International Conference on Microwave and THz Technologies, Photonics and Wireless Communications

IRPhE' 2016

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Abstract Book

Organized by: Institute of Radiophysics and Electronics, National Academy of Sciences

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State Committee of Science of Armenia

May 4-6, 2016 – Yerevan (Armenia)

IRPhE' 2016 Main Topics:

- **Microwave devices, antennas, propagations and remote sensing**
- **THz technique, spectroscopy and applications**
- **Photonics**
- **Wireless communications and related information technologies**
- **Alternative semiconductor and dielectric materials, electronic devices**

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04 May, Wednesday

09:00-10:00	Registration	
10:00-12:30	***The jubilee ceremony devoted to academician Radik Martirosyan (President of National Academy of Sciences)***	
12:30-14:00	Welcome Reception	
14:00-14:30 **Keynote speech:**	**Opening of IRPhE'2016** **Radik M. Martirosyan** National Academy of Sciences, Armenia	Historical overview of Radiophysics (Microwave engineering) development in Armenia
Photonics (PH) **Chairman: Prof. Shunri Oda**		
14.30 -15:00 **Plenary speech**	Andrea Melloni *Politecnico di Milano, Italy*	**PH-1**: Control and calibration of photonics integrated circuits
15:00 -15:15	Aram Papoyan, S. Shmavonyan, A. Khanbekyan, M. Movsisyan, H. Azizbekyan *Institute for Physical Research, Armenia*	**PH-2**: Three-axis optical Hanle vector magnetometer
15:15 - 15:30	Hovik Baghdasaryan, M. Knyazyan, T.T. Hovhannisyan, M. Marciniak *National Polytechnic University of Armenia*	**PH-3**: Conditions of single-frequency radiation from fiber laser with FBG mirrors: numerical analysis by the method of single expression
15:30 -16:00 **Invited**	Kiejin Lee, Shant Arakelyan, Hanju Lee, Sunghoon Jeon , Do-Suck Han, G. Berthiau, Arsen Babajanyan *Sogang University, Korea*	**PH-4**: Microwave and Joule heating visualization by thermo-elastic sensor for carbon fibers composite material
16:00 - 16:15	Hovhannes Haroyan *Yerevan State University, Armenia*	**PH-5:** Slot Nano-Antenna Integrated with Plasmonic Waveguide
16:15 -16:45	Vitaly Morarenko *Keysight Technologies, Russia*	**PH-6:** Detecting of complex modulated optical signals and optical modulation analysis for gigabit and terabit transmission lines
16:45 -17:00	Tabassom Sedighi, P. D. Foote *Cranfield University,UK*	**PH-7:** Bayesian network-based intermittent fault detection in photonic systems

05 May, Thursday

Wireless communications and related information technologies (WL) **Chairman: Prof. Garik Markarian**		
09:30-10:00 **Plenary speech**	Garik Markarian, Stuart Grant, Denis Kolev *Lancaster University, UK*	**WL-1:** From quality of service to quality of life: How advances in wireless technologies found their way in modern healthcare
10:00-10:30 **Invited**	Maksim Sokovishin *Keysight Technologies, Russia*	**WL-2:** Defining a channel sounding measurement system for characterization of 5G air interfaces --- **WL-3:** WLAN at 60 GHz. signal creation and demodulation.
10:30-10:45	Hayk Manukyan, P. Sahu, D. Sehrawat, R. Ganeshe *Cobham Wireless, UK*	**WL-4:** Mobile wireless communications test and measurement technologies development toward 5G
10:45-11:00	Suren Eyramjyan *National Instruments, Armenia*	**WL-5:** National Instruments technologies in 5G research and prototyping
11:00-11:15	Gurgen Khachatrian *American University of Armenia*	**WL-6:** Security challenges of cloud computation
11:15-11:30	H.Haroyan, G.Harutyunyan, T. Harutyunyan, Sargis Sargsyan *YSU, "Antel Design" Armenia*	**WL-7:** Spectral efficiency improvement in nonlinear wireless systems
11:30-11:50	Karen Nikoghosyan, George Yeghoyan *Redinet CJSC, Armenia*	**WL-8:** Green communication for GSM Network **WL-9:** Renewable Hybrid Off-Grid Power Solution for GSM Network
11:50-13:00	Coffee break **Poster Session** **&** **Exhibition: Keysight Technologies & National Instruments**	
13:00-14:00	LUNCH	

THz technique, spectroscopy and applications (1st session) (TH) **Chairman: Prof. Sergey Vainshtein**		
14:00-14:40 **Plenary speech**	Sergey Vainshtein *University of Oulu, Finland*	**TH-1:** From miniature, low-power-consumption sub-THz emitter based on collapsing domain phenomenon to mm-wave pulsed radars and transmission/reflection imagers with sub-ps time-of-flight precision.
14:40-14:55	Martin Ayvazyan *National Polytechnic University of Armenia*	**TH-2:** Waveguide junctions with various cross sections for the Teraherts range
14:55-15:10	M. Klos, R. Bartholdt, J. Klier, J.-F. Lampin, Garik Torosyan, R. Beigang *Institute for Physical Measurement Techniques, Germany*	**TH-3:** Photoconductive antennas based on low temperature grown GaAs on silicon substrates for broadband Terahertz generation and detection
15:10-15:40 **Invited**	Alexei O. Orlov, Gergo P. Szakmany, Gary H. Bernstein, and Wolfgang Porod *University of Notre Dame, USA*	**TH-4:** Integrated nanoscale thermoelectric converters of Infrared and Terahertz irradiation
15:40-15:55	Coffee Break	
THz technique, spectroscopy and applications (2nd session) **Chairman: Prof. Seizi Nishizawa**		
15:55-16:25 **Invited**	Seizi Nishizawa, Eugene H. Morita, Takeshi Nagashima, Katsuko S. Furukawa, and Takashi Ushida *University of Fukui, Japan*	**TH-5:** Progressive THz spectrometric technologies applied for non-invasive evaluation of bio-medical tissues
16:25-16:40	Viataly Kalantaryan, R. Martirosyan, Yu. Babayan, H. Badalyan, S.Yayloyan *Yerevan State University, Armenia*	**TH-6:** What is the primary target of the action millimeter waves on biological objects?
16:40-16:55	Anahit Nikoghosyan, T. He, J.Shen, R.M. Martirosyan *Yerevan State University, Armenia*	**TH-7:** Dielectric anizotropy of human bone in spectral range 0.2 to 2.5 THz
16:55-17:10	Gevorg Abgaryan, Yu. H. Avetisyan, A. H. Makaryan, V. R. Tadevosyan *Yerevan State University, Armenia*	**TH-8:** Terahertz pulses generation via optical rectification in LiNbO3 crystal by step-wise phase mask

