difference of the refractive indices which is governed by the applied intensive electric field.

As a result from the optical phase retardation, induced in the LC film, the optical Interference makes the LC films feasible for electrical phase switching. LC devices operate through the change in the refractive index of the LC material upon applying an alternative current electrical field. LC films are used in various electro-optical (EO) devices , such as light shutters and are currently of growing interest for new applications in light control. LC material allows to switch the intensity and also direction of the light, which characteristic is a basice for the widely used nano-scale holographic LC.

Keywords: Polymer-dispersed liquid crystals (PDLC), single layers, gradient layers, thin films, coherent light diffraction, optical phase, optical interference

1. INTRODUCTION

Since recent years an activity has developed in the field of research and design of optical systems based on polymer-dispersed liquid crystals (PDLCs)[1–3]. These mixed soft-solid composite smart materials are very at-

tractive for variety of electro-optical (EO) applications[1–4]. Most commonly, the PDLC films for electro-optics consist of nematic liquid crystal (LC) droplets disposed within an optically transparent and isotropic solid polymer matrix. Sandwiched between two electrically conductive and transparent plates, such PDLC films are practically used in various EO devices such as vision products (direct view information displays, image projectors, switchable windows), as well as light-shutters and varaible optical attenuators[1–7], and are currently of growing interest for new applications for light control[8–12].

As known, the PDLC devices operate through the change in the refractive-index of the dispersed LC material upon applying an alternating current (AC) electric field. Besides the switching between a scattering and transparent state, the controllabe diffraction of the incident light and related properties of these materials, which are both interesting and important, have attracted experimental and theoretical attention[13]. Some applications of PDLCs are based on a gradient and/or periodical distribution of LC droplet size and LC refractive index. Such PDLC films are of special interest for a number of EO applications, e.g. electrically switchable and tunable light filters, light switches/shutters, Fresnel lens[14]. The gradient distribution of droplet size in PDLC systems provides the opportunity both their structural and EO properties to be spatially controlled and tuned which is certainly of importance for electrically switchable and tunable PDLC-based phase gratings, prism gratings[14], optical switches utilizing diffraction[15] and other PDLC devises for control of both intensity and spatial distribution of the passed or reflected light.

To prepare PDLC single layers with a regular linear-gradient droplet size distribution, we have used nanosecond laser photo-induced phase separation[16]. The PDLC film was formed in a wedge-shaped cell. In this way, the formation of PDLC, as well as the droplet gradient, are fully and finely controlled by both wedge geometry and UV laser exposure rate. In this way, single layers of relatively large LC micro-droplets with a well-defined and constant cavity configuration can be produced. The highly controllable droplet size of such a PDLC material allows its EO properties to be continuously tuned.

Here, we present experimental results for electrically-controlled coherent light diffraction from two-dimensional (2D) gradient microscale PDLC films, which are of importance for device applications. Single-layered PDLC 2D-films of droplets of size up to several tens of micrometers were studied by optical microscopy, optical transmission and diffraction of the incident light, and related to both material and structural properties of the PDLC system.

The PDLC films under study consist of the liquid crystal E7 dispersed in a matrix of the photo-cured polymer NOA65.

2. EXPERIMENTAL

2.1. The PDLC samples

The samples used in this study were a 17.5 × 17.5-mm single-layer PDLC films formed by photo-polymerization in a cell whose gap is variable Wedge-shaped cell was constructed from a 25-um-thick Mylar spacer and two 1 mm-thick glass slides (n = 1.517 at 633 nm) each coated inside by a thin (~ 50 – 80 nm) transparent conductive layer of indium tin oxide (ITO) (Fig. 1).

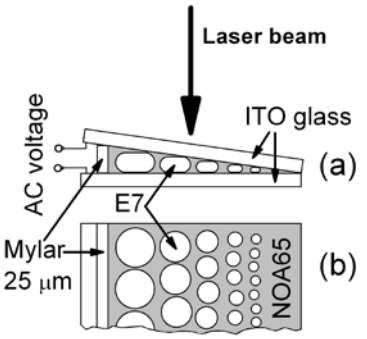

Fig. 1. Schematic illustration of gradient single-layer PDLC wedge film: (a) – side view; (b) – top view. Single droplets within the planar PDLC 2D-layer are depicted. The arrow indicates the direction of the incident laser beam.

The PDLC flms were prepared using the optical adhesive NOA65 (Norland Products Inc.) monomers and the nematic liquid crystal E7 (BDH) as precursors. The liquid prepolymer NOA65 is optically transparent in the visible and curable upon an ultraviolet illumination. The refractive index of the cured NOA65 polymer is 1.524 (λ = 633 nm and at 20° C). The liquid crystal E7 is an eutectic mixture of cyanobiphenyls and terphenyls[17], capable of giving a nematic phase of high chemical and photochemical stability at room temperature. Its nematic-isotropic phase transition (clearing point) is at about 60° C. The material has positive dielectric anisotropy, $\Delta\varepsilon_{\|}$ = 19 and $\Delta\varepsilon_{\perp}$ = 5.2 at 20° C and 1 kHz frequency[18]. Ordinary and extraordinary refractive indices of E7 are n_0 = 1.5185 and n_e = 1.737 (λ = 633 nm and at 20° C)[5].

The E7 liquid crystal has a good solubility in the prepolymer. Both compounds were mixed in the weight ratio 50:50% and heated above the iso-

tropic clearing temperature to achieve a good mixing. This mixture was introduced by capillary action into the cell. Linear droplet-gradient microscale PDLC planar single layer (2D-layer) was produced by high-power nanosecond UV laser curing[16].

2.2. Experimental set-up

The morphology of the prepared PDLC thin film was characterized by transmission optical microscopy (Zeiss NU-2 Universal Research Microscope). The microscope images were recorded by a Hitachi VK-C150ED video camera and computer.

The optical diffraction from the PDLC film were studied by the experimental system schematically shown in Fig. 2. The PDLC cell holder was mounted on a micro-manipulating translating stage. The sample is illuminated by linearly polarized (>500:1) TEM_{00} laser light from the attenuated beam of a 5-mW He-Ne laser (NG HN-40) having a beam divergence less than 0.8 mrad. The laser beam was directed normally to the PDLC cell. The laser power in PDLC was of about 3 mW, the laser beam diameter ~ 1 mm. The intensity of the light passed through the examined PDLC was detected at a distance of 76 cm from the PDLC cell by a photodiode combined with a pinhole aperture with diameter of 1 mm. The diffraction profile was recorded two times (from left to right, and vise versa) to ensure repeatability of the measurements. The spatial resolution of these measurements was 100 μm.

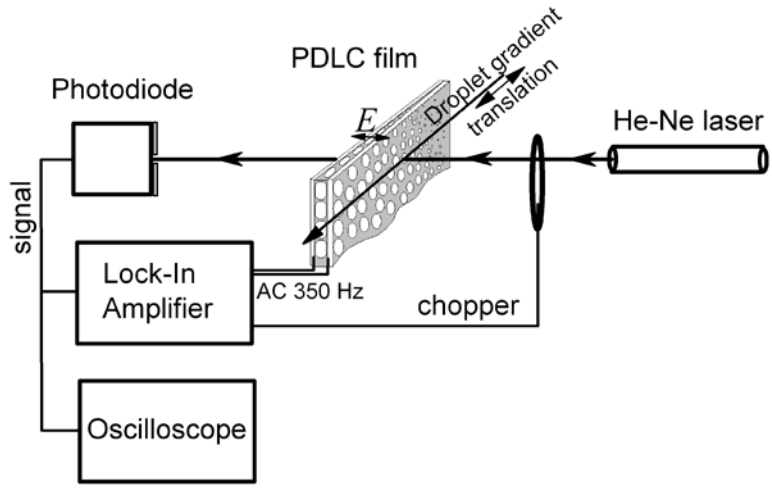

Fig. 2. Schema

The signal from photodiode was measured by lock-in amplifier (SR830, Stanford Research Systems) controlled by a computer[19]. A sinusoidal voltage with an amplitude 0 – 30 V_{rms} at 350 Hz was applied to the ITO elec-

trodes of the cell. For the measurement of the voltage-dependent light transmittance of the PDLC film, the laser beam was chopped at 90 Hz. All experiments were carried out at ambient temperature.

