ՀԱՅ-ՌՈՒՍԱԿԱՆ (ՍԼԱՎՈՆԱԿԱՆ)
ՀԱՄԱԼՍԱՐԱՆ

Միջազգային սիմպոզիում

«ՕՊՏԻԿԱՆ ԵՎ ՆՐԱ ԿԻՐԱՌՈՒԹՅՈՒՆՆԵՐԸ»

1-5 հոկտեմբեր, 2015
Երևան–Աշտարակ, Հայաստան

Տեղեկություն սիմպոզիումի վերաբերյալ և զեկուցումների թեզերը

ԵՐԵՎԱՆ
ՀՌՀ ՀՐԱՏԱՐԱԿՉՈՒԹՅՈՒՆ
2015

РОССИЙСКО-АРМЯНСКИЙ (СЛАВЯНСКИЙ) УНИВЕРСИТЕТ

Международный симпозиум

«ОПТИКА И ЕЕ ПРИЛОЖЕНИЯ»

1-5 октября, 2015
Ереван-Аштарак, Армения

Информация о симпозиуме и Тезисы докладов

ЕРЕВАН
ИЗДАТЕЛЬСТВО РАУ
2015

UDC 535:06

Optics & its Applications: Symposium Information & Book of Abstracts of the 3rd International Symposium (Armenia, 1-5 October, 2015). – Yerevan, 2015 – 160 p.

The book includes the abstracts of reports submitted to the SPIE.FOCUS Armenia: 3rd International Symposium "Optics & its Applications" (OPTICS-2015). Abstracts printed as presented by authors. Full texts of the reports selected by the Program Committee of the Symposium will be published in the Journal of Physics: Conference Series (JPCS).

The Book of Abstracts of the SPIE.FOCUS Armenia: 3rd International Symposium «Optics & its Applications» is issued by decisions of Scientific Council of the Organizing Committee of OPTICS-2015, and Publishing Council of Russian-Armenian University (session of Council, September 15, 2015).

Edited by **Narine Gevorgyan** (RAU, Armenia)

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Foreword

It is our great pleasure and honor to welcome you to the SPIE.FOCUS Armenia: 3rd International Symposium "Optics & its Applications" (OPTICS-2015) in Yerevan-Ashtarak, Armenia, October 1-5, 2015. This event is dedicated to the International Year of Light and Light-Based Technologies and we devote several public lectures to this occasion, e.g. "Light from the baby Universe" by David Blaschke and "Light in Photography" by Suren Manvelyan.

This time our main organizer is SPIE under the Federation of Optics College and University Students (FOCUS) conference grant: SPIE.FOCUS Armenia. We gratefully acknowledge this support as well as contributions from other organisations: the Abdus Salam International Center for Theoretical Physics (ICTP), Optical Society (OSA), Laboratory of Terahertz Technology of Bauman Moscow State Technical University (BMSTU), Russian-Armenian University (RAU), Greek-Armenian industrial company LT-Pyrkal, King Abdullah University of Science and Technology (KAUST), Institute for Physical Research of National Academy of Sciences (IPR of NAS), and Ritea.

The objective of this Symposium in Armenia is to bring together experienced and young scientists working in various areas of optics, to share their ideas and achievements, present their works and to discuss the most recent developments in their areas. This scientific event will provide opportunities for researchers from industrial companies, academic and research institutions to exchange informations and to launch cooperations. It shall attract young scientists of the region to the modern and multifacetted field of optics and its applications and encourage them to start a career as researcher. A special lecture is devoted to the topic of career development.

In this Abstract booklet you shall find not only the information about the plenary and contributed talks as well as poster presentations. We give also a short summary on the co-organizing institutions, their history and goals as well as the events which will take place during the Symposium.

The Symposium will host 111 scientists from 18 countries namely: Armenia, Belgium, China, Czech Republic, France, Georgia, Germany, India, Iran, Italy, Latvia, Mexico, Poland, Russia, Saudi Arabia, Sweden, Ukraine & USA.

On behalf of the organizing committee, we sincerely hope that this symposium meets and eventually exceeds all your expectations and we wish you a wonderful stay in Armenia!

With kind regards,
Direcotrs of OPTICS-2015

ORGANIZING COMMITTEE

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LT-Pyrkal, Armenia

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Hayk SARKISYAN
RAU & YSU, Armenia

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Heads of Project:

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Organizing Centers

- ✓ **SPIE**
- ✓ **YSU & NAS SPIE Armenian Student Chapter**
- ✓ **Russian-Armenian (Slavonic) University**
  Institute of Mathematics and High Technologies
- ✓ **Institute for Physical Research of NAS**
- ✓ **LT-PYRKAL**
- ✓ **Armenian ICO TC**
- ✓ **Yerevan State University**
  Department of Physics

Co-organizing student chapters:

- ✓ OSA YSU & NAS Chapter, Armenia
- ✓ SPIE Bauman Moscow State Technical Univ. Chapter, Russian Federation
- ✓ OSA Bauman Moscow State Technical Univ. Chapter, Russian Federation
- ✓ SPIE Lund Univ. Chapter, Sweden
- ✓ SPIE Wroclaw Univ. of Technology Chapter, Poland

Topics:

- *Optical properties of nanostructures*
- *Silicon photonics*
- *Quantum optics*
- *Singular optics and its applications*
- *Laser spectroscopy*
- *Strong field optics*
- *Biomedical optics*
- *Nonlinear & ultrafast optics*
- *Photonics & fiber optics*
- *Mathematical methods in optics*

Program highlights:

- Plenary and Invited talks, sectional reports
- Presentations of young scientists (*Special awards from SPIE Armenian Students Chapter for best student presentation*)
- Poster presentations
- Student chapters presentations
- Public lectures
- Professional development lecture
- Presentations of international societies
- Hands-on research activities
- "Optics zone" (demonstration of experiments)
- Exhibition
- Photo contest "Light in daily life of Armenia"
- Social events

The Symposium Program includes: presentations of institutions & societies (10, 20, 40 min), plenary talks (40-45 min), invited talks (30 min). The program also includes: young scientists presentations (10, 20 min); sectional oral presentations (20 min), and poster contributions (posters are accepted up to format A0: 1189mm x 841mm), proposed by participants and accepted by the Scientific Council of the Organizing Committee.

Symposium Venue

Department of General Physics and Quantum Nanostructures
Institute of Mathematics and High Technologies
Russian-Armenian (Slavonic) University
123 Hovsep Emin str., Yerevan, 0051, Armenia

LT-PYRKAL
21 Shopron Str., Yerevan, 0090, Armenia

Institute for Physical Research of NAS
Ashtarak-2, 0203, Armenia

Department of Physics
Yerevan State University
1 Alex Manoogian str., Yerevan, 0025, Armenia

CONTACTS

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http://rau.am/optics2015/

Proceedings

JOURNAL OF PHYSICS: CONFERENCE SERIES
The open-access journal for conferences

The Symposium Proceedings will be published in the *Journal of Physics: Conference Series* (JPCS). This is an on line series from the Institute of Physics (IoP).
Expected online publication: December 2015

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Presentations of International Societies & Institutions

Katarina Svanberg

- ✓ International society for optics and photonics (SPIE): http://spie.org/

Angela Guzman

- ✓ International Commission for Optics (ICO): http://e-ico.org/
- ✓ Optical Society (OSA): http://www.osa.org/
- ✓ International Year of Light: http://www.light2015.org/

Aigars Ekers

- ✓ King Abdullah University of Science and Technology (KAUST): http://www.kaust.edu.sa/

SPIE student chapters presentations

1. **Yerevan State Univ. Chapter, Armenia**
   Hakob **Hakobyan**
2. **Charles Univ. in Prague Chapter, Czech Republic**
   Lukas **Nadvornik**
3. **Univ. of Delhi at Acharya Narendra Dev College Chapter, India**
   Sadashiv **R**aj **Bharadwaj**
4. **Wroclaw Univ. of Technology Chapter, Poland**
   Mateusz **Szatkowski**
5. **Bauman Moscow State Technical Univ. Chapter, Russian Federation**
   Irina **Dolganova**
6. **Lund Univ. Chapter, Sweden**
   Helene **Coudert-Alteirac**
7. **Taras Shevchenko National Univ. of Kyiv Chapter, Ukraine**
   Danylo **Babich**

Hands on Research Activities

1. Generation of similariton in passive fiber and similaritons' collision

Coordinator: **Levon Mouradian**
Venue: *Ultrafast Optics Laboratory, Yerevan State University*

2. A novel approach for quantitative study of atoms in strong magnetic fields up to 8000 Gauss with the help of an optical one-dimensional nanometric-thin cell with the thickness of a Rubidium or Cesium atomic vapor column of length L ~ 400 nm

Coordinator: **Armen Sargsyan**
Venue: *Laboratory of Laser Spectroscopy, Institute for Physical Research of NAS*

Exhibition

Greek-Armenian Industrial company LT-PYRKAL
ttp://lt-pyrkal.com/en/

Coordinator: **Gagik Buniatyan**
Venue: *LT-PYRKAL*

Light in the daily life of Armenia

Photo contest

Participants of SPIE.FOCUS Armenia wishing to participate in the photo contest are welcome to send 1 or 2 photos (maximum) until October 4 to the e-mail: **armenia.ico@gmail.com**

Submissions should contain the following information about the photographer and the photo(s):

- ✓ Full name;
- ✓ Affiliation;
- ✓ Phone number;
- ✓ Type of camera;
- ✓ Approximate date of the photo and the place where it was taken.

Note: photos should be taken in Armenia in 2015 ☺

There will be special awards from
the SPIE Armenian Students Chapter for
The best photo
Light in daily life of Armenia!!!

International Year of Light

On 20 December 2013, the UN General Assembly 68th Session proclaimed 2015 as the International Year of Light and Light-based Technologies (IYL 2015).

In proclaiming an International Year focusing on the topic of light science and its applications, the UN has recognized the importance of raising global awareness about how light-based technologies promote sustainable development and provide solutions to global challenges in energy, education, agriculture and health. Light plays a vital role in our daily lives and is an imperative cross-cutting discipline of science in the 21st century. It has revolutionized medicine, opened up international communication via the Internet, and continues to be central to linking cultural, economic and political aspects of the global society.

IYL 2015 programs will promote improved public and political understanding of the central role of light in the modern world while also celebrating noteworthy anniversaries in 2015—from the first studies of optics 1,000 years ago to discoveries in optical communications that power the Internet today.

This International Year will bring together many different stakeholders including scientific societies and unions, educational institutions, technology platforms, non-profit organizations and private sector partners.

INTERNATIONAL
YEAR OF LIGHT
2015

Open-air experiments in Optics

Aug 01 – Dec 31

Interdisciplinary group of young researchers organizes open-air shows all over Armenia. Shows will concentrate on Optical experiments.

Contact	Anahit Gogyan, agogyan@gmail.com
Date	August 1, 2014 - December 31, 2015
Location	All over Armenia
URL	https://lightarmenia.wordpress.com/

Light in the daily life of Armenia

Sep 14 – Oct 03

You are welcome to send 1-2 photos until Oct. 3 to the e-mail: armenia.ico@gmail.com
Submissions should contain the following information: name; phone number; type of camera; date of the photo and the place where it was taken.

Contact	Narine Gevorgyan, gnarine@gmail.com
Date	September 14, 2015 - October 3, 2015
Location	Yerevan, Armenia

SPIE.FOCUS Armenia: 3rd International Symposium “Optics and its Applications”

Oct 01 – Oct 05

The following topics will be covered: Optical properties of nanostructures; Silicon photonics; Quantum optics; Quantum informatics; Singular optics and its applications; Laser spectroscopy; Strong field optics; Nonlinear & ultrafast optics; Photonics & fiber optics; Mathematical methods in optics.

Contact	Narine Gevorgyan, gnarine@gmail.com
Date	October 1, 2015 - October 5, 2015
Location	Yerevan, Ashtarak, Armenia
URL	http://rau.am/optics2015/

Light from the Baby Universe

Oct 01

Speaker: David Blaschke (Poland)
Time: 15:00
Venue: LT-PYRKAL, 21 Shopron Str., Yerevan, 0090

Contact	Narine Gevorgyan, gnarine@gmail.com
Date	October 1, 2015
Location	Yerevan, Armenia

The Light in Photography

Oct 05

Speaker: Suren Manvelyan (Armenia)
Time: 15:15
Venue: Russian-Armenian (Slavonic) University
123 Hovsep Emin str., Yerevan, 0051

Contact	Narine Gevorgyan, gnarine@gmail.com
Date	October 5, 2015
Location	Yerevan, Armenia

Laser Physics 2015 - International Conference

Oct 06
Oct 09

The conference will cover all aspects of laser physics with focus on new and exciting developments and results in physics of coherent light sources, nonlinear and quantum optics, photonics, optical properties of nanostructures, etc.

Contact	Anahit Gogyan, agogyan@gmail.com
Date	October 6, 2015 - October 9, 2015
Location	Ashtarak, Armenia
URL	http://ipr.sci.am/lp/

SPIE.

SPIE, the international society for optics and photonics, was founded in 1955 to advance light-based technologies.

Serving more than 264,000 constituents from approximately 166 countries, the not-for-profit society advances emerging technologies through interdisciplinary information exchange, continuing education, publications, patent precedent, and career and professional growth.

SPIE annually organizes and sponsors approximately 25 major technical forums, exhibitions, and education programs in North America, Europe, Asia, and the South Pacific.

SPIE provided $4 million in support of education and outreach programs in 2014.

SPIE publishes the SPIE Digital Library, containing more than 415,000 research papers from the Proceedings of SPIE and the Society's 10 scholarly journals with around 18,000 new papers added each year, and more than 215 eBooks from the SPIE Press catalog. The SPIE Press publishes print monographs, tutorial texts, Field Guides, and reference books. SPIE also publishes a wide variety of open access content.

Membership includes Fellows and Senior Member programs. The Society has named more than 1,000 SPIE members as Fellows since 1955, and implemented its Senior Member program in 2008.

The SPIE awards program serves to recognize outstanding contributions from individuals throughout the scientific community.

The SPIE international office is located in Bellingham, Washington and the SPIE Europe office is located in Cardiff, Wales.

INTERNATIONAL COMMISSION FOR OPTICS
COMMISSION INTERNATIONALE d'OPTIQUE

The International Commission for Optics was created in 1947. It is an Affiliated Commission of the International Union of Pure and Applied Physics (IUPAP), and a Scientific Associate of the International Council of Science (ICSU). Its objective is to contribute, on an international basis, to the progress and diffusion of knowledge in the field of optics.

The Commission has three categories of Members: Territorial Committee Members (53 members including two Associate Members), International Organisation members (6 members). The governing body of ICO is its General Assembly, usually held every three years during an ICO Congress that includes an international conference on optics. Between General Assemblies, a Bureau is responsible for the conduct of the Commission. The Bureau consists of the President, the Past-President, the Secretary General and the Associate Secretary, the Treasurer, and fourteen Vice-Presidents, (eight elected) of whom at least two are from industry.

In order to serve and be representative of the optics community worldwide, ICO maintains contacts with its Members and with optical scientists in all countries and welcomes all new contacts. Together with the other societies involved, it contributes to the coordination of international activities in optics such as in particular scientific meetings.

In addition to its Congresses, ICO initiates international topical meetings, and acts as a cosponsor for a number of international scientific meetings organised by other bodies. All the update information on meetings with ICO participation is appearing on the special section at this web site.

ICO has established a Committee for the Regional Development of Optics and has contacts with the International Centre for Theoretical Physics, ICTP, Trieste, Italy in order to find new ways to help to optical scientists and engineers in developing countries, in particular through the exchange of information and through the joint organisation of schools. Under a Proceedings

Donation programme, some libraries in developing countries can receive copies of the proceedings of Conferences with ICO participation.

Schools with ICO participation are of a typical duration two or three weeks, for the main benefit of optical scientists and engineers in non industrialised countries. The contribution of ICO is mainly in the form of support in establishing the programme and finding the appropriate instructors.