17:20-19:00

Sightseeing Tour

06 May, Friday

Alternative semiconductor materials, electronic devices (EL) **Chairman: Prof. Alexei Orlov**		
09:30-10:00 **Plenary speech**	Shunri Oda *Tokyo Institute of Technology, Japan*	**EL-1:** Silicon quantum dots for future electronics and photonics
10:00-10:30 **Invited**	Gyorgy Csaba, Gary Bernstein, Sharon Hu, Michael Niemier, Alexei Orlov, Wolfgang Porod *University of Notre Dame, USA*	**EL-2:** Nanomagnet Logic
10:30-10:45	Zhyrair Gevorkian, V. Gasparian, Yu. Lozovik *IRPhE, Armenia*	**EL-3:** Large Diffusion Lengths of Excitons in Perovskite and TiO_2 Heterojunction
10:45-11:00	Levon Hovakimian *IRPhE, Armenia*	**EL-4:** On electron holographic phase imaging of threading dislocations
11:00-11:15	Arsen Babajanyan, Sul A Choi, Kyungchul Kim, Hanju Lee, Barry Friedman, Kiejin Lee *Yerevan State University, Armenia*	**EL-5:** Pre-annealing effects on a pentacene organic thin film transistor with a polymer dielectric interface
11:15-11:30	Ashkhen Yesayan, Stepan Petrosyan, Farzan Jazaeri, Jean-Michel Sallese *IRPhE, Armenia*	**EL-6:** The effect of interface traps on electrical characteristics of nanowires and nanowire junctionless FETs
11:30-11:45	Arcruni Margaryan, Stepan Petrosyan, Lenrik Matevosyan, Karapet Avjyan *IRPhE, Armenia*	**EL-7:** Two dimensional coordinate-sensitive photodetectors based on (p)InSb - (n)CdTe heterojunction
11:45-12:00	Stepan Petrosyan, Varsenik Khachatryan, A. Yesayan, Suren Nersesyan *Russian-Armenian University, Armenia*	**EL-8:** Influence of surface recombination on the open circuit voltage of the nanowire solar cells with radial p-n junction
12:00-13:00	LUNCH	
Microwave devices, antennas, propagations and remote sensing (MT) **Chairman: Prof. Kiejin Lee**		
13:00-13:30 **Plenary speech**	Boris Kutuza Institute *of Radio Engineering & Electronics. Moscow, Russia*	**MT-1:** Principles of Earth Microwave radiometry from space
13:30-13:45	Artashes Arakelyan,, A. Hambaryan, A.A.Arakelyan *ECOSERV Remote Observation Centre Co. Ltd., Armenia*	**MT-2:** A new approach in local and global anti-hail protection technique

13:45-14:00	N. Khachatryan, Ruben Ter-Antonyan *National Institute of Metrology, Armenia*	**MT-3:** The new dual-reflector axisymmetric antenna with circular generatrix. The main reflector
14:00-14:15	Apet Barsegyan *Integra Technologies Inc., USA*	**MT-4:** 1.6-Kilowatt GaN-based L-band pallet Amplifier
14:15-14:30	M. Ivanyan, N. Khachatryan, E. Tagvoryan *National Institute of Metrology, Armenia*	**MT-5:** Features of radar cross-section determination using near-field measurements
14:30-14:45	A. Hakhoumian, N.G. Poghosyan, Tigran Zakaryan *IRPhE, Armenia*	**MT-6:** Estimation of Phase Noise Impact on MTI Performance in FM-CW Radars
14:45-15:00	A.Hakhoumian, T. Zakaryan, Eduard Sivolenko *IRPhE, Armenia*	**MT-7:** Pedestrian caused Doppler signal detection by bispectrum processing in Ku-Band coherent CW Radar
15:00-15:15	Edvard Rostomyan *IRPhE, Armenia*	**MT-8:** Dynamics of Buneman instability in plasma-filled devices for microwave generations
15:15-15-30	A. Margaryan, R. Ajvazyan, J. Annand, H. Elbakyan, L. Gevorgian, S. Zhamkochyan *Alikhanyan National Science Laboratory,*	**MT-9:** A radio frequency spiral scanning deflector for keV electrons
15:30-16:00	Discussion, Closing IRPhE' 2016	
19:00	Gala Dinner	

12:00-13:00, 05 May, Thursday

Poster Session	
A.S. Nikoghosyan, T. He, J.Shen, R.M. Martirosyan, M.Yu.Tunyan, A.V. Papikyan, A.A. Papikyan *YSU, Armenia*	**TH-9:** Optical properties of human bone and CERABONE® in the Terahertz range
A.S. Nikoghosyan, Sh. Arakelyan *YSU, Armenia*	**TH-10:** THz waves propagation in a LiNbO3 wedge antenna
D. Bagdasaryan, A. Hakhoumian, R. Martirosian, A. Makaryan, V. Tadevosyan, F. Nazari, A. Julfayan *IRPhE, Armenia*	**TH-11:** Ferromagnetic detector of infrared radiation

T. Abrahamyan, St. Sargsyan, A. Babajanyan, Kh. Nerkararyan *YSU, Armenia*	**PH-8:** Detection of resonant oscillations of the liquid surface by using a tapered fiber opto-mechanical sensor
S. Nerkararyan, A. Babajanyan, Kh. Nerkararyan, *YSU, Armenia*	**PH-9:** The resonant coupling of the quantum dots in the environment of metal nanoparticle at optical frequencies
R.V. Ter-Antonyan *National Institute of Metrology, Armenia*	**MT-10:** On radio physical design of the Dual-Reflector Radio Telescope with a fixed main spherical reflector and a movable subreflector type Gregory **MT-11:** Practically Interesting Subreflector for the spherical reflector located under Caustic
G. Avetisyan *IRPhE, Armenia*	**MT-12:** Change of flux density characteristic of the radio source Cassiopeia A for the period 2008-2015 years
O. Mahmoodian, A. Hakhoumian, N. Pogosyan and V. Mckhitarian *IRPhE, Armenia*	**MT-13:** Conical Bessel beam radial line slot antenna
S. Petrosyan, A. Yesayan, S.Nersesyan and V.A. Khachatryan *IRPhE, Armenia*	**EL-9:** Capacitance of MOS structures based on inhomogeneously doped semiconductor nanowires and nanospheres
S. Petrosyan, S. Nersesyan, A.Yesayan and V.A. Khachatryan *IRPhE, Armenia*	**EL-10:** Critical radius of full depletion in semiconductor nanowires
L. Matevosyan, A. Kechiantz, K. Avjyan, E. Zaretskaya *IRPhE, Armenia*	**EL-11:** Preparation technology and optical properties of $CH_3NH_3PbI_{3-x}Cl_x$ perovskite thin films