3. RESULTS AND DISCUSSION

In general, the voltage-dependent optical transmission and diffraction of the laser light through the PDLC 2D-film are affected by a number of parameters, such as droplet shape and size[1–4,20]. That is why, we examined the texture of the prepared PDLC films. A typical PDLC texture was observed by optical microscopy (Fig. 3 a). The optical micrographs show well formed ellipsoidal nematic droplets organized in a single PDLC layer. The LC droplets are sufficiently separated from the fully-cured polymer matrix and one from the others. Observed perpendicularly to the wedge plane, the LC droplets have circular shapes. Further, the mean diameter (D) of the droplets dispersed in the examined PDLC 2D-film is linearly related to the film thickness (δ). In a good approximation, $D \approx 2\,\delta$, thereby relatively large LC droplets with dimensions up to 25 μm (in height) $\times$ 50 μm (in diameter) were formed[16]. In a region comparable to the area of the laser beam spot, the size distribution of the droplets is quite regular.

In order to investigate the optical properties of the prepared PDLC 2D-films, their polarizing microscope images were analyzed. The PDLC texture displays colored droplets separated with dark regions corresponding to oriented liquid crystal and isotropic matrix, respectively (Fig. 3 b). The cured NOA65 polymer provides a planar anchoring for E7 molecules, i.e. the nematic LC adopts an alignment, which is parallel or tilted towards the polymer surface[4,21,22], what was confirmed for the examined PDLC structure. Generally, the PDLC texture could be modeled as bipolar droplets, with the nematic director, **n**, aligned, on average, between two disclination points positioned at opposite poles of the droplets[4,21,22]. The local optical axes of the bipolar droplets are co-planar with the 2D-layer, what does result in an optical anisotropy.

Regions of fully aligned nematic directors were observed in some zones of the PDLC 2D-film. Since the dimensions of these zones exceed the spot size of the probing laser beam, one can expect an efficient EO control by both the birefringence and optical phase shift induced in such a PDLC structure through electric field (E) dependent refraction index (n) of the dispersed nematic LC. Thus, the electrically induced optical phase can be efficiently utilized in the electrically-controlled coherent light diffraction.

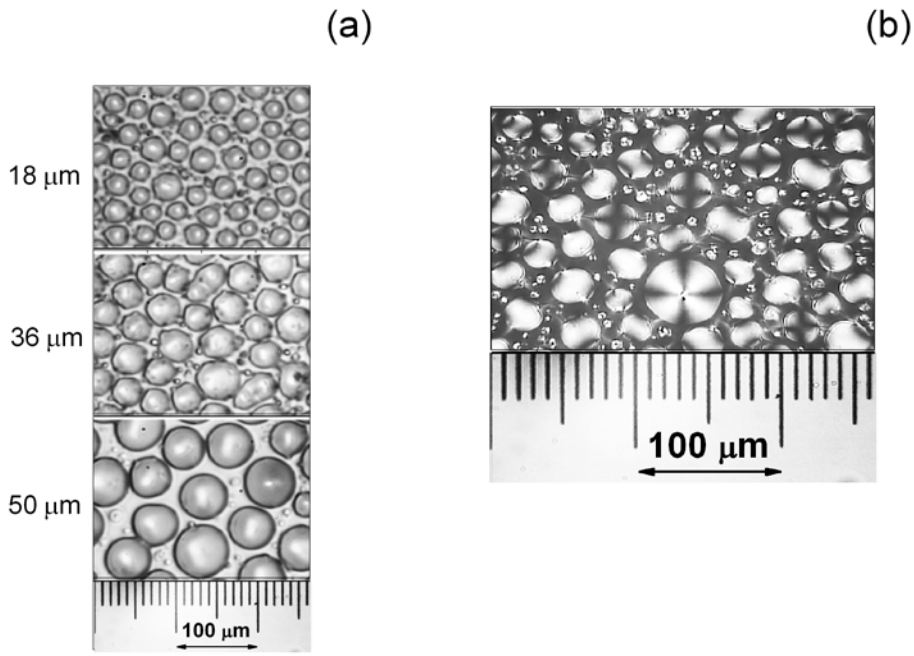

Fig. 3. The optical microscope images of single-layer gradient PDLC film at various thickness. The mean droplet diameter is indicated in (a). In (b) the examined PDLC film is between crossed polarizers. Magnification: 25 ×.

At normal incidence, the optical phase shift (Δ) induced by light propagation through PDLC material of thickness δ is given by:

$$\Delta = \frac{2\pi}{\lambda}\left[n\,(E) - n_p\right]\delta \qquad (1)$$

where λ = 633 nm, and n_p = 1.524 is the refractive index of the cured polymer at 633 nm and 20° C. As known, *n* is a function of the LC droplets size[4]. As a result, the phase retardation can be electrically controlled by the field-induced change *n(E)*, as well as spatially controlled by the droplet size (the larger LC droplets result in a larger phase shift). Thus, exploiting the double modulation effect from δ and *E*, one can generate a variable phase difference. The induced phase Δ does result in an optical interference of the laser light propagating through the microscale PDLC 2D-film. In actuality,

the periodical structure of alternating regions of a fixed refractive index n_p and field-dependent index *n(E)* forms an electric-field induced variable phase grating based on optical interference.

The EO response of the gradient PDLC 2D-film was examined by measurement of the laser light transmission (i.e. the zero-order diffraction). Fig. 4 presents the frequency spectra of the amplitude of the modulated transmitted light when the voltage of the applied electric field was fixed to 20 V, and its frequency was scanned in the range from 1 Hz to 3 kHz. Both the flexoelectric (the 1st harmonic) and the dielectric (the 2nd harmonic) responses of the PDLC film as measured by the lock-in instrument strongly depend on the film thickness, amplitude of applied voltage and temperature, in accordance with data previously reported for other E7/NOA65 (50:50 wt. %) PDLC films at room temperature[19,23]. In the measurements presented in the following, the frequency of the sinusoidal AC voltage supplied to the PDLC 2D-film was kept constant at 350 Hz.

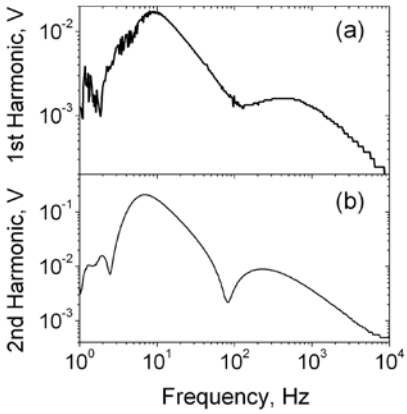

Fig. 4. Frequency spectra of the amplitude of the first and second harmonics of circularly polarized light transmitted through the PDLC 2D-film at thickness δ = 18.4 μm. The voltage of the applied electric field was 20 V, the temperature 20° C.

Due to the relatively high dielectric anisotropy and birefringence of the droplets, a significant light scattering occurs from the PDLC 2D-film in the absence of an applied electric field. When electric field is applied to the film, switching of the droplets could be easily observed. Then the PDLC film exhibits a light switching from scattering (OFF-state) to transparent (ON-state) modes. As known, the mechanism responsible for the electrical switching is the change of the effective (average) refraction index of the dispersed LC molecules (n_{eff}) with the applied electric field[1–4]. In the OFF-state, the local average orientation of the rodlike nematic molecules in dispersed LC micro-

droplets is random, leading to a mismatch between n_{eff} and the index of the polymer (n_p), thus resulting in a strong scattering of the incident light. A sufficiently high electric field aligns the nematic director **n** parallel to the electric field (and to the direction of the light propagation as well), and, if n_{eff} of the aligned LC matches n_p, then the bulk PDLC material appears transparent (ON).

Fig. 5 presents a series of the voltage-dependent light transmittance of the PDLC film recorded for various film thickness δ. For purpose, the examined PDLC wedge cell was translated across the incident laser beam. The intensity-voltage dependencies show a relatively low operating voltages of the PDLC 2D-layer under study.

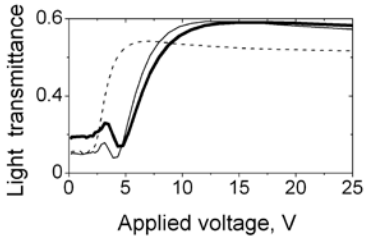

Fig. 5. Voltage-dependent intensity of laser light (λ = 632.8 nm) transmitted through a single-layer PDLC film of various thickness: 10 μm (dashed); 15.5 μm (thin line); 18.5 μm (bold line).

The picture of coherent diffraction observed in both OFF-state (zero voltage) and ON-state (30 V AC voltage) of the examined PDLC 2D-layer appears somewhat complicated. In both cases, depending on the film thickness, various diffraction patterns take places in the diffraction profile. The intensity of some of them prevails that of the typical diffraction ring (Figs. 6 and 7). Such features result from the single-layer arrangement and are not present in conventional PDLC systems where the degree of the order is low and the polydispersity is significant.