A Newsletter covering ICO activities is published four times a year and posted in the ICO webpage. Printed copies of the ICO Newsletter may be obtained from the ICO secretariat as per request.

The board members of ICO Armenian Territorial Committee are

President: **Aram Papoyan** (IPR of NAS)

Vice-Presidents: **Gagik Buniatyan** (LT-PYRKAL)
Levon Mouradian (YSU)

Secretary: **Narine Gevorgyan** (RAU)

Treasurer: **Paytsar Mantashyan** (IPR of NAS)

Russian-Armenian (Slavonic) University

Russian-Armenian (Slavonic) University (RAU) is a unique institution in the South Caucasus region being under the joint authority of the Russian Federation and the Republic of Armenia. The decision to establish RAU in Yerevan was taken in 1997 when the RA and RF governments signed the agreement to open a Russian university in Armenia. What followed was a period of firm effort led by two governments. In almost two years the vision of Russian-Armenian University had become a reality. The first intake of students was held in February 1999 for Science of Law, Public and Municipal Administration and Journalism. Since then the University has been constantly growing and encompassing new branches of learning and research. Starting from 2002 scientific centers, institutions and problem research groups have been developing within the university. In the same year RAU offered its first post-graduate course to the students. The reconstruction of the building was ended in 2004. On October 15 of the same year Park of Gratitude was opened at the university as a symbol of the past, present and the future of Russian-Armenian friendship. This very day is considered to be the University Day.

On April 29th, 2005 RAU was accredited by the Ministry of Education of the Russian Federation.

Nowadays RAU offers a wide range of undergraduate and postgraduate programs. There are 5 Institutes at RAU. Students are trained in 32 Chairs which involve highly qualified specialists. Most of them have Doctor's or Candidate's degree. The University offers training in almost all branches of modern science and humanities giving both Bachelor's (4 years) and Master's (2 years) degree. Senior students have an opportunity to continue the education either in Russia or in other countries.

The aim of the university is to prepare highly qualified specialists meeting the demands of the new century and to support them to find jobs corresponding to their knowledge and skills. Professors from the Republic of Armenia and the Russian Federation do their best to make this goal come true.

Since its creation the university has been governed by 2 presidents; the founding president, famous expert in Russian language and literature, Academician Levon Mkrtchyan was followed by Former Prime-Minister of the

Republic of Armenia, Doctor of Economic Sciences, Professor, Academician of the Russian Academy of Natural Sciences, member of National Academy of Science of Armenia Armen Darbinyan who has been the president since November 1, 2001.

Contact information

Director of the Institute of Mathematics and High Technologies:

Eduard Kazaryan
Academician of National Academy of Science of Armenia,
Doctor of Physico-Mathematical Sciences
E-mail: edghaz@mail.ru

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Web: http://rau.am/

National Academy of Sciences of Armenia
Institute for Physical Research

Main scientific directions:

Laser physics and material science, *in particular*:

- *atomic physics, laser spectroscopy*
- *quantum and nonlinear optics, photonics*
- *quantum information, computing and communication*
- *matter wave physics*
- *interaction of radiation with matter*
- *new solid-state lasers, laser materials and schemes*
- *growth and characterization of laser and scintillation crystals*
- *thin film structures for microelectronics and laser technologies*
- *solid state physics, organic ferromagnetism*
- *high-temperature superconductivity*
- *synthesis and characterization of nanomaterials*
- *scientific instrumentation*

Research in these areas is carried out in 12 laboratories:

- Theoretical Physics Laboratory
- Optics Laboratory
- Laboratory of Laser Spectroscopy
- Laboratory of Crystal Growth of Luminescence Materials
  - X-ray Analysis
- Quantum Informatics Laboratory
- Crystal Optics Laboratory
  - γ-Radiation Station
- Solid State Lasers and Spectroscopy Laboratory
  - Coating Facility
- Solid State Physics Laboratory
- Superconducting Detectors' Physics Laboratory
- Non-Linear Crystals and Elaborations Laboratory
- High-Temperature Superconductivity Laboratory
  - Electron Microscopy and X-ray Microanalysis
- Physics Engineering Laboratory

Some figures

- Founded: **1968**
- Location: **Ashtarak, 25 km north-west from Yerevan**
- Overall campus territory: **700 000 m^2**
- Total number of employees: **174**
- Publications: about 100 per year, including 50 in refereed journals
- Organized conferences: Annual "Laser Physics" International Conference (1996-2011); International "Young Optician School" (2007); International Advanced Research Workshop "Modern Problems in Optics & Photonics" (2009); International Scientific Workshop "Photonics & Micro- and Nano-structured Materials" (2011); International Symposium "Optics and its Applications" (2011); International Advanced School on Frontiers in Optics & Photonics (2012); 2nd International Advanced School on Frontiers in Optics & Photonics (2014); ICTP smr2633: 2nd International Symposium "Optics and its Applications" (2014); QuantArm 2014: International Conference and Workshop Quanta and Matter
- Education activities: Basic Chair of Quantum and Optical Electronics of the Russian-Armenian (Slavonic) University
- International collaboration: with over 50 leading scientific centers (France, Germany, USA, Italy, UK, Russia, Latvia, Bulgaria, Poland, Japan, Spain, Australia, Switzerland, Croatia, Canada, Taiwan, Greece and others); CNRS International Associated Laboratory (LIA) "IRMAS"

Contact information:

Institute for Physical Research
of the National Academy of Sciences of Armenia
(public research organization)

Postal Address: Ashtarak-2, 0203 Armenia
Phone: +374 10 288150
Fax: +374 232 31172
E-mail: ifi@ipr.sci.am
Web: http://www.ipr.sci.am

Director: Aram Papoyan
DrSc, Corresponding Member of NAS
E-mail: papoyan@ipr.sci.am

General information about LT-PYRKAL cjsc

21, Shopron Str., Yerevan, 0090, Armenia
Tel: (+37410) 660551; Fax: (+37410) 660552;
E-mail: info@ltp.am ; Web: http://www.lt-pyrkal.com

LT-PYRKAL Armenian-Greek Closed Joint Venture was established in 1999. According to the founders' aim the Company was established with the capability of carrying out especially complicated projects on Lasers and EO systems. Its main activity is carried out mainly on contractual bases. The infrastructure of the Company is created in a way that provided realization of the practically full cycle of Scientific Research- Laboratory Prototyping-Industrial Production.

One of the main directions of the Company is the growth technology development of active laser crystals and optical crystals. Works are carried out in the direction of development and market promotion of various rare earth doped laser elements on the bases of Fluoride and Oxide host crystals. These works are developed in the following directions: manufacturing of small laser rods with high concentrations aiming at obtaining high energies from small sizes; growth of the laser rods up to 120 mm with small concentrations; search of new crystals for laser and other applications.

Development technology and manufacturing of high-quality acousto-optical and electro-optical Q-switches have been carried out within the Company, together with their control devices with improved characteristics that would be used in modern laser systems requiring simple parameter control. Thus, a powerful acousto-optic fused quartz Q-Switches has been developed at the wavelength of 1.064μm with water-cooled system and control power of 100 W, which has low price and successfully competes with the Western analogs.

The main part of electronic devices with which the Company developments are equipped are also designed and produced within the Company. These are the power supply units for pulsed and CW lasers, Acousto-Optic and Electro-Optic Q-Switch Drivers, automated electronic systems of laser radiation parameter control and monitoring. The indicated devices are equipped with micro-control systems, the software of which has also been developed within LT-PYRKAL.

The Company is constantly accepting orders of leading Western Companies on polarization and laser optics components; these are cavity flowtubes and reflectors of complicated configurations made of doped borosilicate glasses, fused silica, sapphire; lenses, laser mirrors, band-pass filters, prisms, lightguides, substrates, and phase plates.

During past years the Company has developed and manufactured prototypes of intracavity and ring parametric oscillator with wide tunable range in middle IR range, remote system for gas trace components detection in the atmosphere, i.e. LIDAR based on the principle of differential absorption of IR radiation passing through the atmosphere. Among other designs are OPO based eye-safe laser, CW diode pumped Q-switch laser, a range of free running and Q-Switched lamp pumped pulsed solid-state Nd:YAG laser with pulse energy up to 1.5 Joule at 1.06 μm wavelength. Investigations and developments of other laser systems for applied purposes are being carried out.

The Company is regularly participating in International Trade Exhibitions. A wide range of Company products has been presented at the exhibitions: laser crystals doped with various materials, doped and un-doped fluorides, sapphire; optical elements (plain and spherical), band-pass filters; aucousto-optic and electro-optic Q-Switches with their control units; pulse laser power supply units; cavity flowtubes and reflectors of various configurations. Presently around 80 employees are working in the Company.

Faculty of Physics
Yerevan State University

The process of training specialists in the field of physics and mathematics began in YSU in 1922. The establishment of an independent faculty of Physics and Mathematics comprised of separate Chairs of Physics and Mathematics in 1933 was a significant step towards developing physics in Armenia.

To strengthen the development of physics, and in order to provide more new specialists in our republic, the Faculty of Physics was separated from the Physical and Mathematical Faculty in 1959. The first dean of the faculty was NAS RA Academician Norayr Kocharyan.

The staff of the faculty is comprised of highly qualified specialists. Currently NAS RA three Academicians and NAS RA five Associate members, 36 Doctors of Sciences, and more than 80 Candidates of Sciences are involved in the tutoring staff of this faculty.

Starting with 2006-2007 Academic year the specialization (distance learning) of Pedagogue Specialist of Physics is also available.

The scientific-research activities, which are conducted in the laboratories of the faculty, correspond to the present demands of the field. There is also an equipped computer room with modern technologies, which enables students to get acquainted with modern scientific experiments and automated systems of technology management.

Different international grants and many projects, financed by the state budget, testify to the active scientific life at this faculty.

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Acknowledgement

Thanks for generous support to all sponsors!!!!

Visiting Lecturers

Lorenzo Pavesi is Professor of Experimental Physics and head of the Department of Physics at the University of Trento (Italy). Born the 21st of November 1961, he received his PhD in Physics in 1990 at the Ecole Polytechnique Federale of Lausanne (Switzerland). In 1990 he became Assistant Professor, an Associate Professor in 1999 and Full Professor in 2002 at the University of Trento. He leads the Nanoscience Laboratory (25 people), teaches several classes at the Department of Physics of the University of Trento. He founded the research activity in semiconductor optoelectronics at the University of Trento and started several laboratories of photonics, growth and advanced treatment of materials. He was the first president and founder of the IEEE Italian chapter on Nanotechnology. He has directed more than 25 PhD students and more than 30 Master thesis students. His research activity concerned the optical properties of semiconductors. During the last years, he concentrated on Silicon based photonics where he looks for the convergence between photonics and electronics. He is interested in active photonics devices which can be integrated in silicon by using optical nonlinearities and modified material properties. His interests encompass also optical sensors or biosensors and solar cells. Recent development is toward integrated quantum photonics. In silicon photonics, he is one of the worldwide recognized experts, he organized several international conferences, workshops and schools and is a frequently invited speaker. He manages several research projects, both national and international. He is a frequently invited reviewer, monitor or referee for photonics projects by several grant agencies. He is an author or co-author of more than 300 papers, author of several reviews, editor of more than 10 books, author of 2 books and holds 7 patents. He is chief speciality editor of the section Optics and Photonics of Frontiers in Materials, in the editorial board of Research Letters in Physics and he was in the editorial board of Journal of Nanoscience and Nanotechnologies, in the directive council of the LENS (Florence), in the Board of Delegates of E-MRS. In 2001 he was awarded the title of Cavaliere by the Italian President for scientific merit. In 2010 and 2011 he was elected distinguished speaker of the IEEE- Photonics society. He holds an H-number of 51 according to the web of science and of 60 according to Google Scholar.

Silicon photonics: a new technology platform to enable low cost and high performance photonics

Lorenzo Pavesi

Nanoscience laboratory, Department of Physics, University of Trento, 38123 Povo (TN), Italy

Photonics devices which can be fabricated by using the same truth of microelectronics: smaller, cheaper and faster. This is what silicon photonics allows you. Thousands of photonic devices integrated in a few cm square which are able to transmit signal over long distances at high speed. Optical networks which handle tens of channels and route them all across an electronic chip. An entire bio-lab with the size of a nail. Solar cells with conversion efficiency beyond the thermodynamic limit of silicon cells. These are all examples where the silicon photonics paradigm has shown all its potential.

Silicon microresonators: how to give a new twist to silicon photonics

Lorenzo Pavesi

Nanoscience laboratory, Department of Physics, University of Trento, 38123 Povo (TN) Italy

Internet boom can be slowed down by power hungry data centers. Silicon photonics is the technology to face this. A new twist to silicon photonics is provided by microresonators which enable complex functions and devices. The large refractive index difference between silicon and silicon oxide allows a tight confinement in silicon waveguides with small bend radius. Therefore, very small silicon microrings with high quality factors are possible. Microrings show different properties that can be integrated into functional silicon photonic devices. Single, coupled or cascaded microring geometries can be used to achieve complex functions. Still many aspects of the physics of photon confinement in small optical cavities have to be investigated. Therefore silicon microresonators are ideal devices for looking at new phenomena and new physics. Here we review and summarize few of these.

Katarina Svanberg started her research career by studying laser light interaction in biological tissue. Her PhD thesis in Medical Science presented pre-clinical research work within experimental photodynamic therapy and tissue spectroscopy. The post doc research activity has been focussed on clinical application of the pre-clinical achievements. Dr. Svanberg has been active as an invited speaker in more than 100 international scientific conferences. She has 100 peer-reviewed scientific papers and is the co-author of 20 scientific review papers. Katarina Svanberg has combined her clinical activity with research work and thus been able to introduce a new cancer treatment modality in Oncology (Photodynamic Therapy) at the Lund University Hospital. The validation of the new modality was presented after performing two different randomized clinical studies at the hospital. She has been a key person in the collaboration in between several clinics and departments at the Lund University Hospital in introducing and applying laser-induced fluorescence spectroscopy for early tumour detection. Dr. Svanberg has been instrumental in bringing out this clinical research work to several other countries within scientific networks, including many countries in Europe, Africa and the US. Dr. Svanberg is a board member of Lund Laser Centre and since 1993. Since 1991 she is also a board member of Lund University Medical Laser Centre, in which she now is the director. Dr. Svanberg is also listed as a principal investigator in a new programme within National Institute of Health, Rockville. She is also deputy Lund co-ordinator within a EU-project for laser application in medicine, in which programme industrial as well as scientific partners collaborate. In addition, she is an appointed distinguished professor at South China Normal University in Guangzhou. Since 2004 she is appointed as one of the Directors in the Board for the International Society of Optical Engineering, USA. The Society has over sixteen thousand members.

Laser-based detection and treatment of malignant tumours

Katarina Svanberg

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Lund University, Lund, Sweden
South China Normal University, Guangzhou, China

Laser spectroscopy has been shown to be a valuable tool both in the detection and the therapy of human malignancies. The most important prognostic factor for cancer patients is early tumor discovery. If malignant tumors are detected during the non-invasive stage, most tumors show a high cure rate of more than 90 %. Even though there are many conventional diagnostic modalities, very early tumors may be difficult to discover. Laser-induced fluorescence (LIF) for tissue characterization is a technique that can be used for monitoring the biomolecular changes in tissue under transformation from normal to dysplastic tissue and further to cancer before structural morphological changes are seen at a later stage. The technique is based on UV or near-UV illumination for fluorescence excitation. The fluorescence from endogenous chromophores in the tissue alone, or enhanced by exogenously administered tumor seeking substances, can be utilized. The technique is non-invasive and gives the results in real-time. LIF can be applied for point monitoring or in an imaging mode for larger areas, such as the vocal cords or the portio of the cervical area [1-4].