Photonics (PH)
Chairman: Prof. Shunri Oda

Control and Calibration of Photonics Integrated Circuits

Andrea Melloni

[1] DEIB - Politecnico di Milano, P.za Leonardo da Vinci, 32, Milano, Italy

The explosive growth of silicon photonics driven by datacenters, sensing, automotive and telecommunication applications demands the development of integrated photonic circuits (PICs) with unprecedented complex architectures. The current technologies already enable device miniaturization and aggregation of many photonic components and functionalities onto the same chip, yet the lack of suitable control technologies is today perceived as a "grand challenge" and major obstacle to the advent of large-scale photonic integrated systems. The photonic chip is becoming an increasingly complex system operating in a multiphysical dynamic environment together with electronics, radiofrequency, thermal management and microfluidics and sensing elements. Advanced tools are essential to reliably set, hold, control and steer the desired working point of the system through feedback-controlled algorithms.

The possibility to control the PIC is a key requirement for different reasons and in many applications: i) reconfigurability of the circuit to provide the required functionality such as in routers, cross connects, tunable bandwidth filters, reconfigurable add-drop multiplexers, etc.; ii) adaptively circuits that modify their behavior depending on the state of the system such as signal polarization state, signal to noise ratio, crosstalk, eye aperture, BER, etc.; iii) locking or stabilization of the circuit in a well defined state independently of the temperature, electrical fluctuations, drifts, stress, aging, etc; iv) compensation of fabrication tolerances and technological non-uniformities. All these requirements become even more critical when dealing with wavelength selective devices, such as microrings resonators, high bit rate signals operating in coherent domain, dense WDM systems and densely integrated PICs realised on semiconductor photonic platforms, such as silicon on insulator (SOI) or indium phosphide (InP). Local and global feedback control tools and strategies will soon become the ordinary way to operate even for simple circuits.

In order to realize a feedback control loop, light monitors and actuators are required, in addition to an electronic control unit and control strategies. Monitoring approaches based on conventional photodetectors are not effectively scalable to large-scale PICs due to the need for multi-point light tapping. In this work, we report on our recent achievements on the development of an in-line transparent integrated detector, named ContacLess Integrated Photonic Probe (CLIPP), that can monitor the light intensity in semiconductor waveguides without introducing any photon absorption in excess to the waveguide propagation loss and on the control strategies for PICs. Results shown in this work demonstrate the effectiveness of the non-invasive CLIPP technology for the feedback-control tuning, switching, and locking of silicon PICs.

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[2] S. Grillanda et al., "Light-induced metal-like surface of silicon photonic waveguides," Nat. Commun. 6:8182, 2015

[3] S. Grillanda et al., "Non-invasive monitoring of mode-division multiplexed channels on a silicon photonic chip," J. Ligthwave Technol., vol. 33, no. 6, pp. 1197-1201, Mar. 2015.

[4] S. Grillanda *et al.*, "Non-invasive monitoring and control in silicon photonics using CMOS integrated electronics," Optica 1, 129-136, 2014

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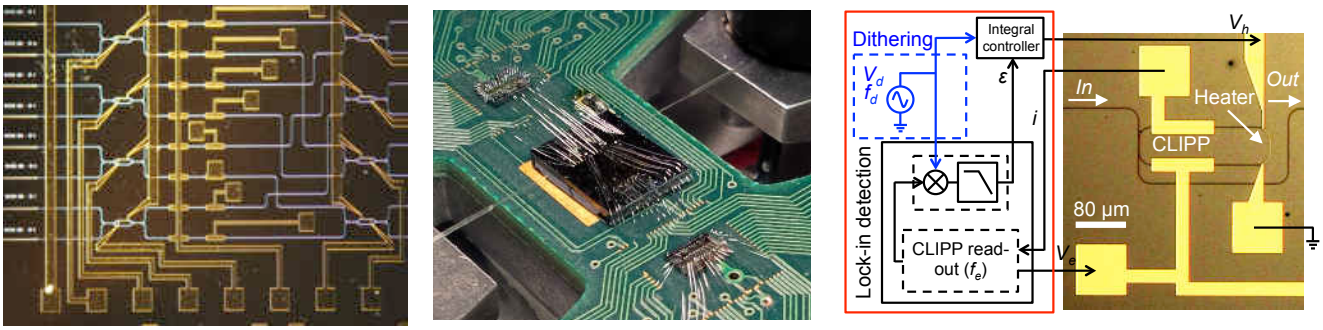

Fig. 1 – (from left to right) An 8x8 Silicon Photonic Router with heathers and CLIPPs, mounted on a PCB with two CMOS ASICs for the control and readout and a detail of a ring resonator with feedback control loop.

Three-axis optical Hanle vector magnetometer

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A concept of optical magnetometer for measurement of magnitude and direction of magnetic field in three orthogonal directions is developed. It is based on scanning of a *B*-field to compensate the measured field to the zero value, which is monitored by a resonant magneto-optical process in an unshielded atomic vapor cell.

As a physical process underlying this approach serves nonlinear Hanle effect [1] or any othermagneto-optical process in atomic vapor resulting in high-contrast zero-field resonance (maximum or minimum of recorded optical signalat $B = 0$).The non-shielded alkali vapor cell is placed in an assembly of three-axis magnetic coils. The measurement procedure implies fully computer-controlled steering of magnetic field produced by three coils towards the unique$\{B_X B_Y B_Z\}$ value$\boldsymbol{B}_{comp}$, which cancels magnetic field in the laser-vapor interaction region (opposite to measured magnetic field $\boldsymbol{B}_{meas}$).

Preliminary proof-of-the-concept measurement was done in two-axis configuration, employing nonlinear Hanle effect in a room-temperature PDMS-coated Rbvapor cell [2]. Magnetic field was linearly scanned at different rates for B_X and B_Y, controlled by a DAQ device (analog outputs). Simultaneously recorded fluorescence signal (analog input) monitored the optical response of the cell. The result of a typical 30-second-longmeasurement run is presented in Fig.1. Stability of laser radiation resonant frequency throughout the measurement was assured by a feedback-based DAVLL frequency locking scheme.