For a certain thickness of the examined microscale PDLC film, well-defined diffraction peaks are observed in addition to the ordinary diffraction ring (Fig. 6 b). As reported for the highly-ordered monodisperse PDLC monolayers[24], the optical interference does significantly affect the electrically switched diffraction of the incident coherent light. This happens in case of compact packing of LC droplets, which resembles the regular structure of an ordered two-dimensional layer. Being not present in the conventional PDLCs, such an operation mode is of practical interest. The diffraction peaks are indicative of a low degree of orientational anisotropy at the en-

semble level. At zero voltage, the intensity of the light scattering is added to that of the coherent diffraction (Fig. 7 b). Like conventional PDLCs[25–27], the non-coherent background from the scattering monotonically declines starting from the laser beam profile. The scattering is minimized in the ON-state (Fig. 7 c). As seen, a significant spatial redistribution of the intensity of the diffracted light can be obtained by applying an electric field. It should be noted that a specificity of the PDLC single layer is the lack of the multiple scattering of light.

Fig. 6. Diffraction images corresponding to: (a) δ = 18.8 μm (D = 37.6 μm); (b) δ = 18.4 μm (D = 36.8 μm). In both cases, the amplitude of the applied AC voltage was 15 V.

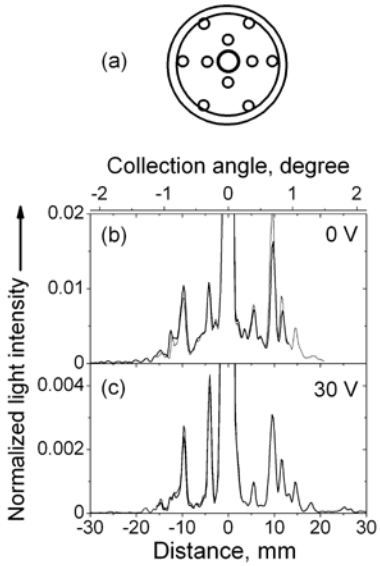

Fig. 7. (a) Illustration of the main diffraction pattern; (b), (c) intensity distribution of the coherent light diffracted from a PDLC single layer with a thickness of 18.4 μm (D = 36.8 μm). The applied voltage is denoted, the temperature is 20° C, the resolution is 0.25 mm. The diffraction profiles are normalized to the intensity of the transmitted laser beam.

The six-fold symmetry of the peak configuration shown in Fig. 6 (b) suggests an interference-based diffraction from hexagonally ordered LC droplets. Such a mechanism is supported by the experiment results we obtained in our complementary measurements of the optical interference effects in the single-layer PDLC films considered here.

The intensity distribution in the observed diffraction pattern strongly varies with δ. This is reasonable, taking into account the change of the droplet size and droplet number density with δ, as well as the change of the effective refraction index of the LC droplets with their size[4]. Fig. 8 presents the diffraction profile measured for various PDLC layer thickness δ. We have to point out that the diffraction peaks shown in Fig. 6 (b) were observed in our experiments in a narrow range of δ. The brightness of the diffraction peaks was most intensive when δ is in the vicinity of 18.4 μm (D = 36.8 μm) and is strongly reduced at lower or higher δ when only the diffraction ring remains, as shown in Fig. 8. Most probably, this results from the rise of the polydispersity and the broadening of the droplet size distribution.

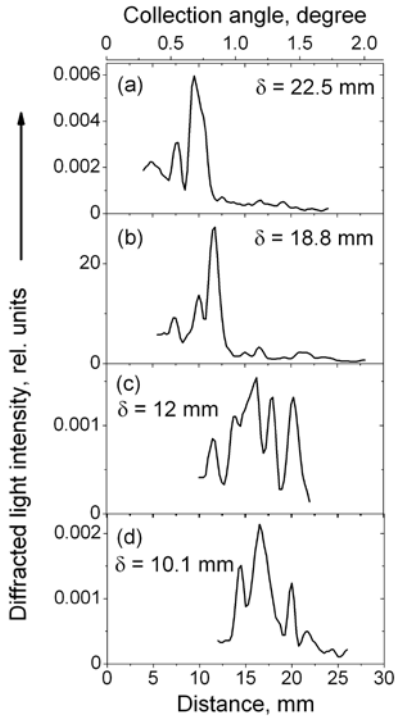

Fig. 8. Diffraction profiles measured for PDLC 2D-layer at zero voltage and various film thickness δ.

4. CONCLUSIONS

We have studied the laser light diffraction from microscale PDLC planar single layers. If such a PDLC two-dimensional layer has a gradient of the size of dispersed LC droplets, it can be used for a spatial control of the diffraction of the incident laser light, in addition to the EO switching. Resulting from the optical phase retardation induced in the PDLC film, the optical interference makes the PDLC 2D-films feasible for electrical phase switching. Thus, a simple microscale PDLC material allows to switch both the intensity and the direction of the light, what is, actually, a key feature characteristic of the widely used nanoscale holographic PDLCs.

Many factors play a role and should be optimized to improve the diffraction performance of the PDLC 2D-films, such as the operation temperature, the frequency of the applied sinusoidal voltage, the angle of both the light incidence and the polarization of the laser beam, as well as the conditions which define the PDLC formation, including the initial LC/momomer, the concentration of the components, the photo-polymerization conditions, geometrical parameters of the PDLC structures, the preparation method, etc. The efficiency of the coherent light diffraction by two-dimensional PDLC layers can be surely enhanced by a proper choose of the polymer and LC components having appropriate difference of the refractive indexes which could result in a stronger phase difference governed by the applied electric field

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EFFICIENT FREQUENCY-DOUBLER FOR ULTRAVIOLET LASER SPECTROSCOPY OF NEW NUCLEI AND IONS

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ABSTRACT

Laser spectroscopy methods for studying of nuclear properties have led to systematic experimental data on nuclear moments and hyperfine anomaly. However, a detailed view of the properties of the elements in the nuclear region $30 \leq Z \leq 58$ shows that only few long isotopic chains (Kr, Rb, Sr, In, Xe, Cs, Ba) have been investigated by optical methods and the corresponding nuclear information has been obtained. The reason is that most transitions from the ground state are in the ultraviolet (UV) region and frequency doubling of dye laser radiation is required. Using a low divergency of the fundamental wave, the pump focused beam does not exceed the phase=matching bandwidth of nonlinear crystal.

Efficient frequency-doubling systems with a specific geometry configuration are used in order to obtain ultraviolet (UV) cw coherent radiation for laser spectroscopy of new nuclei and ions. The compensation of the walk-off angle and the use of external cavity for second harmonic generation give most noticeable doubler efficiency increase. Some frequency-conversion systems are proposed, in case when the fission-fragments have transitions from the ground state not only in the UV but also in the vacuum ultraviolet (VUV) spectral region.

Key words : multi-photon processes, nonlinear laser spectroscopy, frequency-conversion systems

1. INTRODUCTION

Tunable continuous wave ultraviolet (UV) laser radiation is of particular interest in spectroscopy investigations of exotic radionuclides, also when one deals with laser cooling of a small group or even with single ions. Such ions can be trapped and cooled down to lower temperature for laser spectroscopy research, and thus, they quite often need UV excitation light.

In order to extend the laser wavelength to the shorter region, the continuous wave (cw) UV radiation should be produced as second harmonic in a nonlinear crystal irradiated by a single mode cw laser. We next have to consider the walk-off effect, the effects of the linear insertion losses due to the scattering, absorption and reflection from the crystal, and of the nonlinear losses due to the frequency-doubling processes.

We should note, that the second harmonic (SH) wave is produced in proportion to the square of the fundamental wave intensity. Thus, the SH process is quite more efficient in the case of pumping the nonlinear crystal by means of high peak power of intensive pulsed lasers. However, the dye lasers suffer from extremely low conversion efficiencies because of negligible power. Consequently, in case of cw laser radiation we should use more efficient SH conversion systems[1]. At an arbitrary L/L_{NL} ratio (where L_{NL} is the nonlinear interaction length), we have to take into account the power loss in the wave at the fundamental frequency (i.e. fundamental wave depletion). In some cases we can derive nonlinear equations for calculating the conversion efficiency in the substantial non-linear regime, when the efficiency is maximal. Since the laser operates in quasi stationary regime, it is necessary to consider the limiting factors which are connected with spatial beam modulation and the corresponding phenomena, such as diffraction and anisotropy.