Photodynamic therapy is a selective therapy modality for human malignancies. To overcome the limited light penetration in superficial illumination interstitial delivery (IPDT) with the light transmitted to the tumors via optical fibers has been developed. Interactive feed-back dosimetry is of importance for optimizing this modality and such a concept has been developed. The technique has special interest for tumors where there are no other options, such as for recurrent prostate cancer after ionizing radiation [5,6]. For correct dosimetry it is important to assess the optical properties of tissue; this can be done by time resolving propagation techniques [7].

Another technique which has been developed for medical application is based on gas in scattering media absorption spectroscopy (GASMAS). The technique is used to detect free gas (oxygen and water vapor) in hollow organs in the human body and has been applied to the detection of the human sinus cavities [8-11]. The GASMAS technique might also be used for surveillance of prematurely born infants [12]. Approximately 10-15% of all deliveries in Europe and in the US are preterm. As the organs are not fully developed there is a risk of morbidities. In particular the lung function is limited and the babies may develop respiratory distress symptom resulting in decreased oxygen saturation affecting risk organs, such as the brain [13]. GASMAS may also be developed for detection of other diseases, such as middle ear infection in small kids [14]. A certain proportion of these infections are viral induced and in these cases no antibiotics should be prescribed. GASMAS has a potential to discriminate the origin of the disease and thus guide in the decision of appropriate therapy. This is highly needed in view of the antibiotic resistance, which poses a significant threat to global health [15,16]. Such aspects are presently pursued at SCNU, Guangzhou.

Many of these techniques can also be applied to study other organic material, e.g. food. As an example a recent study on fruit maturing combines the techniques of fluorescence, reflectance and GASMAS [17].

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Laser spectroscopy in the handling of antibiotic resistance

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Infectious diseases account for about one-quarter of all deaths worldwide. Since the introduction of penicillin during the 1940s antibiotics have been very important in the therapy of bacterial infections. However, due to over-prescription and wrongly distributed dosage the pathogens have developed resistance. Already the inventor of penicillin, Alexander Flemming, warned for this in his Nobel lecture 1945 by saying that "*It is not difficult to make the microbes resistant to penicillin*". He also foresaw a situation fact that unfortunately is true in some Asian Countries nowadays when he stated that "*Time may come when anyone can buy penicillin in the shops and the ignorant laymen may easily under dose the medication*" A recent report from the UK Chief Medical officer [1] concludes the situation by the wordings that "*antimicrobial resistance poses catastrophic threat to mankind*". WHO states that the antibiotic resistance for health care both in the community as well as in the hospitals represent a major global health threat and the crisis is emphasized further due to the fact that there is a relative lack of innovation in creating new antibiotics. WHO alludes to the fact that we are in danger of returning to a pre-antibiotic era [2-7].

The problem arises from the fact that some of the most common infectious diseases, such as middle ear infection in early childhood and sinusitis in adults, are usually caused by virus and only in few cases primarily by bacteria and still antibiotics are prescribed. It has been estimated that more than half of the antibiotics used in human medicine is unnecessary, as the infections are caused by virus [8]. The reason for that is mainly that there are no efficient objective diagnostic tools to differentiate in between the pathogens.

We have developed a non-invasive optical diagnostic modality, gas in scattering media absorption spectroscopy, GASMAS [9]. The technique is based on the high spectroscopic contrast between the extremely sharp spectral absorption lines of free gases and the slowly varying absorption fingerprints of bulk solid material. The difference in line with is typically a factor of 10,000 calling for a narrow-band laser spectroscopic technique for gases while broad-band approaches are normally used in conventional biophotonics. The technique is used to detect free gas (oxygen and water vapor) in hollow organs in the human body. The GASMAS technique has been shown to have potential to assess middle ear infection as well as sinusitis [10-14]. Another application with promising results is for lung function surveillance in small children. Furthermore GASMAS can also be used to study fruit ripening [15].

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Sune Svanberg was born in 1943 in Trollhättan, Sweden. After matriculation exam in Trollhättan in 1962 he started studies of natural sciences at the University of Göteborg, where he received his BSc in 1966. He enrolled the graduate school in physics at Chalmers University of Technology in Göteborg and first spent half a year at the Technical University of Berlin (Prof. H. Bucka) studying atomic resonance spectroscopy. He brought this field back to his university and defended his PhD in this field 1972 (Thesis advisor: Prof. I. Lindgren). After a post-doc year at Columbia University, New York (Prof. W. Happer) and initial work on atomic laser spectroscopy he continued laser-based spectroscopy at Chalmers up till 1980, when he became professor and head of the Atomic Physics Division at Lund Institute of Technology (technical faculty at Lund University). In Lund a vigourous program of laser spectroscopy, including basic atomic physics and applications to energy, environmental and medical research has been pursued. Basic studies include studies of radiative properties of atoms and ions as well as superintense laser/matter interactions (high harmonics generation, X-ray laser pumping and broadband X-ray generation). Applications include laser radar sounding of pollutants in the atmosphere and hydrosphere, laser diagnostics of combustion processes, and laser-based detection and treatment of cancer and cardio-vascular disease. He has taken the initiative to the formation of three centres for interdisciplinary work: the Combustion Centre, the Environmental Monitoring Centre and the Medical Laser Centre. He also proposed and helped establish a High- Power Laser Facility, including a multi-terawatt 10 Hz laser. In 1995 he was appointed director of the newly established Lund Laser Centre, which also gained the EC status of a European Large Scale Facility. He has trained a large number of PhD students from home and abroad through the years. He is a member of the Royal Academy of Sciences (and during 10 years a member of its Nobel Committee for Physics; two years as chairman), and the Royal Academy of Engineering Sciences. Up till 1995 he was a member of the Swedish National Space Board and the chairman of its Remote Sensing Committee. He served on the Board of the Swedish Research Council during 2004-2009. He is a Dr honoris causa at the Lund University Medical Faculty, at the Science Faculty of University of Latvia, at the Science Faculty of Université de Liège, at the Universidad Nacional de Engineria, Lima, a Foreign Member of the Lithuanian Academy of Sciences and the Académie Royale de Belgique, an Associate Fellow of the Third World Academy of Sciences (TWAS), an Honorary Professor at the Zhejiang University, Jilin University and at HIT-Harbin, China, and a Fellow of the American Physical Society and of the Optical Society of America. He has been a member of the Board of Directors of the Optical Society of America and is the recipient of the first EPS Quantum Electronics Prize (1996) and recepient of the first Azko Nobel Science Award (1999). 2004 he was awarded the SKAPA Innovation Prize, in

2005 the W.E. Lamb Medal, in 2006 the Celsius Gold Medal (Uppsala), in 2009 the Memorial Gold Medal (Lund) and the V.K. Zworykin Award of the International Federation of Medical and Biological Engineering, and in 2010 the Adelskold Medal of the Royal Academy of Sciences. He is an “Einstein Professor” of the Chinese Academy of Sciences 2006. He serves on numerous international conference, evaluation and advisory committees. During the years 1987-93 he was a member of the TetraPak Scientific Council and 1993-2000 a member of the Scientific Council of the Volvo Research Foundation. He has supervised a large number of graduate students to their PhD in Physics. He is the coauthor of about 580 scientific papers and over 30 patents and patent applications, and he helped in the formation of several spin-off companies. He arranged several workshops for physicists in developing countries, where realistic experimental set-ups based on diode lasers and light emitting diodes were integrated for applications at their home universities within the fields of medicine, environment and agriculture.

Laser spectroscopy applied to environmental and ecological research

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South China Normal University, Guangzhou, China

An overview of optical probing of the atmosphere will be given, where mostly active remote-sensing techniques of the laser-radar type will be covered, but also some passive techniques employing ambient radiation. Atmospheric objects of quite varying sizes can be studied. Mercury is the only pollutant in atomic form in the atmosphere, while other pollutants are either molecular or in particle form. Light detection and ranging (Lidar) techniques allow three-dimensional mapping of such constituents, and examples from atmospheric lidar work in Lund and in Guangzhou will be given. Recently, much larger lidar targets have been studied. Monitoring of flying insects and birds is of considerable ecological interest, and several projects have been pursued in collaboration with biologists. Mostly, elastic backscattering and fluorescence techniques are employed.

Multi-disciplinary applications of Gas in Scattering Media Absorption Spectroscopy (GASMAS)

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Gas in Scattering Media Absorption Spectroscopy (GASMAS) is a new variety of tuneable diode laser spectroscopy (TDLS). It combines concepts from atmospheric trace-gas monitoring with those pertinent to biological tissue optics. The former field deals with high-resolution spectroscopy in nonscattering media, while the latter area is characterized by broad absorption structures in strongly scattering media. GASMAS provides novel applications in e.g., the material science and biophotonics fields. The absorptive imprints of free gases inside pores or cavities in surrounding solid or liquid matter are typically many orders of magnitude narrower than those of the host material, a fact which is critically utilized. The gas signals are detected in the weak, multiply scattered light emerging from the illuminated sample. Wavelength-modulation and phase-sensitive detection techniques are employed, typically in connection with single-mode CW lasers. Any gas with useful absorption at wavelengths where the host material does not absorb strongly can be detected. For biological tissue, containing liquid water and blood, this limits the useful region to the “tissue optical window” – 650 nm to 1400 nm – where, however, the interesting gases oxygen and water vapour absorb, at around 760 and 950 nm, respectively. This limitation does not pertain to other materials, in particular not to those which do not contain liquid water. GASMAS experiments which relate to basic physics include studies of nanoporous ceramics, where wall collisions influence the lineshape and provide information on pore size distribution. A small piece of strongly scattering ceramic can serve as an alignment-free multi-pass cell with effective pathlength hundreds of times longer than the physical dimension. Porosity and gas transport studies in construction materials such as polystyrene foams, wood, ceramics and paper are examples of applications in the material science field. The technique is further very powerful for studying gas in the human body and in products which humans eat, such as packaged foods, fruits and pharmaceutical preparations. A key aspect of food packaging is to prevent oxygen to influence the food. Frequently, modified atmospheres, with nitrogen or carbon dioxide as filling gases are used. Applications include monitoring the performance of packaging machines, and measurements of the product on the shelf. Porosity in pharmaceutical tablets is important to determine, since it has bearing on controlled release, etc. Further, there are many applications in biomedicine. The GASMAS technique is fully non-intrusive and non-destructive.

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Traveling Lecturer

Angela M. Guzman joined CREOL, The College of Optics and Photonics, as a Visiting Research Associate Professor in fall 2011. From 2007-2011 she was Research Associate Professor at the Physics Department of Florida Atlantic University. She is Professor Emeritus of the Physics Department at the National University of Colombia, where she graduated as a physicist, obtained her M. Sc. degree in Physics, and worked for over 25 years. She obtained her Dr. Sc. degree from the Ludwig Maximilian University in Munich for research conducted at the Max Planck Institute for Quantum Optics in Garching, Germany, and conducted post-doctoral research at the Optical Sciences Center of the University of Arizona in Tucson, Arizona. In 2011, she was awarded an "Honorary Doctor" degree from the Armenian State Pedagogical University after Khachatur Abobyan.

In 1988, as a young scientist, she was awarded the Colombian "Third World Academy of Science" Prize. In 1989 she was appointed Regular Associate Member of the International Centre for Theoretical Physics (ICTP), Trieste, Italy. She is the recipient of the 1992-93 "Sarwar Razmi" Prize of the ICTP. In 1998 she was elected a member of the Colombian Academy of Science and became Senior Associate of the ICTP. Since 2008 she chairs the Advisory Group for the Trieste System on Optical Sciences and Applications, which provides advice to the ICTP in the area of optics. Dr. Guzman is also the Coordinator of the UNESCO Workshop on Active Learning in Optics and Photonics (ALOP) in Latin America.

Dr. Guzman Chaired the International Council of the Optical Society of America and served as a Member of that Society's Board of Directors during the period 2003-2004. From 2005 to 2008 she served as a Vice President of the International Commission for Optics (ICO) and as a Member of the ICO Bureau. In 2007 she was made Fellow of the Optical Society of America for her contributions to quantum and atom optics and for the promotion of optics in developing countries. In 2010, during the commemoration of the 50^{th}anniversary of the Department of Physics of the National University of Colombia, she received an award as a distinguished alumna of the Department. Since 2008 she holds the elected position of Secretary General of the ICO, and she serves as the editor of the ICO Newsletter.

Dr. Guzman has organized several national and international meetings on optics, including the recent Pan American Advanced Studies Institute on Frontiers in Imaging Science, an activity supported by the National Science Foundation, held on June 2011 at the National University of Colombia in Bogota, and intended to foster international collaboration between young researchers in new imaging methods, with special emphasis on bioimaging. She has been involved in the promotion of optics research and education worldwide, with emphasis in developing countries, particularly in Latin America.

OAM waves and the measurement of their topological charge

C. Acevedo[1], Y. Torres[1], **A. Guzmán[2]**

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[2]*CREOL, University of Central Florida, USA*

After discussing the properties and some applications of OAM waves, we present analytical, numerical and experimental results for the measurement of their topological charge by means of their far-field diffraction patterns through different plane apertures in the shape of polygonal annuli. It is shown that the determination of the sign of the topological charge can be obtained with polygonal annuli with odd order of rotational symmetry about the OAM propagation axis in the paraxial regime. Polygonal annuli with even order of rotational symmetry allow only to determination of the absolute value of the topological charge.

Public Lectures

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David Blaschke is Professor for Theoretical Physics in the Institute for Theoretical Physics at the University of Wroclaw (Poland). Born the 22nd of September 1959, he received his PhD in Physics in 1987 at the University of Rostock (Germany) where he habilitated in 1995 and became Private Docent in 1996. In 1998, he won the competition for a Professorship in Particle and Astrophysics at the University of Rostock, which was partly funded by the Max-Planck Society. In January 2001 he became elected Vice Director of the Bogoliubov Laboratory for Theoretical Physics (about 200 employees) at the Joint Institute for Nuclear Research Dubna (Russia); a position he held for 7 years, thereafter continuing as a leading scientist. In the period 2003 – 2006 he held guest professor positions at the Universities of Bielefeld, Rostock and Zagreb and a visiting scientist position at GSI Darmstadt. Since October 2006 he is Full Professor at the University of Wroclaw, where he teaches several classes on Quantum Field Theory, Matter under Extreme Conditions in Heavy-Ion Collisions and Compact Star Astrophysics and is leading a group of 10 people in the Department of Theoretical Particle Physics. He has directed more than 15 PhD students and more than 25 Diploma/Master thesis students. His research is centered around the problem of bound state formation and dissociation in strongly interacting matter at high densities, temperatures and field strengths, in thermodynamic equilibrium as well as nonequilibrium. In this field he is one of the worldwide recognized experts. He organized more than 60 international conferences, workshops and schools and is a frequently invited speaker. He manages several research projects, both national and international. Most notably he coordinates since more than 10 years the Helmholtz International Summer Schools (2 per year in different topics of the field “Structure of Matter”) at the JINR Dubna. He was co-speaker of the Virtual Institute on “Dense hadronic matter and QCD phase transitions” formed by 6 German Universities with GSI Darmstadt (2003 – 2006), co-speaker of the European Initiative on “Physics of Compact Stars” (2004 – 2008), Chair of the European Science Foundation Research Networking Programme on “The New Physics of Compact Stars” (2008 – 2013) and is presently Management Board member of the COST Action MP1304 on “Exploring Fundamental Physics with Compact Stars (NewCompStar)”. He is a frequently invited reviewer, monitor or referee for several funding agencies and more than 20 scientific Journals. He is an author or co-author of more than 250 papers which earned him about 5000 citations and a Hirsch index h=36 according to INSPIRE; he co-edited more than 10 books. He is elected member of the Editorial Board of the European Journal of Physics A (Hadrons and Nuclei) where he is responsible for the Topical Issues on “Exotic Matter in Neutron Stars” and “The NICA White Paper”. In 2012 he became elected member of the Academia Europaea.