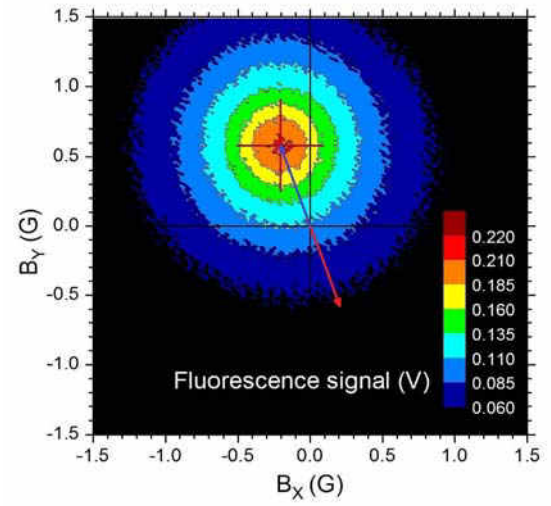

Fig.1. Contour plot of the Hanle fluorescence signal recorded on ^{85}Rb F_g=3 – F_e=4 hyperfine transition of D_2 line while 2-axis scanning of magnetic field in transverse plane from –1.5 to +1.5 G. The center of circular structure (red cross) corresponds to B = 0. The measured *B*-field vector in X-Y plane (B_X = +204 mG; B_Y = –581 mG) shown by a red arrow is opposite to the compensation field (blue arrow) [2].

Our current studies are aimed at development of a new, optimized *B*-field steering algorithm, which will allow to reach the compensation value of magnetic field at significantly smaller number of steps providing much shorter measurement time, as well as realization of a 3-axis version of the magnetometer.With proper optimization of experimental conditions, we expect to reach 5 μG, or 500 pT sensitivity level with ~ 1 s measurement time.

Compared with the state-of-the-art optical vector magnetometers, the proposed technique has lower sensitivity. Nevertheless, among its merits are simplicity and wide measurement range. It can find applications for compensation of an ambient magnetic field, for geophysical and material science studies.

This work is supported by the RA MES State Committee of Science, in the frames of the research project № 15T-1C277.

References

[1] A.V. Papoyan, M. Auzinsh, K. Bergmann, *Eur. Phys. J. D***21**, 63 (2002).

[2] A. Papoyan, S. Shmavonyan, A. Khanbekyan, K. Khanbekyan, C. Marinelli, E. Mariotti, *Appl. Opt.* **55**, 892 (2016).

Conditions of single-frequency radiation from fiber laser with FBG mirrors: numerical analysis by the method of single expression

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Single-frequency fiber lasers are specific light sources suitable for optical communication, interferometric sensing, coherent light detection and ranging, laser spectroscopy, etc. [1]. These lasers operate at only one longitudinal-mode permitting emission of quasi-monochromatic radiation of a very narrow linewidth and low noise. The suitable structures are distributed Bragg reflector (DBR) fiber lasers consisting of two fiber Bragg gratings (FBGs) at the ends of an amplifying fiber [2] (Fig.1).

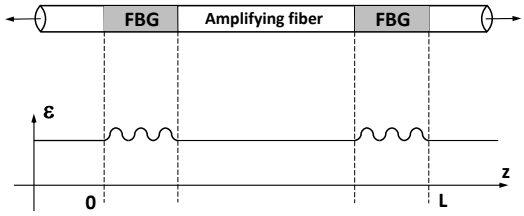

Fig. 1. Schematic of DBR fiber laser

To reach the single-frequency lasing the length of an amplifying fiber should be determined correctly via computer simulation. Since FBG mirrors are modulated structures which are inseparable parts of a lasing structure, then for resonant characteristics of the laser structure correct wavelength-scale numerical simulation is pertinent. For self-consisting numerical simulation the method of single expression is used [3,4]. In the modelling, initially, at the central wavelength of FBGs, known as Bragg wavelength, transmission spectra of DBR fiber laser has been analysed for different lengths of the fiber between FBGs at the absence of loss or gain. Starting from the minimal length of the fibre, full transmission at the Bragg wavelength is obtained for the row of increasing lengths of the fiber. Inclusion of the specific value of gain in the amplifying fiber of these lengths has permitted to obtain radiation along the fiber. At the other wavelengths multiple transparency peaks not corresponding to radiation are observed. An existence of one dominant mode radiation at the Bragg wavelength is explained by the optical field distribution within the resonator. Maximal field amplitude within the active fiber is observed for the resonant Bragg wavelength only. At this wavelength maximal reflection of DBRs and maximal Q-factor of the resonator are obtained. In the conclusion, a possibility of single-frequency radiation from DBR fiber laser at the specific lengths of the amplifying fiber has been obtained by the correct wavelength-scale simulation.

References:

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Microwave and Joule heating visualization by thermo-elastic sensor for carbon fibers composite material

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Visualization of microwave heating in Carbon fiber/poly ether ether ketone (PEEK) composite material was implemented using thermo-elastic sensor. Losses corresponding to the anisotropy of the composite material were characterized by the microwave radiation thermal influence on it. Joule heating made by direct current flux was observed by the anisotropy behavior of the materials. Theoretical model investigated by COMSOL Multiphysics simulations for quantitative comparison of measurements. Theoretical model was in good agreement with simulations and experimental results.

Slot Nano-Antenna Integrated with Plasmonic Waveguide

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Optical antennas, analogues of microwave antennas, are a new concept in physical optics which enable technology for manipulating optical radiation at subwavelength scales [1,2].
Plasmonic slot nano-antenna coupled with plasmonic waveguide is considered (see Fig.1). Various types of slot antenna shapes (rectangular slot antenna- magnetic dipole, triangle slot antenna- bowtie slot antenna) are investigated, as well as numerical investigation of 3D structures based on finite element method (FEM) is realized.

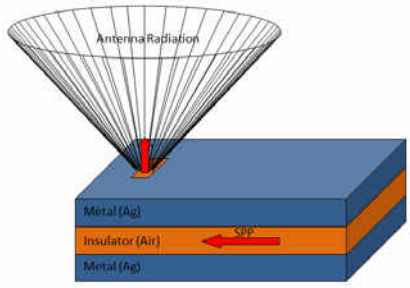

Fig.1. Schematic view of slot nano-antenna radiation coupled with plasmonic waveguide.

The slots near-field interaction is basically realized via magnetic field, unlike dipoles. This fact opens up new possibilities of slot antennas application in optical range, such as improvement and investigation of fine and quadrupole interactions and transitions, quadrupole excitation of nucleus. As the slot-type antenna can be combined with any plasmonic components made on a metallic plane easily, we expect that the slot nano-antenna will be integrated further with other plasmonic devices and play an important role in plasmonic integrated nano-circuits in the future.