Probably, the first step on the way to an efficient cw frequency-doubled dye laser radiation is the intracavity SHG. The doubling crystal is placed inside the laser cavity so it profits from the high intracavity light power. But then, we have to avoid the amplitude-modulated fluctuations which lead to a spectral broadening of the SH output. So, a multimode frequency-modulated cw operation can be achieved. Some light improvement can be made by inserting an intracavity spectral filter, but even then this will not limit much the broadening and therefore the SH spectral line width will increase.

In this paper three efficient SH generation systems are presented. They have the following advantages: i) the dispersion of the phase-matching in the nonlinear crystal is avoided and ii) the fundamental wave divergence is lower than the phase-matching bandwidth. We apply pair of walk-off compensating crystals as well. We should most emphasize on the concept of SHG in external ring cavity.

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We will concentrate in this work on the schematic diagrams of frequency-doubler systems and their output parameters, which are suitable especially for laser spectroscopy of nuclei in UV range. SH efficiencies for various configurations are reported.

2. EXPERIMENTAL METHODS AND RESULTS

We use potassium dihydrogen phosphate KH_2PO_4 crystal (KDP) for frequency doubling of cw dye laser radiation, pumped by argon ion laser, since it covers the whole region 560 – 630 nm of the Rhodamine 6G dye laser. It is preferable to have an angular tuning of the phase-matching with the KDP negative uniaxial crystal. We apply type 1 phase-matching, which corresponds to one and the same polarization of both input mixing waves. Since we should have low divergency of the fundamental wave which will not exceed the phase-matching bandwidth $\Delta\theta$

$$\Delta\theta = \frac{0{,}443\lambda_1\left[1+\left(n_{02}/n_{e2}\right)^2 tg^2\theta\right]}{Ltg\theta\left|1-\left(n_{02}/n_{e2}\right)^2\right|n_2^e(\theta)},$$

then we use a cylindrical focusing lens (Fig. 1) in front of the nonlinear crystal. SH radiation passes next through a collimator and the coherent light intersects the atomic beam. We should note that especially within the plane of the phase-matching we direct a beam of low divergency.

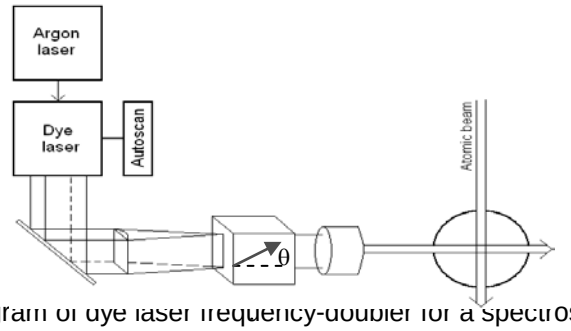

Fig. 1. Schematic diagram of dye laser frequency-doubler for a spectroscopy in UV.

Thus, the wave mismatch is not arising. The phase-matched bandwidth does not cut the transmitted fundamental wave and the conversion efficiency increases.

The dispersion properties of uniaxial nonlinear crystal are determined only by the polar angle θ. But at the same time, the efficiency of the nonlinear conversion process is determined by both θ and φ angles. The used KDP crystal in the setup is cut at the phase-matched angle $\theta = 65^{o}$. It should be mentioned that the spectral line width in our case of 3 MHz is narrow enough, and we avoid the possible dispersion of the phase-matching. Besides, we can use also the auto-scan system of the dye laser, since the auto-scan does not exceed the phasematching bandwidth $\Delta\theta$.

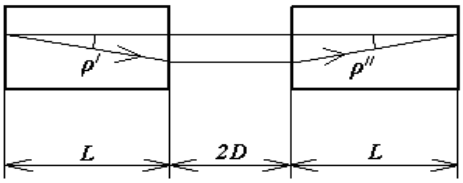

Fig. 2. Compensation of the walkoff in pair of KDP crystals.

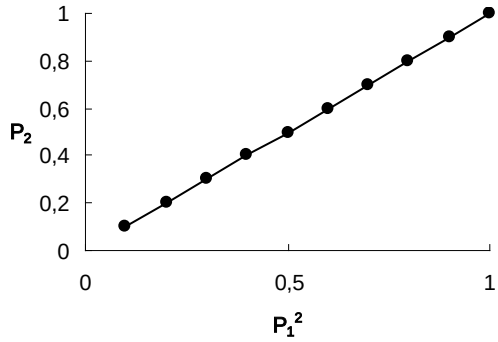

Fig. 3. Second harmonic power output versus the squared fundamental power (arbitrary units).

The SH efficiency is 9% for walkoff-compensated crystals.

The second way is to use next diagram of SHG, when the frequency doubling is in two crystals which are placed with opposite directions of the optical axis (Fig. 2). In this case the walk-off in the first crystal is compensated by opposite walk-off in the second one. The apparent intercrystal phase shift is due to: i) air dispersion for the distance between both crystals, and ii) to the antireflection coating. The expression for the SH intensity gives:

$$I_2 = \frac{2\varpi^2 d_{eff}^2 L^2 I_1^2}{\varepsilon_o c^3 n_2 n_1^2} 4\sin c^2\left(\frac{\Delta\kappa_1 l}{2}\right),$$

where d_{eff} is the effective second-order nonlinearity of these crystals. The dispersion of walk-off ρ angles should be also taken into account. Namely, the walk-off compensation corresponds to $\rho' = \rho''$.

When compensating the air dispersion for a distance of 6.1 cm between both crystals, we measured an increase of SH power by 50% (Fig. 3) as compared to SH power in single crystal. The total SH efficiency increases due to both the air dispersion compensation and to the antireflection, which gives a SH power growth by 75% in pair of walk-off-compensating crystals. The generated cw SH power at 295 nm is shown as a function of the squared fundamental power in Fig. 3. The data are corrected for the transmission losses of the cylindrical lens and the beam splitter (6% each). For a fundamental power of 450 mW, a SH efficiency of 9% is achieved for just one pass through both walkoff-compensated KDP crystals.

The tuning curve of the SH of cw dye laser is presented in Fig. 4. The frequency of the SH can be scanned by tuning the phase-matched θ angle within all the range of the used dye laser radiation. As it is evident from Fig. 4, the SH power (mW) is reduced, when the fundamental wavelength is tuned lower than 580 nm and higher than 620 nm. But the SH efficiency maintains the same value. The P_2 reduces only due to the less fundamental input P_1 power near the edge 560 – 580 nm or 620 – 630 nm. The SH generation in external cavity[2] is the most optimized version of cw frequency-doubling process.

The nonlinear crystal has antireflection coatings on the optical surfaces which minimizes the reflection losses and ensures relatively high level of output SH power. The use of long enough KDP crystal is a guaranty to obtain a sufficient SH efficiency when pumping by cw radiation. The cavity geometry is chosen in a way to reproduce the beam profile. The focus inside the crystal has to match the optimum focus for the frequency-doubling process, and the curvature radius of M3, M4 spherical mirrors equals to 15 cm (Fig. 5). The mirrors (Fig. 5) are high reflection coated. The M1 mirror is partially transparent in the visible (560 – 630 nm). The spherical mirror M4 focuses the fundamental wave onto the crystal. The SH wave leaves the cavity through the harmonic output M3 (Fig. 5), which is 10% transparent in UV (280 – 315 nm.). Three photodetectors PD are included at the detection unit assembly, and give a feedback to the EC (Electronic Control unit). The length stabilization of the cavity is made (Fig.5) to avoid the destructive interference of the circulating wave with itself.

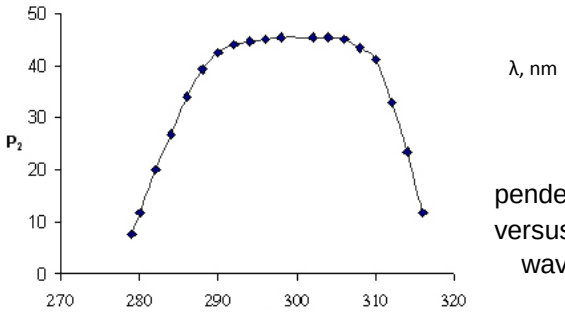

Fig. 4. Experimental dependence of the SH power P_2 (mW) versus the nonlinear converted UV wavelength λ (nm).