Light from the Baby Universe

David Blaschke

University of Wroclaw (Poland)

When Penzias and Wilson in 1964 measured an isotropic microwave background radiation with an equivalent blackbody temperature of about 3 Kelvin, they proved a prediction of the Big Bang Cosmology which then ruled out prevailing alternative theories like the steady-state Cosmology.
A finding which earned them the Nobel prize in Physics 1979.

According to the Big Bang theory the Universe we know, space-time and matter, was created in an extremely hot and dense plasma-like state 13 billion years ago. Then the electromagnetic field (light) was in a dynamic equilibrium with all known species of particles and antiparticles (matter). Following Einsteins General Theory of Relativity, formulated exactly 100 years ago, space had to expand in time entailing a rapid cooling of this universal "black body" system, undergoing a sequence of cosmic phase transitions like: antiparticle annihilation after a few microseconds, primordial element synthesis after three minutes and formation of neutral atoms 380.000 years after the Big Bang. From this very moment on when the Universe became electrically neutral, it was transparent for the photons which now could traverse the space without being rescattered. Their light is thus a messenger from this Baby Universe and measuring their distribution over the sky we obtain a picture of it!
What a big disappointment it was that no sign of any structures could be found in the snapshot taken by Penzias and Wilson! This lasted until 1992 when the COBE satellite for the first time saw tiny fluctuations, a blurred picture of the Baby Universe – another Nobel prize! A few years later the WMAP satellite obtained the first sharp photo which presently gets still improved by PLANCK.
In this talk I shall tell the story of these snapshots and how we can learn from them about our past, present and future!

Suren Manvelyan was born in 1976, he started to photograph when he was sixteen and became a professional photographer in 2006. His photographic interests span from Macro to Portraits, Creative photo projects, Landscape, and much more. Suren's photos have been published in numerous magazines and newspapers in Armenia and worldwide.

His latest popular series of close ups of a human eye – entitled "Your beautiful eyes," together with a similar series on "Animal eyes," have had millions of views on the Web. They were published by National Geographic, Yahoo!, Die Zeit, The Sun, Daily Mail, The Independent, Telegraph, La Republica, Liberation, Guardian, Wired, Huffington Post, Wedemain, The Shortlist, DT Magazine, MAXIM, and many others. The photos were also used by BBC Spain, BBC Brasil, WNYC, Gizmondo and many others.

In parallel to photography, for the past ten years Suren has also enjoyed teaching physics, mathematics, projective geometry and astronomy at the Yerevan Waldorf School. From 1997 to 2011 he served as a scientific researcher at the Institute for Physical Research of National Academy of Sciences.

Suren received his PhD in Theoretical Physics from the Yerevan State University in 2001 where his research focused on Quantum Chaos. He received the President Award of the Republic of Armenia next year for his research work in the field of quantum technologies.

Suren plays on five musical instruments the guitar, cello, piano, block flute, and lyre.

The Light in Photography

Suren Manvelyan

Freelance Photographer, Armenia

The talk is devoted to use of light in photography. What kind of lights are exists, how and for what to use them. How work soft and hard light in portrait and still life. What light one needs to stress texture and what light will hide texture.

The physical processes behind the interaction of light with matter in matrix of digital cameras will be discussed too.

Professional development lecture

Aram Papoyan studied physics at the Yerevan State University. He got his PhD in 1991, and DSc in 2004. In 2010 he was elected as a Corresponding Member of the National Academy of Sciences (NAS) of Armenia. His main research interests are: laser physics, atomic spectroscopy, quantum and nonlinear optics. He is a (co)author of about 170 published works. Dr. Aram Papoyan is a Director of the Institute for Physical Research of NAS, member of Presidium of NAS, President of the Armenian Territorial Committee for Optics, Armenian Coordinator of Armenian-French International Associated Laboratory IRMAS, and Coordinator of the EU FP7 Project No.295025-IPERA. He was (co)chairman of 9 international conferences, symposiums and workshops, including 4 workshops and schools for young researchers and students.

Aram Papoyan awarded the ICO Galileo Galilei Award 2015. The award citation reads “For his important achievements in high resolution spectroscopy of Alkali atoms and for his valuable contributions to the promotion of experimental atomic physics in Armenia”.

How to write scientific article: a scientific approach

Aram Papoyan

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Scientific article is the main outcome of the fundamental, as well as applied research. Meanwhile as a rule, training on article writing is missing in higher school curriculum. The lecture is intended to help students and young researchers in choosing a proper journal, processing and formulating the obtained results, and writing the article assuring that it meets mission of the journal, requirements of the referees, and expectations of potential readers.

Plenary Talks

Application of effective medium theory for development of nanostructured gradient index microoptical components

Ryszard Buczyński[1,2], Adam Filipkowski[1], Bernard Piechal[1], Dariusz Pysz[1], Mariusz Klimczak[1], Andrew J. Waddie[3], Mohammad R. Taghizadeh[3] and Ryszard Stępień[1]

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Nanostructured gradient index (nGRIN) elements are a new class of planar-surface micro-optical elements which transform optical wavefront by discrete, subwavelength changes in the refractive index perpendicular to the optical axis. The nanostructured medium have a form of a solid glass block that can be cut, polished, and shaped as plane-parallel plates. Their optical properties are determined only by their inner nanostructure distribution. The effective medium Maxwell-Garnett theory is applied to design internal nanostructure of medium, where the effective refractive index is determined by a spatial average of the individual refractive indices of the constituent nanorods.

A low-cost modified stack-and-draw technology is used for development of nanostructured components. It can be used to create a wide range of nanostructured gradient index micro-optical components as microlenses, axicons and polarization-sensitive components. The nGRIN components are an attractive approach for compact optical systems as they can be easily integrated with other micro-optical components as optical fibers.

Observation of surface plasmon polaritons in GaN layers via reflection and emission of terahertz radiation

D.A. Firsov[1], G.A. Melentev[1], V.A. Shalygin[1], V.Yu. Panevin[1], L.E. Vorobjev[1], H. Nykänen[2], L. Riuttanen[2], O. Svensk[2], S. Suihkonen[2], V.V. Korotyeyev[3], Yu.M. Lyaschuk[3], V.A. Kochelap[3]

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Development of new solid state based methods allowing to produce and detect radiation with frequency near one or several terahertz is a longstanding problem. One of the promising ways to solve this challenge involves the use of electromagnetic waves propagating along the surface separating conducting and dielectric media, i.e. surface plasmon polaritons (SPP). Resonant frequencies corresponding to SPP arising at the metal–vacuum interface belong to visible or near-infrared spectral ranges. Extension to long wavelength range is possible if we use semiconductor instead of metal. In such a case, SPP resonant frequency can be easily put in terahertz range with proper choice of semiconductor doping level. In contrast to visible and near-infrared ranges, properties of SPP in terahertz range are still insufficiently studied. In the present paper, reflection and emission of terahertz radiation related to excitation of SPP in GaN epitaxial layer are studied experimentally and theoretically. Coupling between free space electromagnetic waves and SPP is provided with grating etched on the surface of the sample.

The presentation is organized as follows. After introduction dealing with common properties of surface electromagnetic waves, we will consider a theoretical model describing optical properties (reflectivity and absorptivity) of semi-infinite semiconductor with a regular grating at its surface. The model is based on a rigorous electrodynamic solution of the Maxwell's equations. Then, the samples and experimental technique will be described. Two experiments will be referred: (i) study of reflectivity spectra for polarized terahertz radiation, and (ii) study of terahertz radiation emission spectrum under longitudinal electric field. Experimental data and results of the theoretical simulation will be discussed.

In conclusion, the first experimental results on reflection and emission of terahertz radiation related to excitation of surface plasmon polaritons in GaN layers are presented and rigorous electrodynamic analysis is developed.

This work is partially supported by RFBR (Grant 14-02-90444) and the Ministry of Education and Science of Russian Federation.

Luminous Interaction between Armenia and France

Claude Leroy[1], David Sarkisyan[2], Armen Sargsyan[2],
Yevgenya Pashayan-Leroy[1], Aram Papoyan[2]

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The International Associated Laboratory IRMAS (CNRS-FRANCE & SCS-Armenia) has been created in 2009 and renewed in 2014. This LIA has reinforced the already existing strong collaboration -since 2006- between the Institut for Physical Research of Ashtarak, Armenia and the Laboratoire Interdisciplinaire Carnot de Bourgogne, Université de Bourgogne (UB), Dijon, France.

These last 5 years, 9 Armenian PhD students have defended or are engaged in cosupervised thesis between IPR and ICB ; and since two years, 5 Armenian students have studied or are studying in our International Master II of Physics at UB.

I will present this strong collaboration during OPTICS-2015 and show how an effective collaboration between experimenters from IPR and theoreticians from ICB has led to high-level publications in the domain of fundamental applications of laser radiations acting on the matter. A particular review about the nano-cells exclusively built in IPR, Ashtarak in the group of Pr. David Sarkisyan will be presented. The power of this unique tool will be demonstrated and the particular properties of laser radiations interacting with alkali gaz in nano-cells will be examined.

Optical Vortices in Microscopy

Agnieszka Popiołek-Masajada, Jan Masajada

Chair of Optics and Photonics, Wrocław University of Technology,
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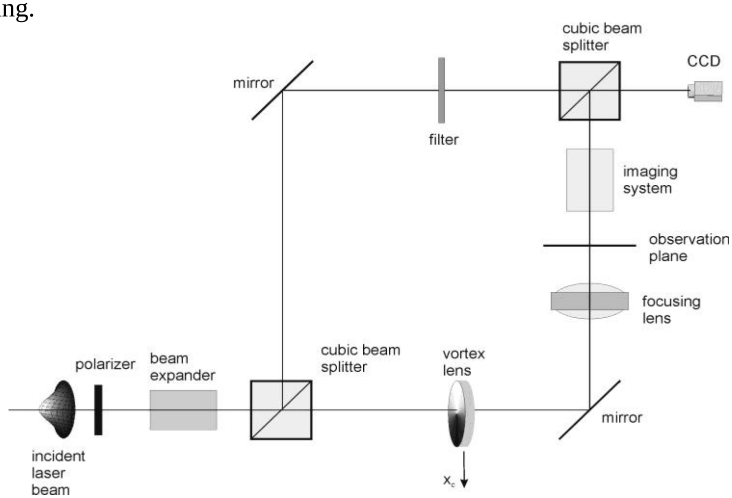
In recent years there is an increasing interest in production and applications of the twisted light. Understanding its spatial structure and propagation is an important task in modern optics and photonics. This class of light beam has a characteristic helical wavefront, which mathematically is described by an azimuthal phase term exp(i$m\phi$) where ϕ is the azimuthal coordinate in the beam cross-section and m is an integer called topological charge. In such a beam the light intensity is zero on the optical axis and around this dark point (vortex point) the phase gradient becomes infinitely large. This region in the beam is extremely sensitive to any phase changes along the beam path.

Optical vortices can be generated in few ways. One of the possibilities is to introduce the helical phase into the Gaussian beam by the use of a the spiral phase plate. Such a beam, with the embedded vortex, can be used as a marker inside the beam. We additionally propose to shift a vortex plate inside the beam what causes a precise nanometer shift of the embedded vortex in the focused spot. We called such a system Optical Vortex Scanning Microscope (see figure below). I will consider the possibilities of using such a system in microscopic imaging.



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Exciton-plasmon interactions in hybrid graphene-semiconductor structures

Tigran V. Shahbazyan

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Doped monolayer graphene with Fermi energy in the range 0.2-0.6 eV exhibits a stable in-plane plasmon wave in the infrared frequency range with gate-tunable wavelength well below the radiation wavelength at the same frequency. A large local density of states of graphene plasmons as compared to surface plasmon polaritons on metal surfaces ensures a very efficient graphene plasmon coupling to excitons in semiconductor nanostructures such as quantum dots (QD) and quantum wells (QW) situated at close distance to the graphene sheet. We present our recent results on weak and strong coupling between plasmons and excitons in graphene-semiconductor structures. In the former case, we discuss highly efficient long-range energy transfer between QD excitons mediated by graphene plasmons over distances far exceeding the Forster radius. In the latter case, we discuss excitations in graphene laying on top of narrow-gap semiconductor QW and show that Coulomb interactions between QW excitons and graphene plasmons lead to coherent mixed states characterized by Rabi splitting of about 50-100 meV for small graphene-QW separations.

Invited Talks

Generation and experimental study of laser radiation in liquid crystalline photonic structures controlled by defects

Roman Alaverdyan

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In the report the results of experimental investigations of the photoluminescence of dye-doped liquid crystals with chiral admixture and multi-layer photonic structures (chiral photonic crystals) based on them as well as the experimental investigations' results of the generation of laser radiation in these systems will be presented. The influence of ferromagnetic and ferroelectric nanoparticles with low concentration on the photoluminescence of dye and on the generation of laser radiation in these structures will be discussed.

The possibilities of increasing Q microcavities formed by means of dye-doped chiral liquid crystalline photonic structures in the presence of defects controlled by electromagnetic (including optical) fields and hydrodynamic flows will be discussed.

Geometrical optics of inhomogeneous aniso-tropic medium with twisting

Levon Aslanyan

Yerevan State University, Yerevan, Armenia

The evolution of state of light polarization in a smoothly inhomogeneous anisotropic medium is analyzed theoretically. The analysis is carried out both with use of a system of a coupled equations and the Poincare sphere. A system of coupled equations has been solved with respect to the Cartesian com¬ponents of the electric field component using a rotating coordinate system. The analytical expressions describing the polarization state in such a medium are obtained. In particular, the results of analysis are applicable to a nematic liquid crystal with twist orientation. It is shown that although the polarization state, when light propagates in such a medium, undergoes oscillations, spatial frequency of which depends on the thickness of the sample, nevertheless, the phenomenon of adiabatic tracking is observed at the exit in the case of both input e and o waves. The experiments confirm the results of theoretical analysis.

Interband Coulomb coupling in narrow-gap semiconductor nanocrystals: k · p theory

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We derive the matrix elements of Coulomb interaction between states with different numbers of electrons and holes in a semiconductor nanocrystal within the eight-band k · p theory. These matrix elements are responsible for multiple exciton generation which may contribute to the enhancement of the efficiency of solar cells. Our calculations are performed within the multiband envelope function formalism based on the states resulting from diagonalization of the eight-band **k · p** Hamiltonian. We study in detail and compare two contributions to the interband Coulomb coupling: the mesoscopic one, which involves only the envelope functions and relies on band mixing, and the microscopic one, which relies on the Bloch parts of the wave functions and is nonzero even between single-band states. We show that these two contributions are of a similar order of magnitude. We also study the statistical distribution of the magnitudes of the interband Coulomb matrix elements and show that the overall coupling to remote states decays according to a power law favorable for the convergence of numerical computations.

Study of Beta-Carotene by Raman and Absorption Spectroscopy and its Importance as a Bio-Marker

Suman Dudeja

University of Delhi (South Campus), New Delhi, India

Based on a proposal that halophilic microorganisms could have potentially flourished in extra-terrestrial settings and that bio-molecules found in these halophilic microorganisms could be used as potential bio-markers, we study beta-carotene in different polar and non-polar solutions by Raman and absorption spectroscopy. It is noticed that polar solutions modify the original Raman and absorption spectra of beta-carotene significantly. It is thus important to take into account the interaction of beta-carotene and solutions when considering Raman and absorption spectra of beta-carotene as potential bio-markers.

This study is expected to be useful for applications to analyze other conjugate organic molecules of extra-terrestrial importance as bio-markers.

Nonlinear effects in optical pumping of a cold and slow atomic beam

N.N. Bezuglov[1], M. Bruvelis[2], G. Shayeganrad[3], I. Guerri[3], A. Fioretti[4,5], D. Ciampini[3,4,5] M. Allegrini[3,4,5], E. Arimondo[3,4], **A. Ekers[6]**, and F. Fuso[3,4,5]

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We explore a unique atom-light interaction regime that is heavily affected by time-dependent optical pumping that occurs when a cold and slow beam of Cs atoms out of a pyramidal MOT (see [1, 2] for more detail on such beams) travels through a resonant laser beam. Such arrangement allows us to study the excitation dynamics in the limit of very long light-atom interaction time (~180μs). In the experiment, the resonant excitation of hyperfine levels of the $6^2P_{3/2}$ state is detected via photoionization that ensured a non-perturbing analysis at very high detection efficiency.