According to the theory developed in [3] an additional electrical field is appears in the wire due to imperfect conductivity of metal. Based on Babinet's principle by applying $E \leftrightarrow H$, $Z \rightarrow -1/Z$ interchanges radiated field distributions is found for slot antenna [4].

One of the key parameters of antenna theory is the antenna efficiency, which characterize the antenna and waveguide impedances matching. The impedance matching between antenna and waveguide is calculated by using standing wave ratio (SWR) parameter. Based on SWR calculations coupling efficiency of slot antenna and waveguide is estimated depends on slots and waveguide sizes distance between slot antenna and waveguide as well as dielectric constants filled waveguide and slot.

References

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Detecting of complex modulated optical signals and optical modulation analysis for gigabit and terabit transmission lines

V. Morarenko [1]

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In on/off keying (OOK), we are able to detect the signal simply with a photodiode, which converts the optical power into an electrical current I_{Photo}. However, the result only contains the amplitude (Fig. 1).Thus, the QPSK signal in the time domain on the right side cannot be directly mapped to the IQ diagram on the left without ambiguity.

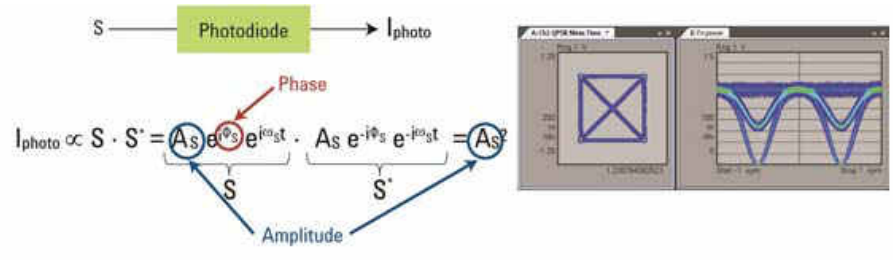

Fig. 1. In direct detection, the photo current I_{Photo} only provides information on the light amplitude.

The key to solve both problems lies in measuring not the absolute phase but the phase relative to a known reference signal. Figure 2 gives, for the case of a QPSK signal, an idea of the whole setup, which is called an "IQ demodulator".

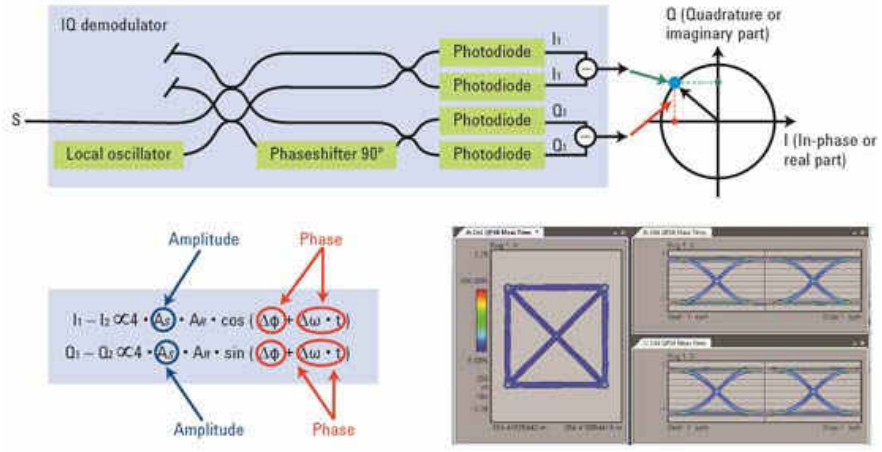

Fig. 2. IQ demodulator providing two independent measurements that both contain information on amplitude and phase.

Then, with **real-time sampling,** we can reconstruct the complete signal in all domains and without limitations regarding the modulation format. At the same time, we have to be aware that we need four-channel high-speed equipment for this approach, such as a high-performance real-time digitizer with very low jitter and noise and a high effective number of bits (ENOB) over the whole frequency range.

The Keysight's N4391A optical modulation analyzer is optimized for analysis of these kinds of new optical modulation formats. It supports transmission rates of 40/100 G and beyond. For example, if two N4391A are combined together, it will be possible to achieve a 126 GHz frequency span and analyze terabit signals.

Bayesian network-based intermittent fault detection in photonic systems

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Photonic circuits and systems usually have fewer components than electronic circuits. However, the interactions of the components can be complex. The failure of the optical and digital circuits has created a lot of concerns in testing these devices. There are many sources of faults in photonic systems depending on the nature of the components used. The component fault sources may be classified into, (i) hard faults and (ii) intermittent faults. Hard faults are mainly due to permanent component failures, such as the break of a fiber connection, and the damage of a laser source or a photodetector. These defects cause hard faults that can easily be isolated. Intermittent faults occur because of aging connections in circuit points that fail intermittently long before they fail permanently. Approximately 50% of all system malfunctions are intermittent failures. Hence, the challenge is detecting, isolation and predicting the intermittence as early stages as possible to avoid any major breakdown to the system. Early intermittent fault or failure detection will support the activity of the system and may help the system on performing a certain action to solve the problem that will occur.

The first step in developing a realistic intermittent fault detection model is to review the variation types of defects and their root causes and effects. Typically, if a connection is defective, it is most likely due to a break in the cable. Nonetheless, if the connection is intermittent, there are various possible causes:

- The cable's attenuation may be too high because of poor quality splices or too many splices.
- Dust, fingerprints, scratches, and humidity are among the reasons of connector contamination.
- Low transmitter strength.
- Bad connections in the wiring closet.
- The faulty connection of fiber to the patch panel or in the splice tray.

Break or open fiber typically occur more frequently than intermittent faults and have great consequences, but these are easily detectable.

This paper demonstrates a novel fault detection approach for intermittent faults, Bayesian network, in photonic circuits and systems. These include both passive as well as active components. Bayesian network is a graphical probability model for representing the probabilistic relationships among a large number of nodes and probabilistic inference with them. Bayesian network provides a framework for addressing problems that contain uncertainty and complexity. Over the last decade, the Bayesian network has become a popular representation for encoding uncertain expert knowledge in expert systems which can readily handle incomplete data sets and allow learning about their relationships.
In this paper, the measurable nodes of the Bayesian network correspond to states of measurable parameters in the system, and immeasurable nodes represent the intermittent failure of various components. Nodes for environmental factors are also contained. Then the probability of the intermittent failure of any of the components, given the present state of the system under investigation will be accurately estimated.