The piezo-mounted mirror M2 is fed with a synchronizable signal from the EC unit (Fig. 5). The reflected part of the injected wave interferes with the transmitted part of the light circulating in the cavity. The phase difference of both the waves is a measure for the necessary length correction.
A high enhancement cavity together with a good stabilization and an appropriate nonlinear crystal leads to high conversion efficiencies. The piezo-mounted mirror M2 allows to have a controlled adjustment of the cavity length in the nm-range[3]. The EC unit drives the piezo-element for the stabilization. All dichroic mirrors are of high performance coating and together with a good quality crystal lead to higher conversion efficiency up to 18% below 1W of the fundamental input power.

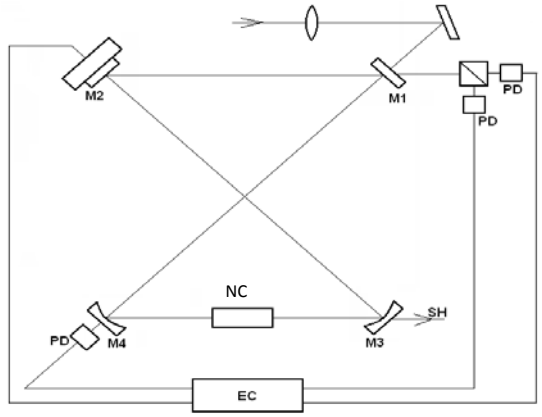

Fig. 5. Experimental setup of the external frequency doubler with a length adjustment of the cavity. M1 – flat input mirror; M2 – piezo-mounted flat mirror; M3, M4 – spherical mirrors of *f* = 7.5 cm; EC – electronic control unit; PD – photodetectors for a feedback to the EC; NC – nonlinear crystal.

3. DISCUSSION

We will consider now the main applications of the tunable UV laser source. In the nuclide region $30 \leq Z \leq 58$ only few long isotopic chains (Kr, Rb, Sr, In, Xe, Cs and Ba) have been investigated by optical methods[4,5,6] and the corresponding nuclear information has been obtained.

Some elements of the same region including short lived neutron-rich isotopes in ground and isomeric states, are recently of great interest. A detailed view of the optical properties of these elements shows that most transitions from the ground state are in the UV region and frequency doubling of dye laser radiation is required.

Table 1 lists some favorable UV transitions for these elements, suitable for laser spectroscopy research.

Table 1. Optical transitions from the ground state for the neutral atoms and single ions of the elements with $30 \leq Z \leq 58$.

Z	element	λ, nm	transition	external cavity SH efficiency
30	Zn I	308.6	$4s^2$ - 4s4p	18%
31	Ga I	287.4	$4s^2$4p - $4s^2$4d	18%
32	Ge I	303.9	$4p^2$ - 4p5s	18%
39	Y I	297.5	4d$5s^2$ - $4d^2$5p	18%
42	Mo I	300.2	$4d^5$5s - $4d^4$5s5p	18%
44	Ru I	287.5	$4d^6$$5s^2$ - $4d^6$5s5p	18%

Following Table 1, let us take into account that the SH power at the optical transitions of GaI and RuI reduces only due to the less input P_1 power near the edge 560 – 580 nm. Though the SH efficiency maintains the same of 18%, the UV output at 280 – 290 nm decreases.

We should note that all three schemes developed of frequency doubling are suitable for laser spectroscopy of nuclear moments and isotope shifts of radionuclides. The walkoff compensated diagram with pair of KDP nonlinear converters has some advantages, since due to avoiding the dispersion at a given distance between the crystals, it is possible to maintain the same spectral bandwidth of 3 MHz for the SH radiation in UV. Besides, we record additional amplification in the second crystal when the total efficiency achieves 9% for one pass of the fundamental wave. But even though the most preferable is the external cavity SH achieving an efficiency of 18%. Another approach in developing the ultraviolet sources for laser spectroscopy is the use of injection seeded lasers and nonlinear optical converters[7,8] when the output frequency coverage could be extended to the ultraviolet and deep UV range. In these systems, the frequency doubling could be used to generate single-mode cw radiation for high resolution laser spectroscopy. Such sources would be a subject for further study and development for applications in laser spectroscopy and diagnostics laboratories.

4. CONCLUSION

Applying negative uni-axial nonlinear optical crystal, three schematic diagrams of frequency doubling systems are realized. Owing to the low light beam divergence comparing to the phase-matching bandwidth of the crystal, and due to walk-off compensation, the experimentally measured SH efficiency increases. The most preferable is the external ring cavity for second harmonic generation (SHG) in dielectrics of high second-order nonlinear susceptibility. In order to produce radiation in the shorter UV wavelength region, a frequency conversion in crystal of quadratic nonlinearity is used. The SH output corresponds to the optical transitions from the ground state for some new nuclei and ions from the fission fragments of $30 \leq Z \leq 58$. Further development of UV laser sources on the basis of injection seeded nonlinear converters is also discussed.

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Mobility Shortages During Financial Crisis. Restrictive effects of income insufficiency

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***Abstract**: This paper presents the results and conclusions from a survey undertaken in Blagoevgrad municipality, Bulgaria, in May 2013. The aims were to reveal the dependencies between population mobility (within the urban areas and abroad) and the income shortages. The attention was focused on the question: are people less mobile in the conditions of crisis? Does it affect their daily life, their future incomes and habits? Does it affect the environment?*

***Keywords:** mobility, crisis, changes, urban population, environment, trends*

1. INTRODUCTION

This paper is based on an author's personal survey, held during May 2013. It concerned some economic and daily changes in people's lives during the past few years. In the year 2013 the incomes kept loosing purchasing value (ranking last place in the whole European Union), unemployment hit levels of 13,8% and more than 456 000[1] for a country with a population of 7 282 041[2]. Undoubtedly, there is an economic and financial crisis in Bulgaria at the present stage. The survey aims to reveal how people are driving, moving and travelling in these new conditions,

[1] According to CROSS Agency, an article, based on the National Statistics Institute for 2013, title: ""More than 456 000 unemployed for the first quarter of 2013" http://www.cross.bg/trimesechie-purvoto-vuzrast-1366246.html#axzz2Xy52Fwp1

[2] According to National Statistics Institute for 2013, www.nsi.bg

which of their habits are changed, how these changes impact them, do they affect nature and economy etc.

2. METHODS OF RESEARCH

This research is based on the highly reliable statistical method, the method of sample-size surveys and the method of comparison. To achieve the best results, the most accurate sources of information are used. These are the data-bases of National Statistic Institute of Bulgaria. A sample size survey was held among 80 students, studying in Blagoevgrad and their families. Participants come from the whole country, living in villages, small and big towns. They live under the same legislative, tax, and social circumstances as all other Bulgarian people, which allow accepting the results as representative at a national level. This survey was anonymous and paper-based.

3. RESULTS AND CONCLUSIONS

This paper reveals part of the information received. All the answers and the results refer to the 12 months preceding the month of May 2013.

At the **first stage** we aimed to figure out the participant's self-estimation about the dynamics of their lives. We asked them: "Do you consider you have a dynamic way of life?". The results are shown at Figure 1.

☐ not at all 10 %	☐ not exactly 15 %	☐ average 20 %	☐ almost 25 %	☐ yes, definitely 30 %

Fig. 1 Do you consider you have a dynamic way of life?

Subjectively, participants perceived themselves more like **intensely moving**, leading a relatively active lifestyle. This is understandable since the focus group of the study is comprised of young, regular students. Normally, the young lead most dynamic lifestyle.

The **second stage** of survey asked the participants if they use urban transport, and, if they do – how often?

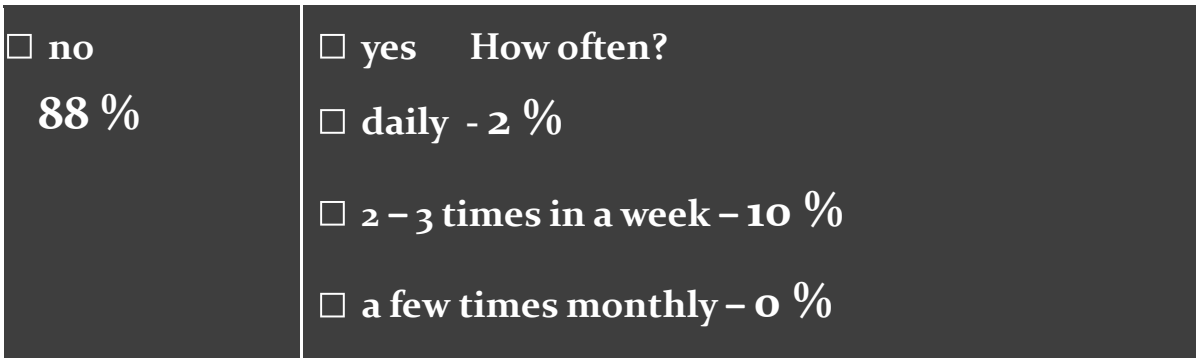

Fig. 2 Do you use urban transport, and if you do - how often?