We observe some interesting and hitherto unreported features in the power dependence of the population of the F'=3, 4, or 5 levels of the $6P_{3/2}$ state following excitation from the same lower level F''=4 in the $6^2S_{1/2}$ state (see Fig. 1). We show that, depending on the light-atom interaction time, the critical intensity at which the population redistribution via optical pumping can lead to significant changes in the excitation spectra can occur far below the saturation intensity. We observe a huge increase (100 times!) of the ratio of F"=4→F'=5 and F"=4→F'=4 excitation signals as the excitation laser intesnity is increased from 0.1 to 100 mW/cm^2, while an unexpected minimum occurs in the power dependence of the ratio of the F"=4→F'=4 and F"=4→F'=3 signals (see Fig. 1).

We explain the observed features by the presence of "bright" and "dark" resonances that lead to power-dependent effective branching coefficients, and the laser-induced mixing of hyperfine levels that eventually leads to population retrieval from the dark states, or to inhibition of optical pumping if bright states are present. The interplay between the various factors can lead to significant and intuitively unpredictable variations in hyperfine level populations even at very low laser intensities.

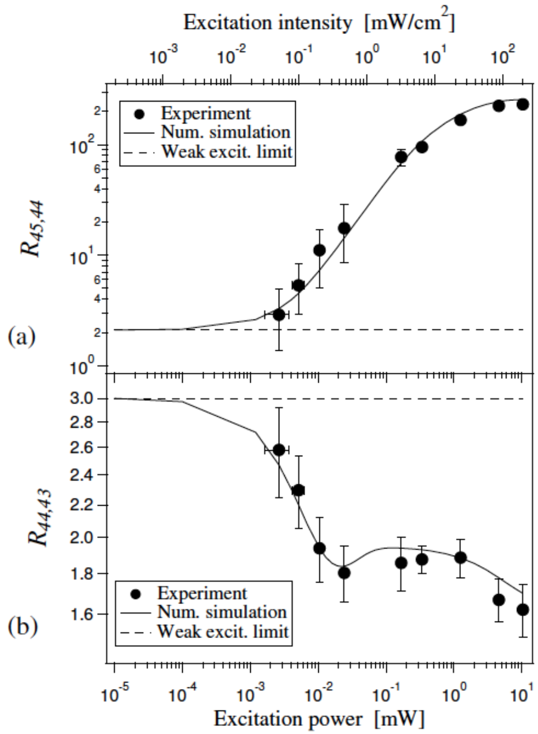

Fig. 1. Ratios of ion signals upon excitation of F”=4→F’=5 and F”=4→F’=4 (top panel) and F”=4→F’=4 and F”=4→F’=3 (bottom panel) as a function of the exciting laser power/intensity: dots – experiment; solid line - simulation using OBEs, dashed line – ratios of the respective line-strengths.

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Quantum information and double light storage in five level systems

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Quantum information is one of the most attractive fields of investigation for a wealth of interesting phenomena. Information after all is something that is encoded in the state of a physical system. Therefore, the study of information should be linked to the study of the underlying physical processes.

Despite a huge number of publications, light storage remains in the focus of attention of researchers, since it is one of key components in optical (quantum) information processing. We demonstrate in this report a new technique of double storage of optical information in the same medium with subsequent retrieval in desired sequence.

Storage procedure is based on the formation in a five-level system that interacts with the fields of three laser pulses, of a state similar to the dark state in a three-level system. This state completely imitates a three-level system not only for a single atom but also in the medium and, under certain conditions, all the coherent effects observed in the three-level media may efficiently be realized in five-level media. This has an important advantage in both fundamental science and practical applications.

Fundamental Physics with nano-cells

Yevgenya Pashayan-Leroy[1], David Sarkisyan[2], Armen Sargsyan[2], Claude Leroy[1], Aram Papoyan[2]

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Nano-cells are such powerfull devices that many Laboratories in the world are expecting to collaborate with Dr. David Sarkisyan (IPR, Ashtarak) who is the unique conceptor and maker of nano-cells. Atomic spectra suffer of Doppler broadening in normal size cells and only quite expensive technics allowed to reduced this effect before the invention of the nano-cells by Dr. D. Sarkisyan. In my speech I will pass in review many interesting effects which have been observed and studied when laser fields interact with alkali vapor gas within these nano-cells:
- VSOP : Velocity selective optical pumping
- EIT : Electromagnetically induced transparency
- EIA : *Electromagnetically induced absorption*

Comparison betwen experimental results obtained in IPR, Ashtarak with theory developed in ICB, Dijon will be presented.

Oral Presentations

Plasmon-Phonon Coupling In Lead Salt Semiconductor Quantum Well Structures

K.H. Aharonyan, N.B. Margaryan

National Polytechnic University of Armenia

The electron-phonon coupling is the macroscopic merger of the charge-density oscillations (plasmons) of the electron gas (EG) to the lattice longitudinal optical excitations (LO-phonons). In most discussions, the contrasts of material parameters in heteroboundaries (MPCH) of quantum well (QW) and barrier are weak that is why have been commonly ignored. Recently, in Refs.[1,2] the dispersion relations of Q2D EG plasmon-phonon modes in EuS / PbS / EuS QW system with the strong MPCH effect have been studied theoretically. The obtained strong enhancement of plasmon-like and phonon-like modes attributed to dielectric and effective mass QW / barrier distinctive contrasts.

In present paper, the investigations of the plasmon-phonon coupling properties in lead salt QW structures are extended in view of the comprehensive numerical analysis of the dispersion modes, energy-loss function and the oscillator strength of the plasmon-phonon peaks depending on the interplay between both the QW width and 2D EG density magnitudes.

The calculation of plasmon-phonon collective modes for moderate low ($3.5.10^{11}$ cm^{-2}) density value with two different QW width values d =2.5 *nm* and 10 *nm* is carried out. In both cases the plasmon-like branches are effectively suppressed due to the small material value of the transverse optical (TO) frequency ω_{TO}. It is shown, that by decreasing the QW width from d =10 *nm* to d= 2.5 *nm*, the allowed frequency region of the plasmon-like mode is enhanced ~7% while for phonon-like mode the enhancement is ~50 %.

The calculated energy-loss function is introduced as a function of the mode frequency for different values of the 2D wave vector $k=0.2k_F$ and $k=k_F$, respectively. As shown, for long wave related vectors $k=0.2k_F$ both the plasmon-like and phonon-like parts are present, but the oscillator strength in on the whole is connected with the phonon-like part. Actually, the spectral weight of plasmon-like mode almost vanishes, but the weight of phonon-like mode is finite and has most of the weight. Mainly this is a consequence of lead salt material small value of the TO frequency ω_{TO}, for that the plasmon-like mode quickly merges with the electron-hole continuum at a critical wave vector. For large wave related vectors $k=k_F$, the plasmon-like part is absent. As follows, the oscillator strength is transferred to the phonon-like peak and to the pair-excitation continuum. Besides that, by decreasing the QW width, the spectral weight of phonon-like modes for the long wave related vector case decreases weakly (2%), but for large wave vector case, on the contrary, increases noticeably (18%). Thus, in lead salt based narrow QW, the plasmon-phonon coupling goes strong for the phonon-like modes only.

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Application of Fresnel diffraction from a 2D array of reflective disks in optical profilometry of a flat surface

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Optical methods of three-dimensional profilometry have been of growing interest in both industrial and scientific applications. These techniques provide absolutely non-destructive measurement due to their non-contact nature and maintain their high precision in a large field of view. Most of these techniques however, are based on interferometry which happens to be considerably sensitive to environmental noises such as turbulence and vibration. We have used the phenomenon of Fresnel diffraction from phase-steps instead of interferometry to maintain a higher precision and reduce sensitivity to environmental noises. This phenomenon has been recently introduced as a method for precise measurement of wavelength, thickness and refractive index. A 2D array of reflective disks is placed above the test surface to provide the required phase-steps. In this paper, theoretical principles of Fresnel diffraction from phase-steps are discussed and the experimental results of testing an optical flat surface are presented. A flat mirror surface has been tested as an optical test surface and is been profiled. The results show that the method is precise and is not sensitive to environmental noises such as vibration and turbulence. Furthermore, the method seems to be a powerful means for testing of curved surfaces, too.

Using Hartmann wave front sensor data and deconvolution to taken aberration effects on extended bio-objects images

Hadi Bakhshi, Ahmad Darudi, Alireza Moradi

Physics department of university of Zanjan, Iran

In imaging systems like microscopes a high image quality is desire and due to important on bio objects, many techniques use to get best results. In this paper, we are reporting the theoretical & experimental results that are used to omit aberration effects on image of bio-objects and select an optimized size for PSF and distorted bio-images. The experimental setup consists of following components; a Hartmann pattern of 35×35 aperture on a CMOS chip as our Hartmann sensor (HS), microscopy setup and rotating glass plate in the light path that distorts the image of the bio-object in real time, as static aberration. The wavefront gradient is measured from the image motions of an extended bio-object at each subapertures. By using the data of wavefront sensor, the aberration effects will be removed.

Innovative Approach towards Understanding Optics

Amit Garg, **Sadashiv Raj Bharadwaj**
Raj Kumar, Avinash Kumar Shudhanshu, and Deepak Kumar Verma

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Over the last few years, there has been a decline in the students' interest towards Science and Optics. Use of technology in the form of various types of sensors and data acquisition systems has come as a savior. Till date, manual routine tools and techniques are used to perform various experimental procedures in most of the science/optics laboratories in our country. The manual tools are cumbersome whereas the automated ones are costly. It does not enthuse young researchers towards the science laboratories. There is a need to develop applications which can be easily integrated, tailored at school and undergraduate level laboratories and are economical at the same time. Equipments with advanced technologies are available but they are uneconomical and have complicated working principle with a black box approach. The present work describes development of portable tools and applications which are user-friendly. This is being implemented using open-source physical computing platform based on a simple low cost microcontroller board and a development environment for writing software. The present paper reports the development of an automated spectrometer, an instrument used in almost all optics experiments at undergraduate level, and students' response to this innovation. These tools will inspire young researchers towards science and facilitate development of advance low cost equipments making life easier for Indian as well as developing nations.

Si_3N_4 based Asymmetric Mach-Zehnder Interferometers for biosensing applications

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In this work, we present a study on photonic devices based on Si_3N_4 Asymmetric Mach-Zehnder Interferometers (aMZI) for biosensing applications [1,2]. In particular, we are interested in Aflatoxin M1 (AFM1) detection in milk, since AFM1 induces liver *cancer* and other hepatic diseases. We measured the bulk Sensitivity (S) and Limit of Detection (LOD) of our devices. The sensors were based on an array of four Si_3N_4 aMZI, fiber-coupled to a VCSEL (wavelength 850 nm), a silicon photodetector and packaged into a microfluidic platform. For sensitivity measurements, we performed volumetric sensing measurements. For this purpose, glucose-water solutions at various concentrations and refractive indexes were flown over the sensors [3]. We observed that all three exposed sensors on the same sample chip had very similar sensitivities. The fourth aMZI, which was covered by SiO_2, was used as a reference for VCSEL and temperature fluctuations. We measured sensitivity of 10095 rad/RIU in our sensors.

To characterize the LOD of the sensors, we measured the uncertainty of the experimental readout system. The LOD is defined as the minimum input quantity that can be distinguished with more than 99% fidelity, and can be calculated as $LOD=3\sigma/S$, where σ is the output uncertainty, given as the standard deviation obtained on repeated measurements of blank solution (where no analyte is present) [4]. From the measurement on three aMZI, we observed the same value of LOD, which was $\approx 7.3 \times 10^{-7}$ RIU.

After the sensors characterization on homogeneous sensing, we tested the surface sensing performances by experimenting with Aflatoxin M1, using various concentrations of toxin in solvent solutions of corresponding concentrations. Measurements will be reported and discussed in the talk.

This work was supported by the FP7 EU project "Symphony" (Grant agreement no: 610580) [5].

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The High-intensity HHG beamline at the Lund Laser Centre: towards XUV-pump XUV-probe experiments

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To achieve a deeper knowledge of the interplay between charge and structural dynamics in molecules, it is necessary to simultaneously probe the dynamics in the molecule on femtosecond and attosecond timescales, on which nuclear motion and charge dynamics occur, respectively. In order to reach these timescales, we take advantage of an extremely non-linear process, high-order harmonic generation (HHG). When an intense infrared (IR) femtosecond laser pulse is focused in a gas, odd harmonics of the driving field are generated, with pulse duration in the femtosecond range for individual harmonics, and attosecond for the light pulses emitted at each half laser cycle.

Nonlinear ionization using high-energy photons is very interesting as a tool for probing electron correlation and dynamics of highly excited systems. Recently, two-photon double ionization of Neon has been demonstrated at the high-intensity HHG beamline of the Terawatt laser system at the Lund Laser Centre [1,2]. The competition between a direct or a sequential process of two-photon double ionization has been investigated [2]. The next step is to perform XUV-pump XUV-probe experiments.

The beamline is driven by a Ti:Sapphire laser which delivers laser pulses at a central wavelength of 800 nm with a pulse duration of 35 fs and a total energy per pulse of 150 mJ at 10 Hz repetition rate. In order to reach high XUV intensities in the experiments, the beamline uses a very loose focusing geometry for generating high harmonics and a tight focusing of the XUV beam into the experiment. The beamline includes a diagnostic stage, equipped with an XUV spectrometer and an XUV CCD camera to fully characterize the harmonic beam, before sending it further down to the application stage. Here the components needed for XUV-XUV pump-probe experiments are installed: a splitting/delaying unit (split mirror) and a focusing unit.

The split mirror is composed of two silica plates with IR anti-reflection coatings. The XUV beam impinges equally on the two plates at grazing incidence, and is thus split in two pulses. The reflectivity of the setup is measured to be approximately 50%. One of the plates is driven by piezoelectric actuators, allowing a very fine control of the translation and the relative tilt, thus of the delay between the two pulses and of the beam pointing. The piezo actuators can be varied with nanometric precision, which leads to a sub-femtosecond control of the delay. An active stabilization system has been developed, using an external laser diode as a reference to control the tilts and translations of the plate.

The performance of the split mirror assembly has been benchmarked using the output from an OPCPA system to perform broadband all-reflective autocorrelation measurements [3], demonstrating an excellent stability and repeatability over its total delay range of 40 fs, with a resolution below 50 attoseconds.

The assembly is being incorporated into the high-intensity HHG beamline in order to perform XUV-pump XUV-probe experiments, which will allow us to achieve an autocorrelation of the XUV-pulse, and to study time dependent fragmentation of small molecules and attosecond relaxation dynamics in atoms.

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Light Scattering in Growing Ordered Structures. Computation of Scattering Phase-Function.

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Local order of scattering medium is essential in multiple-scattering problem [1,2]. It causes coherent effects in light scattering character [3,4]. Meanwhile, the type, degree, and influence of ordering depend on several parameters, of which the symmetry, particle form and size (form-factor), as well as group (cluster) form and size (structure-factor) play significant role [5-7].

We consider scattering phase function computation for growing ordered structure, i.e. cluster formation. For the set of cluster 2D models we obtain scattering phase function from the numerical solution of Maxwell equations [8,9]. The results illustrate a deformation of scattering phase function and its transformation during the growth of particle cluster. Using post-processing of our results we show the energy and peak characteristics of this process, which indicate the possibility to determine the generalized equations for scattering phase function depending only from form- and structure-factor.

We propose in the present paper an approach of estimation of the 2D phase function of cluster consisted of simple-form particles using reciprocal lattice method. Our results demonstrate a good agreement with Fourier approach.