Detection of resonant oscillations of the liquid surface by using a tapered fiber opto-mechanical sensor

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Ground resonant oscillations measured by using optical signal radiated from a gold-covered tapered fiber located at air-liquid interface. The intensity of the output signal is strongly depend on the position of the tip to toward air-liquid interface and varied with surface vibrations. The phenomenon permits to real-time detection of nano-metric oscillations of the liquid surface and provides the basis for development of various sensitive opto-mechanical sensors.This method can be used for detection of week mechanical vibrations in order of 50nm such as seismic waves and the modeling of the processes occurring on the water surface of the Earth. Another application of this detection method can be the gas sensors because the adsorbed gas molecules will change the effective refractive index of the external dielectric layer (waveguide) providing the energy transfer between two waveguide modes and enhancement of the output signal.

The resonant coupling of the quantum dots in the environment of metal nanoparticle at optical frequencies

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We investigated the phenomenon of resonant transfer of the excited energy between quantum dipole emitters (QDEs) by the localized plasmon polaritons (LPPs). As the QDEs in system are the molecules or semiconductor quantum dots and as the LPPs care the nanometer size metal particles (NMPs). The dependence of the frequency of Rabi oscillations on system parameters (the distance between NMP and QDE, the radius of NMP and dielectric permittivity of the surrounding media) is determined. It is defined the condition when the period of Raby oscillations is considerably shorter than system relaxation time. The process can be observed in fluorescence spectroscopy through the splitting of emission peaks. Strong coupling is an important ingredient for future plasmonic based quantum information schemes and might play a significant role in biosensor applications.

Wireless communications and related information technologies (WL)

Chairman: Prof. Garik Markarian

From Quality of Service to Quality of Life: How Advances in Wireless Technologies Found Their Way in Modern Healthcare

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In this presentation we reflect Prof. Radik Martirosyan's influence on the creation and the development of the Laboratory for Problem of Information Transmission within the Institute of Radiophysics and Electronics and its expansion beyond the boundaries of the Institute.

We also show how research interests of members of the laboratory expanded reflecting modern trends in Information Theory and present our latest results in the field of wireless technologies for ambient assisted living. With aging population and improved healthcare, governments all the world are facing very similar problem – how to provide efficient healthcare in the environments where traditional methods are no longer feasible and economically viable. The current consensus in focused on shifting provision of healthcare services to homecare environment, however, this raises obvious questions covering a wide range of challenges from legal to technological to ethical and clinical.

In our research, which is a collaborative research conducted in close collaboration with clinicians from South Manchester University Hospital (SMUH), we demonstrate that traditional approach, known as telemedicine or m-HEALTH needs to be reviewed, ensuring the delivery the required quality of healthcare. In addition to ensuring reliable communication protocols for biometric data transmission, special factors such as risk prediction, trust of the received data, ethical issues, safety and security, nurse-machine interfaces need to be taken into account and incorporated within the system architecture.

We will present a novel concept of risk prediction and mitigation for cardio vascular intensive care units, called IRIS. The IRIS system utilizes the latest advances in wireless broadband communications, Bayesian networks and data mining to provide risk prediction scores for cardiac patients. In the main paper we will present the overall concept, supported by the overall system architecture and the first results obtained during clinical trials at the SMUH. We also will discuss ideas for future research and possible collaboration with researchers from Armenian National Academy of Sciences

Defining a Channel Sounding MeasurementSystem for Characterization of 5G Air Interfaces

Maksim Sokovishin[1]

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With its aggressive performance goals, the emerging 5G standard will almost certainly incorporatea combination of millimeter-wave (mmWave) frequencies, ultra-broad bandwidths and massivemultiple-input/multiple-output (MIMO) methods. Although each of these adds difficulty to the designof transmitters and receivers, the most significant unknowns are in the over-the-air radio channelsbetween user equipment (UE) and base station (BS). To fully characterize the channel (see figure 1), it is necessaryto create mathematical models of channel performance and use them to define new air interfacestandards for 5G.

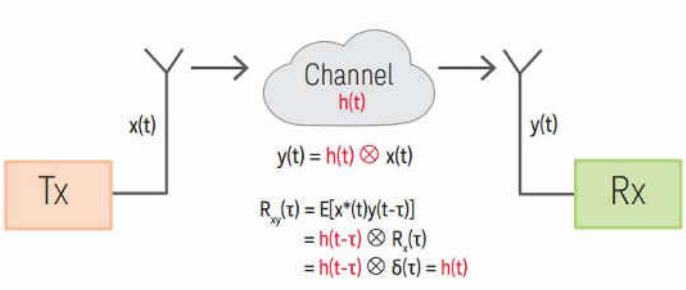

Fig. 1.Approximate mathematical model of the RF radio channel

Drawing from the preceding comparisons, Keysight's preferred approach uses widebandcorrelation as the baseband sounding technique and switched-transmit/parallel-receivefor assessing MIMO data capture. could increase the total measurement speed with minimal cross-channel interference.Figure 2 illustrates the basic architecture. On the left, the transmitter side includesa single-channel wideband signal generator and mmWave switch. On the right, thereceiver side provides parallel signal acquisition with a wideband multi-channel receiverthat can be implemented using high-performance digitizers or wideband vector signalanalyzers.

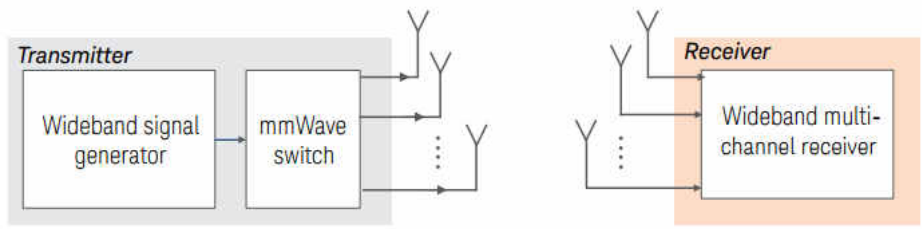

Fig. 2.The basic implementation of the switched-transmit/parallel-receivearchitecture

To achieve precise results, system synchronization and calibration are required. Thechannel sounding system must be capable of measuring and characterizing its ownphase and amplitude impairments and compensating for the following issues: inter-channel phase errors, antenna errors in amplitude and phase, I/Q mismatch errors, spectral flatness errors.