The results we received at this stage (Fig. 2) are far from representative at a national level. Obviously, the students in Blagoevgrad use urban transport **limitedly**. The possible hypotheses are:

- **Smaller distances** – Blagoevgrad is a small town with a population of approximately 100 000 people and the infrastructure – both social and technical, is centrally concentrated. There aren't long distances to overcome.

- **High prices of the public transport** – they are comparable to these in the capital city of Sofia (Blagoevgrad - 0.80 BGN for one-way trip; Sofia - 1.00 BGN). In the same time, distances travelled are up to 10 times shorter, and the living standard is much lower

- **Lack of a variety of lines and means of transport**. There are not more than 2 or 3 major bus lines. There is no subway or other means of urban transport.

- **Inexpediency**. This is very typical for most of the small towns in Bulgaria. There are no electronic signs to show the arrival time of the bus. This makes urban transport inconvenient, especially in hard climate conditions like hot summer and cold winter, typical for these latitudes.

- **Combination of reasons.** The most probable hypothesis is that the lack of usage of urban transportation among young people is a general reason, caused by the most of above-mentioned ones combined.

At **stage 3** we asked the participants: "Did the way you move drive and travel change during the last 12 months?"

About **5%** of the participants provide answers such as:

- *"I walk and ride a bike often"*
- *"I have a daily walk in the past few months"*
- *"Over the past year I try to avoid any transport as much as possible, and impel by walking".*

"Has not changed" - thus have answered the majority of participants (about **95%**). Probably the habit of walking, shared in the next phase of the study began earlier, before the last 12 months.

At **stage 4** the topic to reveal was: "Do you **walk** more often now, than you used to do in the past?" Here we intentionally missed to limit the period to the last 12 months, considering this will let participants compare easier the periods: "now, in the crisis" with "before the crisis".

☐ almost never	☐ rarely	☐ up to 2-3 times a week	☐ every day	☐ other
0 %	2 %	0 %	98 %	0 %

Fig. 3 Do you walk more often now, than you used to do in the past?

The results of this phase of the study (Fig. 3) speak for themselves. In times of crisis the desire of reducing the cost of transport is evident.

The results of this stage only concern particularly urban environments, where distances are shorter. Walking requires good health and a little more free time (or better time management).

Preliminary results of the study confirmed the expected link between some qualitative and quantitative aspects of daily life.

The **quantitative changes** like: loss of income and purchasing power, cost of transport, etc. **resulted in qualitative adjustments,** such as: changes in the ways and habits of movement, choice of vehicles and others.

As a whole, during an economic crisis, people prefer the cheaper ways of transportation in urban environment. The survey confirmed our preliminary

expectations. On one side – this is slower way of movement, like walking, instead of vehicles, as well as urban transport instead of personal car or a taxi. On the other side, these new habits are healthier and more environmentally friendly.

The other stages of the survey, their results and conclusions will be published soon.

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Employment and Income Satisfaction of Students Working Abroad

Income comparison between foreign and native conditions

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***Abstract**: In this paper are presented the results and conclusions from my own survey, held in Blagoevgrad municipality, Bulgaria, between the years 2011 and 2013. It concerns the typical native phenomenon "student's working trips abroad". The attempt is to reveal why these travels are necessary, why they even appear and why are they preferred as a summer job opportunity for Bulgarian youth. Own collected information is used, as well as official statistical data. A comparison between the working conditions here and abroad is applied.*

***Keywords:** students, job, abroad, income, satisfaction, conditions*

1. INTRODUCTION

In the last 5 years we live in the conditions of a global economic and financial crisis. Student's work journeys are a new way of creating opportunities for Bulgarian youth and their families. They represent seasonal migrations, which are not seriously researched so far. Their importance is obviously notable for many students and for Bulgarian economy as a whole. They serve as an "invisible" export of labor forces and import of financial funds. During such seasonal works young people meet different obstacles and difficulties. They work in a completely new surrounding with its native laws, language and rules. Students sacrifice their deserved summer vacation in order to work and become more sustainable and self-dependant. In some favorable cases they can collect small financial capital for their own business at a later stage. Their enthusiasm and efforts are admirable, and the positive effect they cause, upon the national and regional economy is obvious for all.

This survey examines unique problems and phenomena. They are observed in a small number of countries in the world. These are the countries with well developed educational systems and at the same time

with low values of Gross Domestic Product. It is limited predominantly to the following countries: Bulgaria, Moldova, Romania, Russia, Belarus, Turkey, Albania, Macedonia[3].These are mainly some Central and Eastern European countries, without the Third world countries.

The present survey was anonymous for increasing the honesty of participants and to encourage them to share additional information if necessary.

2. METHODS OF RESEARCH

This research is based on the highly reliable statistical method, the method of sample-size surveys and the method of comparison. To achieve the best results, the most accurate sources of information are used. These are the data-bases of National Statistic Institute of Bulgaria. A sample size survey was held among 80 students, studying in Blagoevgrad and their families. Participants come from the whole country, living in villages, small and big towns. They live under the same legislative, tax, and social circumstances as all other Bulgarian people, which allow accepting the results as representative at a national level. This survey was anonymous and paper-based.

3. RESULTS AND CONCLUSIONS

At the **first stage** we determined the participant's profile. The answered the question: "In which university in Blagoevgrad do you study?"

[3] According to the company "Integral Work and Travel", 03.10.2011, http://wat.integral.bg/

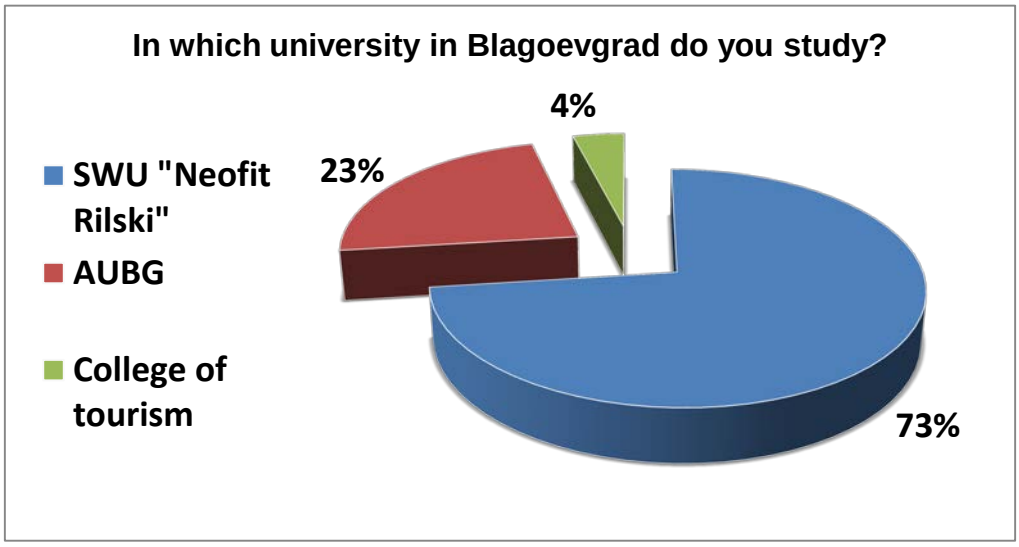

Fig. 1 “In which university in Blagoevgrad do you study?”

We choose the participants proportionally to the total number of students, educated in the 3 institutions in Blagoevgrad (Fig. 1). Their capacity is as following: SWU “Neofit Rilski” has approximatey 12 000 students, American University in Bulgaria – 1127, and The College of tourism – 750.

At **stage two**, through the method of comparison we compared:

- The predominant economic activity of the students working abroad[4]
- The longevity of a working day abroad[2]
- The average monthly income for the same jobs in Bulgaria[5]
- The average hourly income for the same jobs in Bulgaria[3]

We took into consideration also:

- the amount needed to support one person per month in Bulgaria[3]
- duration of the stay of students working abroad[2]

[4] Data from our own survey October 2011

[5] Average monthly salary in Bulgaria for October 2011, National Statistical Institute, www.nsi.bg

- the savings from one student brigade averagely[2]

Then we calculated how much the students would have saved, if they were working for the same period under the same workload hours per day / week in Bulgaria.