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Digital holography microscopy of liquid-crystalline phase separation in multilamellae multicomponent lipid membranes

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Biological membrane lipids are heterogeneously distributed into lipid microdomains. The self-organization of these membranes into different domains is critical in several cell processes. Recently coupling of two dimensional intralayer phase separation and interlayer liquid-crystalline ordering of multicomponent and multilamellae lipid membranes has been reported. In this paper, we use digital holographic microscopy (DHM) for quantitative analysis of dynamical behavior of such membranes. DHM in a transmission mode is an effective tool for quantitative visualization of phase objects such as living organelles. By deriving the associated phase changes, this method provides three-dimensional information on the morphology variation of lipid stacks at arbitrary time scales. Moreover, the thickness distribution of the object at demanded axial planes may be obtained by numerical focusing. The specimens are lipid mixtures composed of sphingomyelin, cholesterol, and unsaturated DOPC phospholipid. Our DHM measurements show that volume evolution of lipid domains follows the same universal growth law, which was shown by their two dimensional size measurements.

Adiabatic tracking for photoassociation of ultra-cold atoms with Kerr-type elastic scatterings

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The formation of molecules from ultracold atom gases by external fields and more generally the coherent oscillations between the atomic and molecular Bose-Einstein condensates (BEC) feature nonlinearites in their quantum description. Here we consider the influence of the third-order nonlinearities:

$$ic_{1t} = \frac{\Omega}{\sqrt{2}} c_1^* c_2 + \left[-\frac{\Delta}{3} + \Lambda_{11} |c_1|^2 + \Lambda_{12} |c_2|^2 \right] c_1,$$

$$ic_{2t} = \frac{\Omega}{2\sqrt{2}} c_1^2 + \left[\frac{\Delta}{3} + \Lambda_{21} |c_1|^2 + \Lambda_{22} |c_2|^2 \right] c_2,$$

where $c_{1,2}$ are the atomic and molecular state probability amplitudes, $\Omega(t)$ is the Rabi frequency, and $\Delta(t)$ is the detuning. The terms with Λ_{11}, $\Lambda_{12} = \Lambda_{21}$, Λ_{22} describe atom-atom, atom-molecule and molecule-molecule elastic scatterings.

Discussing the one-color photoassociation of atoms, we present a detailed analysis, which shows that a good adiabatic transfer can be achieved by the adiabatic tracking approach also in the presence of Kerr nonlinearities. Notably, of the two possible choices of the detuning for tracking, only one leads to a stable adiabatic transfer to the target state, as in the case without Kerr terms [1]. For the other one, there is an unavoidable crossing of the tracking fixed points, thus destroying the adiabaticity, which can strongly degrade the quality of the transfer for small amplitudes of the driving pulse. If one takes strong enough pulses, compared with the size of the Kerr terms, the effect of this nonadiabatic crossing can be made negligible [2].

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Investigation of Nanograting Structures Using Method of Auxiliary Sources

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It is well known that physical and chemical properties of nano structure Depends on the their dimension. besides this, the properties depends on the geometry . For examples: carbon nanotube and graphene . periodic structure changes The properties of Semiconducting material. This is because that periodic structure Affixed the additional boundary condition to the electrons wave function. Additional boundary conditions forbit some quantum states , so electron has to Occupy the QUANTUM leveles with higher energy. So the chemichal potential increase. Nanograting changes material properties. These changes are fully determined by the density of quantum states ρ(E) . Changes in itself can be described by introducing geometry factor *G* such that ρ(E)= ρ0(E)/ *G* where, ρ0(E) is density of states in plain layer. To calculate *G* Schrodinger time-independent equation should be solved in Nanograting geometry. For most geometries, separation of variables is not possible and analytical solution does not exist. It was one of the goals of the work to solve this problem using numerical methods. There is a full mathematical analogy between quantum billiards and electromagnetic resonators . Therefore, it is reasonable to use the Method of Auxiliary Sources (MAS) for quantum billiard calculation, as it is most efficient numerical approach for solving eigen value problems . This method has been propoused by Georgian mathematician V. Kupradze in 1967. It is widely used for solving various electromagnetic problems. Later on, the Method was adopted by Georgian scientists for solving eigen value problems related to wave guides with arbitrary cross-section . In the MAS, field is represented by fields of Helmholtz equation fundamental solutions (auxiliary sources), which radiation centers are placed on some auxiliary contour. Amplitudes of auxiliary sources can be found by satisfaction of boundary conditions. Near eigen values field increases inside of the area, that allow as to find them. We wrote our program in Fortran code. it contains two files.

Influence of transverse and longitudinal magnetic fields on optical coherent effects

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In many applications for efficient control of optical properties of the medium a method based on all-optical coherent effect of electromagnetically induced transparency (EIT) and electromagnetically induced absorption (EIA) is exploited. Investigation of EIT, EIA and related effects are of a great importance.

In the current presentation the influence of external magnetic field on EIT and EIA is studied theoretically. In particular, we have elaborated the theory of mentioned coherent effects in cold atoms where the Doppler broadening is absent, in the presence of transverse and longitudinal magnetic field. An important aspect is that we use only one laser field and we show that transparency window appears for that laser field due to the transverse magnetic component.

Asymmetric scattering of discrete Gaussian wave packets in the field of a standing wave

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We present a model of asymmetric scattering of coherent superposition states of effective two state atoms in the field of a standing wave for both resonant [1] and adiabatic regimes [2]. We show that the behavior of the atomic wave-packets at adiabatic diffraction may significantly differ from the diffraction at resonant scattering. We demonstrate that the discrete Gaussian wave packet at adiabatic diffraction undergoes highly asymmetric scattering (*refraction*) while the evolution of the same wave packet at resonant scattering can be characterized as a high order narrowed scattering (*bi-refringence*). Hopefully, these peculiarities of the standing wave diffraction of atoms with Gaussian initial momentum distribution will be useful for atom interferometric and atom lithographic applications.

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Terahertz Photonic Crystalline Waveguide Based on Shaped Sapphire Crystal

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Development of the terahertz (THz) waveguides is of high importance in applied physics and, in particular, in THz technology [1]. Numerous approaches for guiding the THz waves have been previously considered. The ability for THz waveguiding in the non-flexible hollow-core metal tubes has been introduced in Ref. [2]. In manuscripts [3,4] the plasmonic THz-wave propagation along metal wires and ribbons has been studied. In Refs. [5,6] the polymer photonic crystalline (PC) fibers for THz waves have been introduces, and in Refs. [7,8] the ability to combine the THz PC fibers and the plasminic waveguiding principles has been discussed. Nevertheless, neither conventional metal tube waveguides and plasmonic waveguides, nor polymer PC fibers could be used for the broadband THz waveguiding over a long distance, which is due to the high loss from the finite conductivity of metals, or high absorption of polymers. Furthermore, the existing waveguides do not satisfy the low-dispersion constraint.

In the present work we introduce novel approach for low-loss broadband THz waveguiding. We manufacture the multichannel non-flexible THz waveguide of 300 mm in length based on a shaped single crystal, in particular, the shaped sapphire crystal [9], which was grown via the Stepanov's method [10]. The waveguide has been characterized using both numerical simulations and experimental study. We demonstrate the broadband low-loss THz waveguiding in this crystal. The shaped crystal allows guiding the THz-waves with the minimal dispersion in frequency range of 0.85 to 1.55 THz and the minimal power extinction coefficient of 0.02 dB/cm at 1.45 THz. These results highlight the potentials of the shaped crystal use for highly efficient THz waveguiding [11].

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Selective reflection of a resonant vapor in the cell with plane-parallel windows

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Reflection of radiation from the boundary between a dielectric and atomic vapor is termed as selective reflection (SR), because it has a prominent spectral structure on the atomic transition frequencies. The selective reflection is an essential spectroscopic tool differing in a number of aspects from the absorption spectroscopy because of relatively narrow width of spectral lines. The small widths of spectral lines in SR, resolving the resonances inside the Doppler profile, is associated with nonlocality of the atomic medium polarization and with peculiarity of interaction of atoms having different velocity directions with the cell walls. Indeed, the atoms lose their polarization in collisions with the cell wall. Therefore, the induced dipole moment for the positive velocity atoms near the input window is equal to zero, while for negative velocity atoms it does not vanish. Near the output window, the pattern is opposite.

The present work is aimed at theoretical study of the selective reflection in atomic vapor with plane-parallel windows. The intensity of laser radiation was in these studies sufficiently low (lower than 0.1 mW/cm2) as to avoid nonlinear effects such as optical pumping, saturation, etc. The cell length was much shorter than the length of linear absorption and interference effects, occurring in that cell, may affect essentially the shape of the reflected signal. The theoretical model is based on the selfconsistent solution of Maxwell equations together with the density matrix equation for a multilevel system. We obtain relatively simple expressions passing, in limiting cases, to the well-known expressions.

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Electro-optic and dielectric properties of doped congruent lithium niobate crystals

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Measurements of electro-optic and dielectric properties in Zirconium (Zr)- doped lithium niobate (LN:Zr) crystals are performed as functions of the dopant concentration in the range of 0.625-2.5 mol% ZrO_2 by direct techniques based on interferometric and Sénarmont optical arrangements at the wavelength of 633 nm and at room temperature. Electro-optic coefficients of the first-column (r_{222}) and third-column (r_{113}, r_{333} and r_c) of the unclamped and clamped electro-optic tensor of Zr-doped LN and the corresponding dielectric permittivity as well, have been experimentally determined and compared with the results obtained for the nominally pure LN crystals of congruent composition. We show that the electro-optic and dielectric properties present a kink around 2 mol% of zirconium which seems to be the “threshold” concentration required to strongly reduce the photorefractive effect. The last was confirmed also by the measurements of the shift of the fundamental absorption edge of the mentioned crystals.

All reported results confirm that the LN:Zr is a very promising candidate for various non linear devices.

The study of undulator radiation of transversal oscillator

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We have studied the electromagnetic fields and the radiation intensity for a charge moving around a dielectric cylinder along a helical trajectory the projection of which on the plane perpendicular to the cylinder axis is an arbitrary closed curve. In particular, the influence of the trajectory shift from the circular one on the characteristics of the radiation intensity is discussed. As an application of general results, we have investigated the radiation intensity of a charged longitudinal oscillator moving along a helical trajectory around a dielectric cylinder. Similar to the case of coaxial circular motion under certain conditions for the parameters of the trajectory and dielectric cylinder strong narrow peaks appear in the angular distribution of the radiation intensity in the exterior medium. Instead of a single peak in the case of a uniform coaxial circular motion, for a longitudinal oscillator set of peaks appear. The increase of the oscillating amplitude leads to the increase of the number of the peaks and the peaks are shifted to the direction of small angles.

The main topic of resent study is the investigation of radiation intensity transversal oscillation of rotating charged particle. It is of reason to obtain the same results for later case as for longitudinal oscillator.

Ultrafast TSPD on The Basis of CeB_6 Sensor

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The results of computer simulation of heat distribution on the sensor of Thermoelectric Single Photon Detector (TSPD) after photon absorption are presented. The kinetic processes in absorption of a photon of 100eV (hard UV) and 1KeV (X-ray) energy in different areas of the absorber for different sensor and absorber geometries are investigated. The calculations were performed for a tungsten (W) absorber and a cerium hexaboride (CeB_6) sensor.

The TSPD operation principle is based on photon absorption by absorber as a result of which a temperature gradient is generated on the edges of the thermoelectric sensor. Photon detection becomes possible by measuring the potential, emerging between the two absorbers.

The maximum depth the photons with energies of 1 keV can reach is about 1.5 μm, whereas photons with energy of 100 eV cannot overcome the 0.5 μm thickness. This thickness value of absorbers and the thermoelectric bridge is used in the calculations.

Earlier we presented the results of calculations of the propagation of heat in the TSPD sensor in the absorption of a photon on the different areas of the surface of the absorber. In this work are presented the results of computer modeling of the processes of heat distribution after photon absorption on absorber surface, in the half of the thickness of absorber (1/2h) and at the boundary absorber-substrate. Also, the temperature difference (ΔT) at the ends of the CeB_6 sensor was registered at different heights.

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Helical *m*=1 mode formation dependence on spiral phaseplate properties

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The influence of radial step height of a spiral phaseplate on a diffraction structure is considered. The computing results show that if the ideal phase shift for a helical m=1 mode generation is broken, the diffraction pattern generated from a phaseplate is described by superposition of two components: the vortex and incident Gaussian beams.

Investigation of 1.5 µm luminescence properties in YAG:Er^{3+} crystals in presence of energy transfer processes

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YAG:Er^{3+} crystals are one of the most attractive active materials for developing 1.5 μm eye-safe region DPSS lasers. They have various applications in optical communications systems, medicine, remote sensing and ranging. Further improving of their laser capabilities requires a more detailed study of some of their spectral properties.

The intensity and duration of 1.5 µm luminescence of YAG:Er^{3+} crystals with varying concentrations of Er^{3+} impurity ions (5, 40 and 100 at. %) are investigated. Using blue LD as a pumping source operating in pulsed and CW modes the spatial distribution of the 1.5 µm luminescence across the excitation axis is registered. For the samples under study the luminescence decay durations depending on the registration position as well as concentration of impurity ions are measured. The experimental results of luminescence intensity and duration decays under pulsed pumping show exponential behaviour depeneding on the distance between the excitation and detection positions. The same behaviour is present for luminescence intensity under CW pumping. However, unlike the growth in the luminescence intensity for increasing concentrations of impurity ions under pulsed pumping it remains nearly the same in the case of CW pumping. A simple model based on the presence of energy transfer processes between Er^{3+} ions is proposed to explain the different behaviours of luminescence intensities for CW and pulsed excitation regimes. The same model interprets the luminescence decay time changes across the excitation axis.

Efficient conversion of light to charge and spin in Hall-bar microdevices

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During the last decade, the spin related Hall effects [1] have developed from subtle academic phenomena to practical tools for exploring a variety of fields in the fundamental and applied spintronics research. [2] One of the recently proposed concepts, where these effects can find utility, is the spin Hall based polarimeter. [3]

In this contribution, we report an experimental study of the direct conversion of light into electrical signals in GaAs/AlGaAs Hallbar microdevices. Our approach based on different modulation frequencies of the intensity and polarization of the laser beam allows us to disentangle the charge and spin dependent parts of the induced electrical signal, and to link them to the incident light intensity and polarization, respectively.

In our electrical polarimeter, the degree of circular polarization of incident light is directly converted into transverse electrical voltage via spin-orbit interaction acting on optically generated spin-polarized photocarriers. We demonstrate that the efficiency of the light to spin conversion is strongly enhanced by adding a drift component to the transport of the spin-polarized photocarriers, as compared to a purely diffusive transport regime of the device. We show that this is in agreement with the theory of spin-related Hall effects.

For a micron-size focused laser beam, the experiments also demonstrate that the light to charge and spin conversion efficiency depends on the precise position of the light spot, reflecting the spatially dependent response function of the Hall cross.

All these observations may find utility in designing spin Hall based convertors, modulators, polarimeters or other related opto-spintronic microdevices.

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Calibration of Nano-positioner piezoelectric drivers using Fresnel diffraction from phase-step

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Piezoelectric positioning drivers and actuators play a significant role in accurate measurement devices. Most particularly, they are a basic component of any kind of scanning microscope. This raises the importance of precise and reliable calibration of piezoelectric actuators. Most of the present optical techniques of calibration include precise interferometry which requires highly maintained experimental conditions. We have designed a calibration device using Fresnel diffraction from phase-steps which itself can be also used as a nano-positioner. The phenomenon of Fresnel diffraction from phase-steps has been recently introduced as a method for precise measurement of wavelength, thickness and refractive index. Using this new method, the total cost of the calibration process has been notably reduced. Furthermore due to much less sensitivity to environmental noises, it is possible to use this calibration device as a nano-transducer operating on the positioning component. The device is accompanied with a live data processing programme that can be run in a typical computer. The results show that the method is accurate and precise with a high level of repeatability due to its low sensitivity to environmental conditions.