The various channel parameter estimation algorithms can be categorized to 3 types: beamforming based, subspace based, maximum likelihood (ML) based algorithms. The beamforming based algorithms are simple with poor estimation performance. Thesubspace-based algorithms have good performance, but the maximum number of pathsthe algorithm can estimate is less than the number of receiving antennas, thus thesealgorithms cannot work well for more complex channel scenarios. The ML based algorithm (e.g. SAGE) is well accepted and widely used due to its highestimation precision and its capability of joint parameter estimator for multiple

channelparameters, what's more, the maximum estimating path number is not limited by thenumber of antenna array elements. In general the setup based on the metrology grade equipment is shown on figure 3.

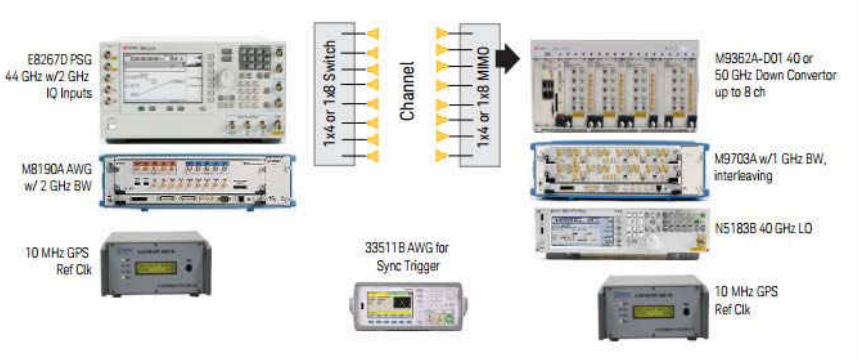

Fig. 3.Keysight 5G channel sounding reference solution
(the transmitter subsystem is on the left and the receiver subsystem is on the right)

By implementing real-time correlation processing in the digitizer's (M9703A) embeddedFPGA, the resulting data compression enables storage into onboard memory. Thecaptured CIR signals can be transferred in real time through the PCIe bus. Figure 4 shows an example screen from the SystemVue 5G verification library that isused to specify instrument configuration for CIR data capture and post processing ofchannel parameter estimations. Using those tools and the pictured system produced thechannel parameter estimation results could be extracted and then processed with the SystemVue or separately.

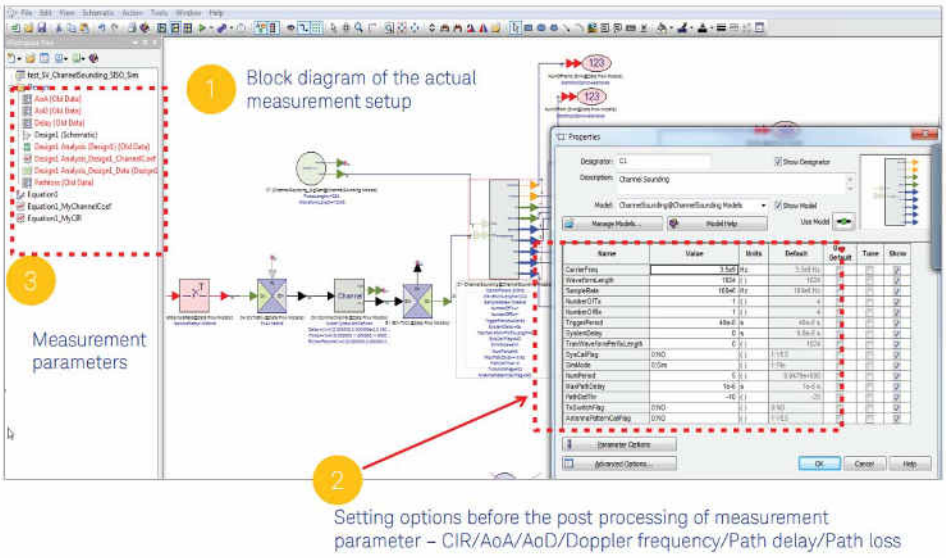

Fig. 4.Extraction of path loss, path delay profile, AoD, and AoA in SystemVue

With its aggressive performance goals, the emerging 5G standard will incorporate achallenging combination of technologies. Although these present challenges are in thedesign of transmitters and receivers, one of the most significant unknowns is in theover-the-air radio channels at mmWave carriers. To fully characterize and understandthese unknowns, it is necessary to create mathematical models and use them to define anew air interface standard.

Keysight's reference solution uses wideband correlation as the baseband soundingtechnique and switched-transmit/parallel-receive for MIMO data capture. This providesthree important advantages: fast measurement speed, MIMO sounding capability and fully characterized high-level measurement performance.

WLAN at 60 GHz. Signal creation and demodulation

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[1]*Keysight Technologies, Moscow, Russia*

The unlicensed frequency band 60 GHz is available everywhere in the world. This range permits higher channel bandwidths for greater throughput. The small wavelengths make possible to use compact antennas and beam forming.

The 802.11 WLAN standard has been continuously updated to permit higher throughput. 802.11ad covers the frequency range at 60 GHz. The WiGig standard was fully integrated into 11ad.

When testing 60 GHz wireless signals, one of the biggest challenges is creating test signals with 2 GHz modulation bandwidth, which is up to 100 times wider than that of the IEEE 802.11ac standard. Our latest generation of arbitrary waveform generators can meet the challenge: the standalone Keysight 81180B 4.6 GSa/s AWG instrument and the AXIe-based Keysight M8190A 12 GSa/s AWG module (Fig. 1).

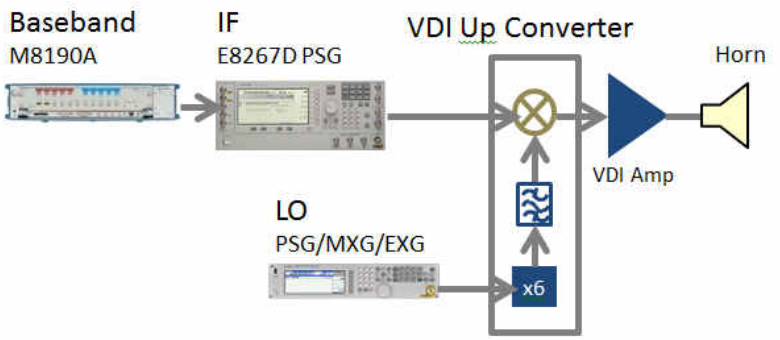

Fig. 1

A custom-designed down converter such as the N1999A provides frequency translation to the IF band. For excellent signal analysis and modulation analysis, consider a Keysight Infiniium 90000 X Series oscilloscope—with up to 32 GHz analog bandwidth—and the Keysight N9030B PXA signal analyzer with frequency coverage that reaches up to 50 GHz and can be extended to 325 GHz and beyond using external mixing (Fig. 2).