We determined the predominant economic activity of the students, working abroad in **stage 3**. The results are shown at Figure 2

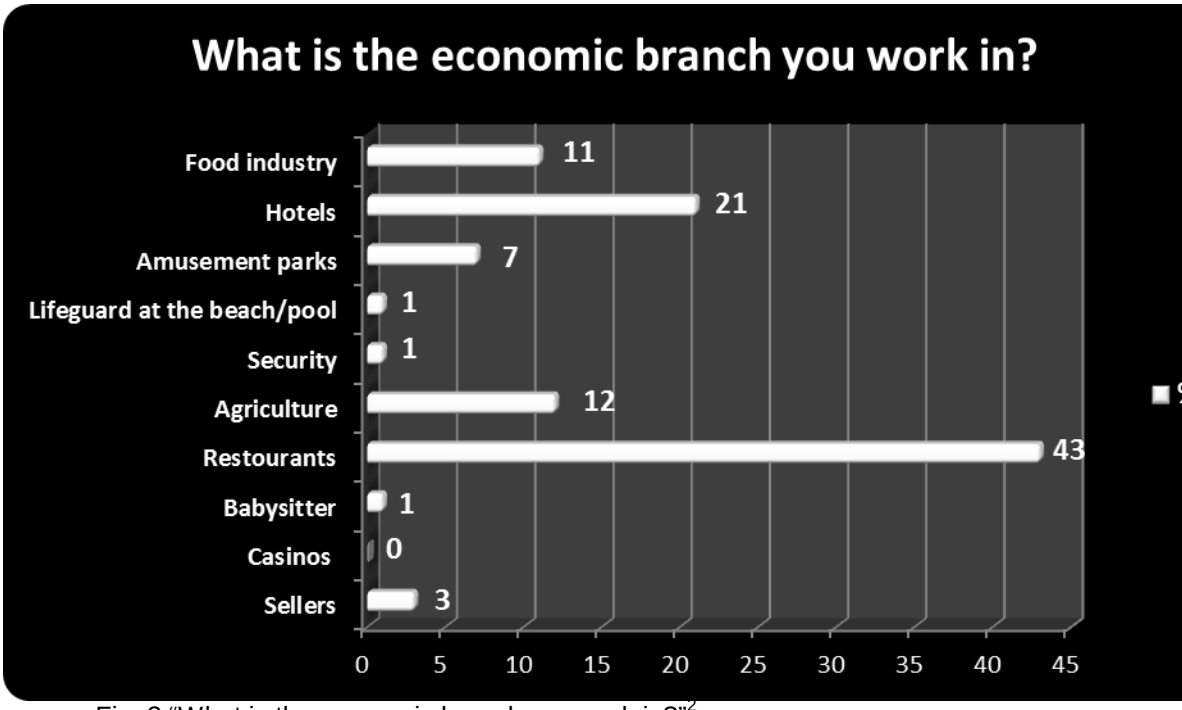

Fig. 2 "What is the economic branch you work in?"[2]

Next stage (**stage 4**) was to figure out the average longevity of a working day abroad. The results are summarized at Figure 3.

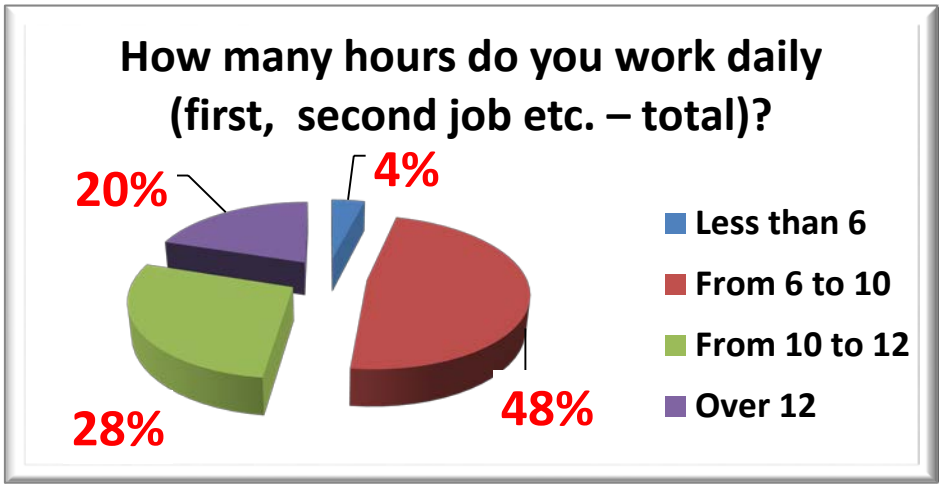

Fig. 2 "How many hours do you work daily (first, second job etc. – total)?"[2]

After that we summarized data for the total duration of stay for students' work abroad. The results are shown on Figure 3.

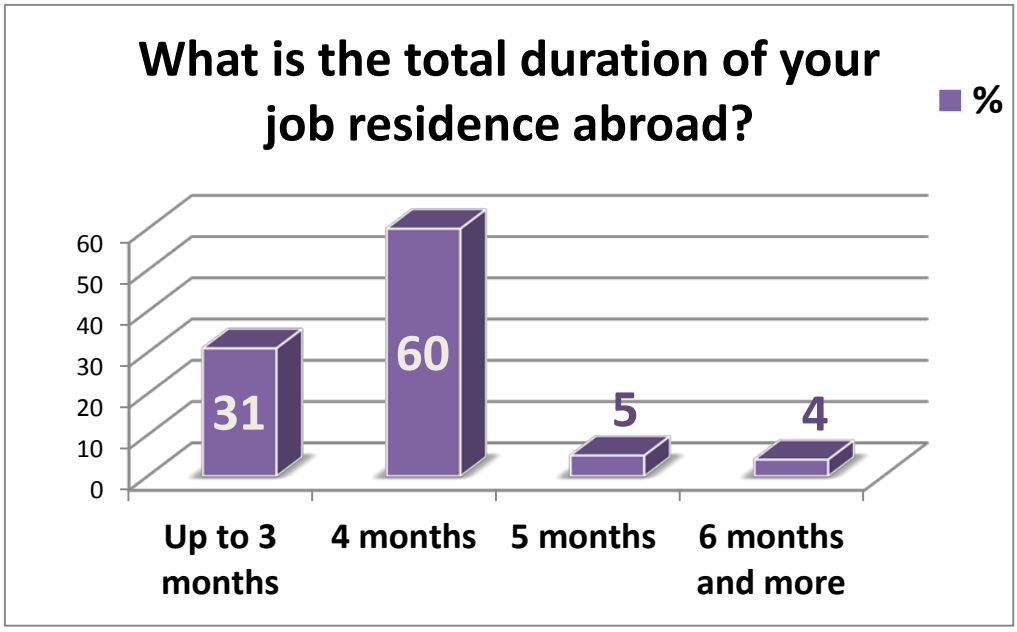

Fig. 2 "What is the total duration of your job residence abroad?[2]

НАЕТИ ЛИЦА ПО ТРУДОВО И СЛУЖЕБНО ПРАВООТНОШЕНИЕ, СРЕДНА БРУТНА И НЕТНА ЧАСОВА ЗАПЛАТА И СРЕДНА БРУТНА ЧАСОВА ЗАПЛАТА ЗА ИЗВЪНРЕДЕН ТРУД ПРЕЗ ОКТОМВРИ 2010 Г. ПО ПОЛ И ПРОФЕСИИ - ОБЩО НА ПЪЛНО И НЕПЪЛНО РАБОТНО ВРЕМЕ

Професии (класове на НКПД-2011)	Наети лица	Брутна часова заплата	Коефициент на вариация	Нетна часова заплата
	Брой	Левове	%	Левове
Общо	**2 272 509**	**3.81**	**0.19**	**3.03**
Ръководители	132 754	8.34	0.78	6.76
Специалисти	378 721	5.55	0.39	4.42
Техници и приложни специалисти	224 001	4.82	0.51	3.83
Помощен административен персонал	211 006	3.34	0.42	2.64
Персонал, зает с услуги за населението, търговията и охраната	485 048	2.33	0.22	1.83
Квалифицирани работници в селското, горското, ловното и рибното стопанство	3 523	2.26	2.45	1.78
Квалифицирани работници и сродни на тях занаятчии	281 256	3.36	0.33	2.65
Машинни оператори и монтажници	278 633	3.18	0.32	2.51
Професии, неизискващи специална квалификация	277 566	2.27	0.28	1.79