Effect of Size and Geometry of Gold Nanostructures in Performance of Laser Hyperthermia; A Multiscale-Multiphysics Modelling

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Hyperthermia is from the most effective approaches in treatment of refractory cancers with a non-chemical approaches. Killing cancerous tissues and cells with minimum side effect to healthy cells is from the main objectives of this method. Regarding the different resources for generation of heat, using laser with metallic nanoparticles can be considered as a powerful candidate for localized heat generation. Metallic nano structures with different size and geometries have different extinction spectra which can be considered as tunable sources for absorption of light in different wavelengths. In this regard, gold nanostructures are brilliant candidates considering not only according to their absorption peaks in visible and near-IR region but also because of their bio compatibility. In this work we have studied the effect of size and geometry of gold nano structures in efficiency of hyperthermia in different tissues. Our approach consists of three steps. First the absorption and scattering efficiency and cross section of nanostructures are calculated based on Mie theory and discrete dipole approximation (DDA) method. The second part, using Monte Carlo (MC) method, we calculate the absorption of light in the tissue with considering different types and concentrations of gold nanostructures. The results of first step are used in MC calculations. In the last part, in order to calculate the effect of this absorption on elevation of temperature of tissue, we have solved Bio-Heat equation for the tissue with absorption profile of second step. Considering different thermal and optical properties of tissues and selection of proper laser with appropriate wavelength, results of the simulation are can be fruitful in selection of nanostructure and laser parameters.

Excilamp with a long feedline

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Excilamps are gas-discharge sources of spontaneous narrow-band radiation produced by decomposition of excimer or exciplex molecules. This process occurs in working gas or gas mixture excited by barrier, capacitive or glow discharges [1]. Traditionally sine [2] or pulsed [3] voltage is used to excite active media of excilamps. In the work [4] an advantage of pulsed voltage excitation was shown, but an excitation of barrier discharge excilamps through a long coaxial feedline by subnanosecond front pulses is non-productive because of considerable reactive load for pulsed power supplies that leads to the efficiency decrease of a device "power supply and radiator". In this paper we used paused sine voltage with a near-resonant frequency to excite barrier discharge excilamps and demonstrated the efficiency increase and impedance matching at lamp feeding through a long coaxial feedline.

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Optical vortex sensitivity due to introduced local phase distrubances

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Optical Vortex Scanning Microscope (OVSM) uses focused laser beam with an optical vortex to scan the sample. The current setup of the OVSM was presented in [1]. The setup is based on the carrier frequency interferometry. Optical vortex is generated by spiral phase plate (vortex lens). The optical vortex can be moved inside the focused light spot by shifting the vortex lens [2, 3]. The range of this movement in the observation plane is reduced comparing to the range of the vortex lens shift. Thus, we have a precise way for sample scanning. This new scanning method was tested experimentally with simple phase micro-objects. It was shown that our system is sensitive to small phase disturbances which have an impact on both optical vortex position and phase profile

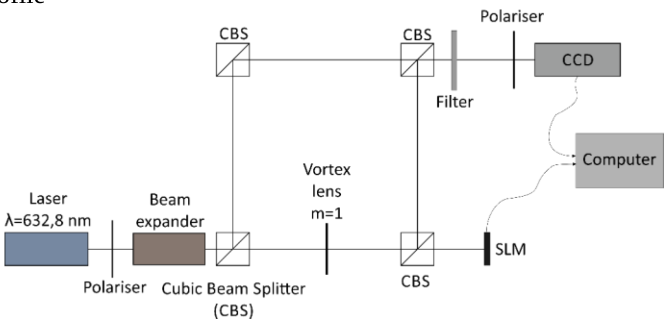

Fig. 1 Setup for measuring optical vortex response due to specified phase disturbance. SLM is used as an object. SLM introduces phase modification into the beam which is carrying the optical vortex generated by vortex lens.

One of the challenges for the OVSM is finding the effective procedures for surface topography reconstruction. We proposed an experimental setup shown in (Fig. 1) to support the works focused on this problem. The Spatial Light Modulator (SLM) is used as an object. SLM allows generating any phase disturbance with specified value and size. The SLM is illuminated by the vortex beam (beam carrying optical vortex). Our system gives an opportunity to measure optical vortex response due to phase modifications introduced by the SLM. We measured optical vortex reaction to simple objects generated by SLM, especially by changing object position and its phase value. Phase retrieval algorithm and results of these experiments will be presented. These results show the way in which the OVSM should be developed.

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Designing the Femtosecond Optical Oscilloscope

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We present the results of our recent experimental and numerical studies on femtosecond pulse spectrotemporal imaging in similariton-induced temporal lens aimed to design a femtosecond optical oscilloscope [1]. We studied nonlinear and dispersive peculiarities of modern high-tech materials, such as photonic crystal fibers, hollow-core fibers etc, to use them in the scheme, and provide compactness and reliability of device. The use of hollow-core fibers, as a dispersive medium instead of pair of prisms or gratings, is of special importance for constructing the industrial tool. Additionally, we are experimenting on the method of dispersive Fourier transformation, using the effect of chromo-modal dispersion in multimode fibers [2], to provide real-time performance of the device.

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Adiabatic population transfer in fife-level media without four-photon exact resonance

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Coherent interaction of light signals with quantum systems have been attracting considerable interest for their importance in both fundamental science and practical applications. A prominent example of coherent interactions is electromagnetically induced transparency (EIT) [1], which allows to manipulate of optical properties of atomic or atom-like media.. The EIT is directly relied to such processes as optical information storage, adiabatic population transfer, constructing desired coherent superposition of different states, control of chemical processes, and many others. This interaction is comprehensively studied, both theoretically and experimentally, for various three level systems and their media. Multilevel atomic and atom-like systems, although do not provide new physical principles in addition to quantum interference and principle of superposition, they widen essentially the possibilities of experimental realizations and practical applications.

In our previous paper [2] we studied both analytically and numerically a five-level atomic system interacting adiabatically with four laser pulses of different durations under the condition of all two-photon detunings being zero. We concentrated on those eigenstates of interaction Hamiltonian whose eigenvalues are different from zero. In the first nonlinear approximation for medium dispersion, we obtained analytical solution. We showed that in five-level system eigenstates for non-zero eigenvalues are similar to the dark and bright states in a three-level system. We demonstrated that, under certain conditions, all the coherent effects observed in three-level media, might efficiently be realized in five-level media. This has an important advantage that the light storage can be performed twice in the same medium; i.e., the second pulse can be stored without retrieving the first one, and then the two pulses can be retrieved in any desired sequence. However the possibility of experimental realisation of this scheme of interaction is the strongly limited by strict conditions on resonance detuning, including zero value of for four -photon detuning which follows from the condition on two-photon detuning.

The aim of this work is the analytical and numerical study of this restriction. First we analyse system behave for small, but nonzero value of four photon detuning. Then numerical solution of Schrödinger equations for the amplitudes of atomic states have been received. We obtain the permissioned value of the four -photon detuning and demonstrated the flexibly controllable population transfer and possibility of light storage with non-zero four -photon detuning

The permission of non-zero value of four-photon detuning gives flexibility in selection of multilevel media parameters and significantly facilitate the implementation of coherent processes such as population transfer and light storage.

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Metal Nanosphere at an Interface: revival of degeneracy of a dipole plasmon

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The dipole plasmon of a nanosphere is known to be three-fold degenerate. When the spherical symmetry is lifted this degeneracy disappears as well. In particular, when a nanosphere approaches a plane interface between two media of different refractive indices, one mode corresponding to the oscillations of the electronic density perpendicular to the interface separates of two other modes that remain degenerate. These two degenerate modes correspond to the oscillations of the electronic density parallel to the interface. An interesting question, which we are going to elucidate in this contribution, is if the degeneracy of all three modes revives when the center of the sphere is at some point midway between the two media.

For the first time, this revival of degeneracy of all three modes was pointed out in [1]. Due to the perturbation approach used in [1] the degeneracy revival was obtained when the sphere center coincides with the interface plane. We performed numerical simulations that showed that the point at which all three dipole modes are degenerate belongs to the media with smaller refractive index.

We compare our numerical results also with the simple quasistatic approach that leads to the divergent separation between the modes when the sphere is situated too near to the interface. Although this approach is inadequate to treat the whole problem, it gives important insight in the nature of the degeneracy revival: the perpendicular mode is more sensitive to the proximity of the media with different refractive index while the sign of the shifts are different when the sphere approaches the interface from the opposite sides.

The passage of plasmonic nanoparticles through the interface between two dielectric media is implemented in many applications [2]. We expect that our results will be useful for diagnosing the spread of nanoparticles in the environment with the spatial resolution in the nanometer range.

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Optical visualization of the Pythagorean triples in the quantum dashes

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The problem of the features of the electron energy spectrum in the quantum dash has been considered. Quantum dashes are geometrically approximated by a parallelepiped with impenetrable walls. The family of triply degenerate energy levels characterized by modular group Γ(2) has been found for the chosen model of quantum parallelepiped. It has been shown that in the basis of every family of triply degenerate levels are primitive Pythagorean triples. To the transition from one Pythagorean triple to another corresponds the fractional rational modular group Γ(2). It has been shown that this fact is directly reflected on the optical properties of the quantum dashes, in particular it allows to "visualize" Pythagorean triples.

Poster Presentations

Study and measurements the effects of the deconvolution's parameters on quality of image reconstruction

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Reconstruction of distorted images and reducing the effects of optical aberration, have always been of significant interest. One of the novel and efficient techniques is using of the de-convolution theory. In this research, we use this method and check and revision the effects of deconvolution's parameters on the quality of reconstructed images. We measure the aberration and wavefront by using the Hartmann wavefront sensor data, and perform the deconvolution by Lucy-Richardson alghorithm in Matlab environment. The experimental results are quantified and will be presented in this paper.

Numerical Simulation of Microresonator Based Biosensors

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Biosensors research grows fast due to increasing demand for diagnosis. One of the good candidates for biosensors are optical microresonators. Here, we investigate effects of biological agent on the frequency spectrum characteristics of a microdisk resonator. It is shown that resonance wavelength decreases linearly for increasing absorbed layer of the DNAs.

Bayesian analysis of mass and radius constraints from pulsar waveform analyses

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We suggest a new Bayesian analysis using disjunct mass and radius constraints for extracting probability measures for cold, dense nuclear matter equations of state.

One of the key issues of such an analysis is the question of a deconfinement transition in compact stars and whether it proceeds as a crossover or rather as a first order transition. The latter question is relevant for the possible existence of a critical endpoint in the QCD phase diagram under scrutiny in present and upcoming heavyion collision experiments. Future observations of selected millisecond pulsars with the NICER mission on board of the International Space Station will result in new high-precision data on waveforms and decisive progress for the Bayesian analysis.

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The electrostatic multipoles, created by electron, localizes in narrow-band cylindrical nanolayer

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A problem of definition and control of electrostatic field, created by electron, localized in cylindrical nanolayer from InSb is considered. Are calculated average values of quadrupole and dipole moments and also are found appropriate corrections to potential and strength of electric field. Obtained results can be applied in single-electron transistors [1], where role of active functional element will play a quantum dot from InSb in shape of cylindrical nanolayer.

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Peculiarities of Rb atomic transition behavior in strong transverse magnetic fields

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This research demonstrates that compared to an ordinary cell, the use of the nano-metric thickness cell allows one to effectively study individual atomic transitions of alkali atoms. The method is based on strong narrowing of the absorption spectrum (which provides sub-Doppler resolution) of the L thick ($L = \lambda/2 = 395$ nm) nano-cell filled with Rb.

In case of hyperfine Paschen–Back regime (when applied strong magnetic field is strong enough to decouple the total electronic angular momentum J and nuclear momentum I) and π-polarization of laser radiation, only 20 atomic transitions remain out of initial transitions. These 20 atomic transitions are contained within two groups of ten atomic transitions each [1-3]. Developed theoretical model very well describes the experiment [3].

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Impurity-bound polaronic states under an external electric field in quantum dots: Image charge effect

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A variational approach is used to study the impurity-bound polaron ground and few excited states' energies in a spherical quantum dot under an external electric field, including image charge effect. The binding energy of the hydrogenic impurity is calculated by taking into account the interaction of an electron with both the confined longitudinal optical phonons and the surface optical phonons. Numerical calculations have been carried out for ZnSe quantum dots embedded in dielectric matrix. Polaronic shifts for 1s, 2s, 2px, 2py, and 2pz hydrogen-like states as functions of an applied electric field are studied.

Temperature-Dependent Fluorescent Dyes Application for Measuring the Millimeter Wave Absorption in Polar Liquids

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Temperature sensitivity of the organic dyes solutions fluorescence intensity is used for non-contact measurement of the electromagnetic millimeter wave absorption in liquids. These measurements are important for using the millimeter electromagnetic waves in the field of biomedicine. There is still not any certain idea of the physical mechanism describing this process despite the widespread technology of microwave radiation in the food industry, biotechnology and medicine. For creating adequate physical model one requires an accurate command of knowledge concerning to the relation between millimeter waves and irradiated object.

This work investigates the absorption of millimeter waves in fluids that simulate biological substance with different water concentration and varying degrees of its cohesion. The microwaves absorption in water-containing media causes local temperature increase, which was recorded with temperature-sensitive fluorescent dyes according to our research. There were three H-bonded liquids selected as the samples with different coefficients of absorption in the millimeter range like water (strong absorption), glycerol (medium absorption) and ethylene glycol (light absorption) . It is known that solutions of organic dyes in proposed fluids are characterized with high luminescence quantum efficiency and with both positive and negative significant temperature coefficient.

The measurements showed that the greatest response to the action of microwaves occurs for glycerol solutions: R6G (building-up luminescence) and RC (fading luminescence). For aqueous solutions the signal is lower due to lower quantum efficiency of luminescence, and for ethylene glycol — due to the low absorption of microwaves. In the area of exposure a local increase of temperature was estimated. For aqueous solutions of both dyes the maximum temperature increase is about 7º C caused with millimeter waves absorption, which coincides with the results mentioned in and confirmed by theoretical calculations of other authors. However, for glycerol solution R6G temperature equivalent for building-up luminescence is around 9º C, and for the solution of ethylene glycol it's about 15º. To our mind, this effect can be explained by the influence of the non-thermal millimeter waves for these solvents since they act directly to polar molecules.

Nonequilibrium particle production in time-dependent strong fields

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The formulation of a kinetic theory approach to the problem of nonequilibrium particle production in strong fields has been advanced recently in studies of the dynamical Schwinger effect for e^+e^- plasma creation in high-intensity lasers [1, 2]. Strong and time-dependent fields govern also the particle production in ultrarelativistic heavy-ion collisions where the kinetic theory approach has been developed for studying the role of the chiral symmetry breaking transition for pion production [3] and photon production [4]. In the present work we develop the kinetic approach to nonequilibrium pion production in a time-dependent chiral symmetry breaking homogeneous field and investigate the question to what extent the low-momentum pion enhancement observed in heavyion collisions at CERN - LHC being discussed as Bose-Einstein condensation of pions [5] can be described within this formalism. To this end we perform a detailed study of the three main processes that are intertwined in this case: (a) the nonequilibrium σ - meson production in the time-dependent external field, (b) the $\sigma\to\pi\pi$ - decay and (c) the ππ rescattering and formation of the Bose condensate [6, 7] and compare the obtained results with the effect observed at the LHC.

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Intersubband transitions in quantum well with consideration of the interaction with impurities and phonons

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Intersubband transitions in quantum wells are considered taking into account an interaction with ionized impurity centers and acoustic phonons. Calculations are made according to Ando's theory. The expressions for absorption linewidths are obtained. Dependence of linewidth on quantum well thickness and temperature are considered. The results are compared with the other mechanisms of scattering.

Few-body magneto-absorption in prolate ellipsoidal quantum dot

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In this paper, on the basis of the geometric adiabaticity the problem of magneto-absorption of few-body electron gas, localized in strongly prolate ellipsoidal quantum dot, has been investigated. Initially the confinement potential of the QD was considered as rectangular and impenetrable. Due to the specific geometry of the QD has been shown that the motion of the particles in the considered system can be separated into fast and slow, in the plane XOY and along the major semi-axis of the ellipsoid OZ respectively. In this case, based on the adiabatic approach has been shown that in the direction of the slow motion, the electron gas is localized in parabolic well. If a long-wavelength radiation falls on the system, then due to the parabolic form of confining potential conditions occur to implement the generalized Kohn theorem for this system [1,2,3].

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Experimental and Theoretical Investigation of Polarization Plane Rotation of Light in Nanoparticle-Enriched Chiral Liquid-Crystalline Photonic Structures with an Anisotropic Defect Layer

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The possibility of defect induction controlled by external electric field in nanoparticle-enriched cholesteric liquid-crystalline (CLC) cell with selective reflection in visible range of light and controlling the rotation of polarization plane of light by induced defect was experimentally and theoretically demonstrated. Three cases of induced defects were examined: defect was induced near the input substrate of the cell, in the center of CLC cell and near the exit substrate of the cell. The CLC layer parameters are: ε_1= 2,47, ε_2= 2,85, σ= 0,324, where σ is pitch of helical structure. Our estimations show that non-locality of the field results in induction of the defect with the thickness of 2,27µm. Consequently, it was experimentally confirmed that the rotation of polarization plane has maximum value when light at first propagates through cholesteric liquid-crystalline photonic structure and then falls to the anisotropic layer. The main result of the experiment is the fact that the rotation of the polarization plane of light occurs at lower voltages when the cholesteric liquid crystal is enriched by nanoparticles. In order to simulate our experimental results, we used Ambartsumian's layer addition modified method [1] adjusted to solution of such problems. A ***CLC layer*** with a defect can be treated as a multi-layer system: ***CLC(1)-Defect Layer (DL)-CLC(2)***. Let us present the solution of the boundary problem of light transmission through the multi-layer system in the form:

$$\vec{E}_r = \hat{R}\vec{E}_i, \quad \vec{E}_t = \hat{T}\vec{E}_i, \tag{1}$$

where the indices *i*, *r* and *t* denote the incident, reflected and transmitted waves' fields, $\hat{R}$ and $\hat{T}$ are the reflection and transmission matrices.

$$\vec{E}_{i,r,t} = E^p_{i,r,t}\vec{n}_p + E^s_{i,r,t}\vec{n}_s = \begin{bmatrix} E^p_{i,r,t} \\ E^s_{i,r,t} \end{bmatrix}, \tag{2}$$

where $\vec{n}_p$ and $\vec{n}_s$ are the unit vectors of orthogonal linear polarizations, $E^p_{i,r,t}$ and $E^s_{i,r,t}$ are corresponding amplitudes of the incident, reflected and transmitted waves. According to Ambartsumian's layer addition modified method, if there is a system consisting of two adjacent (from left to right) layers, *A* and *B*, then the reflection transmission matrices of the system, *A+B* , viz. $\hat{R}_{A+B}$ and $\hat{T}_{A+B}$, are determined in terms of similar matrices of its component layers by the matrix equations:

$$\hat{R}_{A+B} = \hat{R}_A + \tilde{\hat{T}}_A \hat{R}_B \left[\hat{I} - \tilde{\hat{R}}_A \hat{R}_B \right]^{-1} \hat{T}_A,$$
$$\hat{T}_{A+B} = \hat{T}_B \left[\hat{I} - \tilde{\hat{R}}_A \hat{R}_B \right]^{-1} \hat{T}_A, \qquad (3)$$

where the tilde denotes the corresponding reflection and transmission matrices for the reverse direction of light propagation, and $\hat{I}$ is the unit matrix. The exact reflection and transmission matrices for a finite ***CLC layer*** (at normal incidence) and a defect (isotropic or anisotropic) layer are well known. First, we attach the ***DL*** with the ***CLC Layer (2)*** from the left side. In the second stage, we attach the ***CLC Layer (1)*** with the obtained ***DL-CLC Layer (2)*** system.

The ellipticity *e* and the azimuth ψ of the transmitted light are expressed by $\chi = E_t^s / E_t^p$ through the following formulas:

$$\psi = \frac{1}{2} arctg\left(\frac{2\,\mathrm{Re}(\chi)}{1-|\chi|^2}\right), \quad e = tg\left(\frac{1}{2}\arcsin\left(\frac{2\,\mathrm{Im}(\chi)}{1+|\chi|^2}\right)\right).$$

The comparison of experimental results with the theoretical predictions confirms the validity of the approach. We present a new configuration of liquid crystal device that performs as a tunable linear polarizer for both polarized and unpolarized lights. Our results can be used in systems as a broad band optical diode for circularly polarized incident light, as well as in the sources of elliptically polarized light with tunable ellipticity.

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Pulse shaping at the output of a 2-m-long optical fiber

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The adaptation of the fiber delivery setup to shape the spectrum in amplitude and phase at the fiber output is experimentally demonstrated. Initially, a method to generate sub-30-fs pulses with 1.6 nJ energy, directly at the output of a 2-m-long fiber, with a simple configuration, composed of standard commercial components was presented. Then, with the same experimental architecture, we demonstrated the possibility of obtaining short pulses (approximately 34 fs) with energy of 1.5 nJ by using a 2-m-long large mode area fiber. We present a new way to produce shaped spectrum in amplitude and in phase at the delivering fiber exit with a shaping module positioned upstream of it, allowing us to keep the fiber flexibility. Starting from a simpler setup that we have detailed in a previous work, the spectrum is first modulated in amplitude before a basic modulation of the spectral phase is applied. The amplitude and phase modulation are thus highlighted at the fiber output. Technically, we are introducing a spatial light modulator, an active element, inside the grism-based stretcher. Spectral amplitude and phase modulation are accomplished for the first time, to the best of our knowledge, with a simple and compact device combining stretcher and shaping modules.

UV Fhotodetector on the base of silicon nanowire FET

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In this paper capability of the possibility of the silicon nanowire based field-effect transistors as a high sensitive photodetector for UV range of spectrum is demonstrated. Experimental devices (photodetectors) have complex structures: front oxide layer - p/Si nanowire - buried oxide layer -p/Si substrate. They are made by the SOITEC- technology. Spectral measurements carry out at the 300K using monochromator YM-2. For the irradiation we use 2 incandescent lamps remote from structure on 15 cm and irradiation densities on the NW surface in the wavelength range 0.25-0.6μm makes up 1.1 W/cm^2 and 1.6 W/cm^2, correspondingly. Dark and light current-voltage characteristics, low-frequency noises, photosensitivity and detectivity are investigated. It is shown that absorbance of Si nanowire shift to short wave region (250-400 nm) and as opposed to bulk Si photocurrent and photosensitivity reaches more high values in the UV range of spectrum. Values of photosensitivity can reach up to (5-6) A/W at the room temperature. Spectral density of low-frequency noises has relatively high values and therefore values of the special detectivity are not higher. Values of photosensitivity and detectivity can be regulated by spurce-drain and back gate voltages. Absorbance shift to short wave region of Si nanowire and other dependencies are theoretically explained.

Raman spectra of graphene films synthesized by chemical vapor deposition on copper foil using decane as precursor

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CVD method for graphene synthesis provides relatively low operating temperatures (1000 K to 1400 K) and the possibility of obtaining large areas of graphene of high quality.

During the synthesis, hydrogen is used as a co-catalyst [1], but at the same time several negative effects of using hydrogen are reported [2-4]. Thus, the effect of hydrogen on graphene synthesis process in the CVD method requires additional research.

Studied graphene samples were synthesized by CVD on copper foil with H_2 flow rate 150 cc/min, 60 cc/min, and in the absence of hydrogen under identical other conditions. Raman spectra were recorded in the range of 1000-3000 cm^{-1} with a spectral resolution of 3 cm^{-1}.

To evaluate the number of graphene layers the ratio of the peak intensities I(2D)/I(G) and the full 2D peak width at half-maximum were used. To evaluate the defectiveness of graphene layers ratio of the peak intensities I(D)/I(G) was used. To evaluate the average grain sizes ratio of the areas under peaks S(D)/S(G) was used.

It is shown that with decreasing of the hydrogen flow rate average inter-defect distance in graphene samples increases simultaneously with the grain size. At the same time, the covering of the substrate by monolayer graphene is lower for the absence of hydrogen during the synthesis.

The change in the grain size can be explained by a competition of two processes: adsorption of the decomposed hydrocarbon and dissociative chemisorption of hydrogen [2,3,5]. The changes in the defectiveness of graphene can be explained by formation of CH bonds with sp^3-hybridization during the synthesis in the presence of hydrogen [5] and by changes in hydrogen solubility in copper with temperature [6]. The change in the substrate covering can be explained by a co-catalyst role of hydrogen in the endothermic reactions of hydrocarbon decomposition [1].

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Electro-optic and dielectric properties of Holmium-doped congruent lithium–niobate crystals

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Measurements of electro-optic and dielectric properties in Holmium (Ho)- doped lithium niobate (LN:Ho) single crystals are performed as function of the dopant concentration in the range of 0.01-2.0 mol%. The clamped and unclamped electro-optic coefficients r_{222} of LN:Ho and the corresponding dielectric permittivity as well, have been experimentally determined and compared with results obtained for nominally pure congruent LN crystals.

We show that both the electro-optic and dielectric properties present similar behavior with an abrupt huge decrease with concentration for highly doped crystals. This behavior was previously observed with less amplitude in a series of zirconium doped lithium niobate crystals, where the electro-optic and dielectric properties have shown a kink around 2 mol% of zirconium, which corresponds to the “threshold” concentration required to strongly reduce the photorefractive effect. Additional experiments with the LN:Ho series need to be performed with highly doped samples to confirm the real Ho threshold concentration. Nevertheless, these first reported results combined with the ones on reduction of the photorefractive effect in the mentioned crystals [1] confirm that LN:Ho crystal could be considered as a very promising candidate for several nonlinear devices and balanced laser systems.

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The effect of Nano structured TiO2 thickness on efficiency of Dye sensitized solar cell

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Solar energy as an unlimited energy source is one of the most important types of renewable energies. Solar energy consists of two parts; lighting and thermal, which can be converted into electrical energy. Solar cells are tools that convert light energy into electrical energy.

Depending on the technology used in the manufacture of solar cells, they're divided into three generations: first-generation silicon synaptic (single crystal and polycrystalline) the second generation (thin films solar cell) the third generation (Pigment cell) cells.

In more than a decade during which many studies have been carried out on the third-generation pigment solar cells which is based on light absorption by the pigment, the light absorption of these pigments is in the visible light area and the performance mechanism of these cells after the light absorption by the pigment and the release of electrons will be provided and transferred to TiO2 layer and then is considered as electric potential in electrical circuit.

The only material that can be used instead of TiO2 is (ZnO) which the band gap of the both is almost identical, but compared to TiO2 it, has more electron mobility, as well has more flexibility in terms of structure and morphology, but it has fewer chemical stability which creates problems in the process of absorbing pigments and the energy conversion efficiency will be very low.

In this study, we try to raise the solar cell efficiency by changing the thickness of the TiO2 Nano-structured thin layer. Every time, we made our cells with different thicknesses of the layers, and compared the achieved efficiency and we found that somewhat layer thinning has helped to increase efficiency. And we reached to maximum amount of 12% in efficiency.

Origin of visible photoluminescence of Si-rich and N-rich silicon nitride films

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Amorphous silicon nitride films have been long used for a wide variety of applications in microelectronics as the gate dielectric in thin film transistors, charge storage medium in non-volatile memories. Recently, the interest in SiN_x as an appropriate material for future generation of optoelectronic devices has risen again. This application requires an understanding of the nature of light-emission properties in view of fundamental interest and practiacal application. The origin of photoluminescence (PL) of SiN_x films is still an object of controversy. There are a lot of publications devoted to explanation of visible luminescence of silicon nitride films. The most of them are focusing on the PL of Si-rich SiN_x to fabricate light-emitting structure «Si nanoclusters in wide-gap matrix». In this study the PL dependence on annealing temperature for both Si-rich and N-rich silicon nitride films has been discussed.

The Si-rich and N-rich silicon nitride films (300 nm) were deposited on Si by plasma-enhanced chemical vapor deposition at 350°C using SiH4 and N2 as precursors. The composition of as-deposited SiNx films was determined by Rutherford backscattering spectrometry (RBS). The samples were annealed in Ar at 600, 800 and 1100°C for 60 min in a resistance furnace. PL spectra were recorded at room temperature using a UV He–Cd laser (325 nm) and Nd laser (532 nm). The structural properties of light-emitting films were studied using transmission electron microscopy (TEM).

The stoichiometric parameter “*x*” calculated from RBS data amounts to 1.13 and 1.5 for Si-rich (SiN1.13) and N-rich (SiN1.5) samples, correspondingly. It was shown, that PL of as-deposited samples depends on film composition. The PL maxima lie in red region (660 nm) for SiN1.13 and in blue region (450 nm) for SiN1.5. Based on widening with increasing “*x*” bandgap diagram from Ref. [1], PL was attributed to radiative recombination between defect state of Si-dangling band (termed K-center) and band-tail states of conduction band. The increasing PL intensity of the samples annealed at 600 and 800°C depends on anneling temperature and composition of SiNx films. We explain this dependence by creation of K-centres via thermal dissociation of Si-H bond and competing process of annihilation of them during high-temperature anneals. The annealing at 1100°C results in weak PL red band for both types of samples. PL quenching is explained by decreasing of K-centres concentration. Similar position of PL maxima is explained by radiative recombination between K-centre and valence band for SiN1.13 or K-centre and defect state of N-centre for $SiN_{1.5}$. The investigation by TEM revealed out inhomogeneous structure of SiNx films. Thus, PL of Si-rich as well as N-rich SiNx films originates from radiative transitions between band tail states and defects states attributed to structural inhomogeneities.

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Dilatational and flexural acoustic phonon-mediated spin relaxation in a two-dimensional quantum dot in the presence of perpendicular magnetic field

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The spin-relaxation time due to the electron-acoustic phonon scattering in GaAs quantum dots is studied after the exact diagonalization of the electron Hamiltonian with the spin-orbit coupling. It has been shown that in comparison with flexural phonons, the electron coupling with the dilatational phonons causes 3 orders faster spin relaxation. We have found that the relaxation rate of the spin-flip is an order of magnitude smaller than that of the spin-conserving.

Raman G-peak temperature shift of bilayer graphene on copper substrate

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Analysis of the behavior of temperature dependence of the G-peak position in the Raman spectra is very important for determination of the thermophysical properties of graphene [1,2].

Graphene bilayer was obtained by CVD-method on copper substrate. Measurements of the Raman spectra were performed in the range of temperatures 20-294 K.

In the studied temperature range a shift of G-peak position to larger values with decreasing of the temperature is observed. Calculation of the coefficient of G-peak temperature shift for graphene bilayer on copper substrate gives the following value: $\chi_G = -(5.4 \pm 0.4) \cdot 10^{-2} cm^{-1} K^{-1}$. The value obtained in our work is 3.5 times greater than the value reported for graphene bilayer on SiO_2/Si substrate in [3]. The possible reason for this is the following fact: volumetric thermal expansion coefficient of copper is 3 times greater than that parameter for silicon, and silicon oxide.

In opinion of authors of [3], substrate should not strongly affect the value of temperature shift coefficient, because optical phonons with E_{2g} symmetry associated with in-plane oscillations are a reason of G-peak in Raman spectra. However, our results declare about opposite, i.e. substrate affects strongly phonon properties of bilayer graphene. In other words, the approach proposed in [3] when the difference between thermal expansion coefficients of bilayer graphene and substrate is neglected, does not allow to explain a strong dependence of coefficient of G-peak position temperature shift on the substrate material.

Obtained results reflect change of thermophysical properties of those structures, because of interaction with substrate material.

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