Fig. 4 “The average hourly income for the same jobs in Bulgaria, Oct. 2011”[3]

НАЕТИ ЛИЦА ПО ТРУДОВО И СЛУЖЕБНО ПРАВООТНОШЕНИЕ, СРЕДЕН БРОЙ ПЛАТЕНИ ЧАСОВЕ И СРЕДНА БРУТНА И НЕТНА МЕСЕЧНА ЗАПЛАТА ПРЕЗ ОКТОМВРИ 2010 Г. ПО ПОЛ И ИКОНОМИЧЕСКИ ДЕЙНОСТИ - ОБЩО НА ПЪЛНО И НЕПЪЛНО РАБОТНО ВРЕМЕ									
Икономически дейности (КИД-2008)	Наети лица	Платени часове		Брутна месечна заплата					Нетна месечна заплата
		общо	в т.ч. платени часове за извън-реден труд	общо	в т.ч. ДТВ за извън-реден труд	в т.ч. ДТВ за работа на смени	коефици-ент на вариация	медиана	
	Брой	Брой	Брой	Левове	Левове	Левове	%	Левове	Левове
Общо	**2 272 509**	**158**	**0.77**	**603**	**4.39**	**2.26**	**0.20**	**432**	**479**
Добивна промишленост	24 268	165	1.46	956	15.81	22.45	1.16	820	758
Преработваща промишленост	524 606	163	1.43	530	7.57	2.46	0.31	400	419
Строителство	158 352	155	0.40	558	2.53	0.31	0.74	478	441
Търговия; ремонт на автомобили и мотоциклети	422 584	154	0.17	486	0.94	0.63	0.54	369	384
Транспорт, складиране и пощи	142 021	159	0.74	651	4.57	6.24	0.85	482	519
Хотелиерство и ресторантьорство	114 313	143	0.13	347	0.58	0.59	0.73	335	273
Административни и спомагателни дейности	114 289	148	1.18	380	3.32	2.08	1.01	290	301
Култура, спорт, развлечения	31 434	161	1.41	529	3.71	1.25	1.59	431	420
Други дейности	35 249	147	0.05	428	0.22	(0.04)	1.52	325	337

Fig. 5 “The average monthly income for the same jobs in Bulgaria, Oct. 2011”[3]

We applied the data from the official national sources. It revealed the average levels of payment monthly and hourly in Bulgaria for October 2011[2]. The results are shown on Figures 4 and 5

The next step was to examine the amount of financial funds, students saved during their working abroad. This was a delicate question, so it was marked as optional. Unexpectedly high number of participants answered the question – about 84% of all. The results are shown on Figure 6.

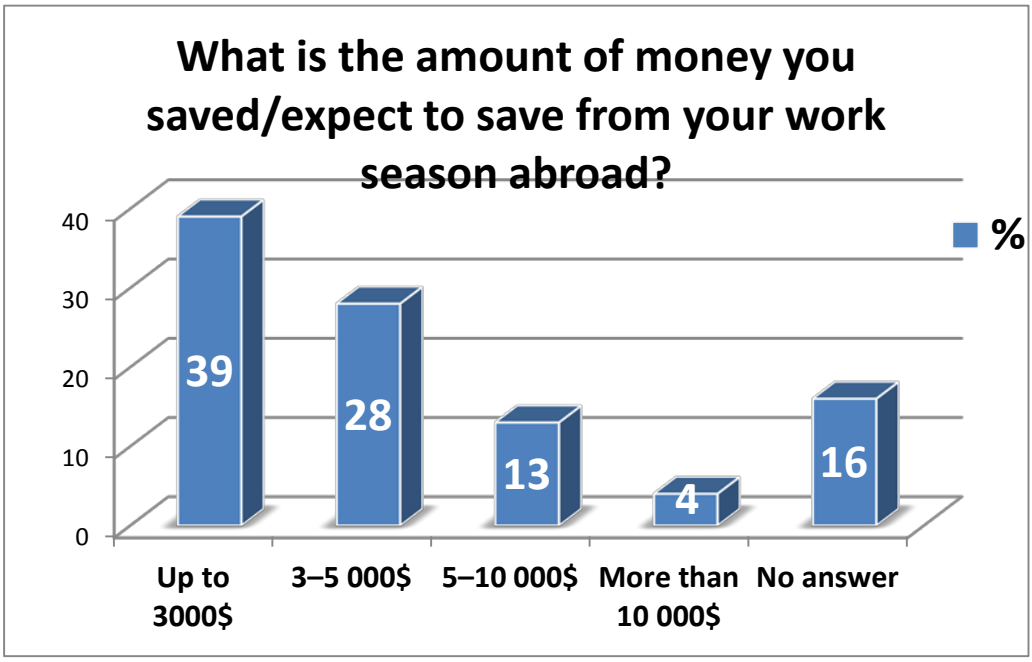

Fig. 6 "What is the amount of money you saved/expect to save from your work season abroad?[2]

Meanwhile in Bulgaria:

- Poverty line for 2011, according to the NSI Confederation was 185. 21 BGN (125.99USD) / Person
- Average maintenance for 2011, according to the NSI Confederation was 494.36 BGN(336.30 USD) / Person
- 1 USD = 1.46889 BGN at Bulgarian National Bank fixings to 11/2011

For a period of 4 months in Bulgaria:

- In a 12-hour day - general average incomes - 2874.00 BGN (1955.10 USD)
- Poverty line – 740.84 BGN (503.97 USD)
- Average maintenance - 1977.44 BGN (1345.20 USD)

The **conclusions** are notable. The calculations reveal that:

For a period of 4 months in Bulgaria:

- Savings at greatest possible scarcity - 2133.16 lev (1451,13 USD)
- Savings during normal maintenance - 897,00 lev (610,20 USD)

These results are evidence that the data obtained in our study in 2011 are real, and that participants are satisfied with the right of participation in employment programs abroad in the summer! They are summarized and shown on Figure 7.

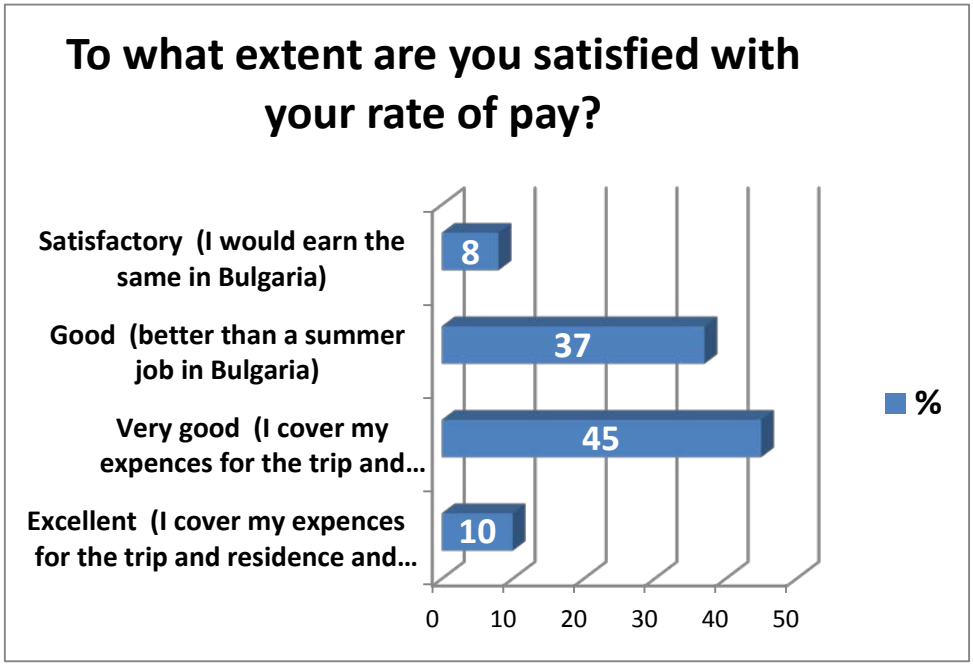

Fig. 7 "To what extent are you satisfied with your rate of pay?[2]

The conclusions from this paper undoubtedly proved, that at the present stage abroad-working programs don't have alternatives according to the rates of incomes and work duration, compared to the native conditions. In the future, Bulgarian government together with the academic councils and

the business must develop strategies to attract young people to stay in the country contributing the national economy, instead of working abroad. This could be achieved after a thoroughgoing analysis and adequate governmental measures.

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2. National Statistical Institute, www.nsi.bg

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