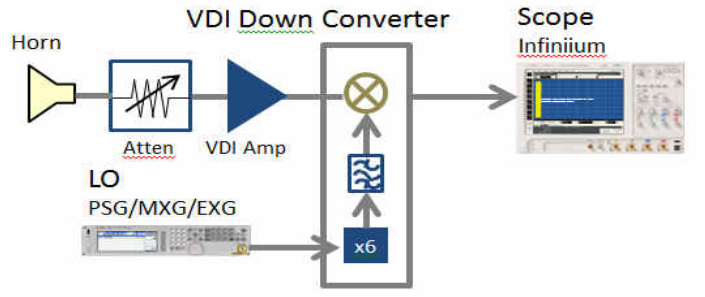

Fig. 2

These instruments are compatible with the industry-leading Keysight 89600 vector signal analysis (VSA) software. The 89600 VSA supports more than 30 hardware platforms and can run on a PC or inside newer Keysight instruments based on Windows. The VSA software supports more than 70 signal formats, provides advanced demodulation capabilities, and performs measurements of EVM and other important signal characteristics.

Mobile Wireless Communications Test and Measurement Technologies Development Toward 5G

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The latest market research reports show that the expected monthly global mobile data traffic willbe 30.6 exabytes by 2020, an eight-fold increase over 2015. Some of the key factors driving such exponential growth in mobile data traffic are availability of low cost smart phones, increased Internet penetration, advent of over-the-top (OTT) social networking applications and increased share of video content in mobile data traffic. Demand for higher data bandwidth puts a considerable pressure on technology and equipment manufacturers; but it puts an even greater pressure on the Test Measurement equipment industry to be the first to supply such equipment to the former industry.

The key intent of this paper is to outline the new technologies and efforts being put forward to tackle such high data traffic, which will otherwise create bottlenecks on access, as well as backhaul, networks.
In this paper we discuss the latest developments and challenges in LTE/LTE Advanced technologies and the role of 5 Component Carrier (5CC) aggregations along with 256 QAM modulation toward 5G. We shall also cover other various data offloading and aggregation technologies between cellular and non-cellular networks, such as LTE-Wi-Fi Aggregation (LWA), Wi-Fi offload (S2A, S2B, and S2C), unlicensed band LTE (LTE-U), and License Assisted Access (LAA) technologies.

One of the recent technologies introduced toward 5G, in order to add a strong backbone to the LTE Network (NW), is five-carrier aggregations along with 256 QAM modulation techniques, as part of a throughput-enhancing technique. In this case, five Carrier Components (CC) are aggregated together, creating a total aggregated bandwidth of 100 MHz and DL throughput of 1 Gbps. This is a major step towards 5G technology.

A new alternative LWA for LTE and Wi-Fi interworking is data aggregation at the radio access network, where an eNB schedules packets to be served on LTE and Wi-Fi radio links. The advantage of this solution is that it can provide better control and utilization of resources on both links. And no extra Wi-Fi core NW is required for this solution.

The third section coversWi-Fi Offload technology. Thisis the interworking technology between LTE and existing Wi-Fi NW to offload cellular traffic over Wi-Fi NW. In this case a Wi-Fi core NW works with LTE EPC for SIM-based authentication and data transfer between UE and P-GW through a Wi-Fi NW. The existing backhaul (home Wi-Fi and infrastructure Wi-Fi) can be re-used by operators to communicate with customer core NW and for data traffic.

In the next section we discuss the utilization of the LTE unlicensed spectrum. For short range radio transmissions there is enough unlicensed spectrum available around the globe. These bands are called ISM (Industrial, Scientific and Medical) bands. 3GPP Release 13 specification forLTE-U talks more about theutilization of unlicensed spectrum for indoor LTE coverage (Home-eNBs). This will provide the advantages of cost-effectiveness of unlicensed spectrum and robustness of LTE technology.

The final section focuses on LAA (Licensed Assisted Access)technology, which comes into the picture when we have the advantage of LTE licensed cellular NW and LTE Home-eNB with unlicensed spectrum co-existing in the NW. 3GPP Rel13 talks about aggregating both the spectrums(licensed and unlicensed) to maximize the throughput. All the above network architectures are designed to increase user experience and reduce deployment cost. In addition to this, the focus is gradually shifting towards Network Function Virtualizations (NFVs) for high availability, scalability, low maintainability and reduced cost. With so much going on in the telecomms world, with new technologies/specifications being introduced so frequently, the job of network test equipment manufacturers is even tougher as they have to lead this race and keep ready with their test equipments so that operators and vendors can test and deploy their equipment.

National Instruments Technologies in 5G Research and Prototyping

Suren Eyramjyan

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National Instruments (NI) is collaborating with top researchers focused on wireless research, specifically 5G wireless communications. The graphical system design approach combines LabVIEW Communications System Design software with the software defined radio (SDR) platform to help researchers innovate faster. Using this approach, engineers can reduce the time from theory to results by testing their designs in a real-world environment.

The company provides appropriate platform solutions for all modern vectors for 5G research, including Massive MIMO systems, mm-wave band utilization, Physical Layer Enhancement (or New Waveforms) and Dense Wireless Networks.

Security Challenges of Cloud Computation

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The emerging cloud technologies opened a new era in information storage and processing. Nowadays many companies and individuals are using public cloud storages such are Dropbox, Box, and Google Drive, to store their data instead of using private data storages. To avoid the security risks the user should store its data in the encrypted form. This will protect the data security in untrusted environment such as cloud, but will significantly change the user's experience as they will not be able easily access any data by making search. To solve this problem new directions in cryptography have been emerged investigating the search possibilities over encrypted data. Two main directions can be distinguished, namely, so-called Secure Pattern Search and Searchable Symmetric Encryption.

1. The first important direction in this area is the Secure Pattern Search in the specific file or string. There is a Secure Database (SB) and different users need to search over SB for a specific data string. The objective of this search is twofold: firstly any user searching for a specific data string in SB should only get YES/No information exposing the existence of his queried string in database no other information in addition, secondly SB owner should not get any information what specific data string was searched. However secure pattern search is an advanced setting not employed yet in practice as the known solutions for this problems are not practical since they require to employ computationally expensive public key operations which makes existing solutions highly impractical.In general this novel secure search engine will allow to search over encrypted data without tracking user's behavior.

2. Searchable Symmetric Encryption technology allows the data owner to protect its data consisting of many different files by using a symmetric encryption in the way that it is still possible to search over encrypted data in the case when all encrypted data is stored in the remote server (the cloud), at the same time allowing the cloud to learn as little as possible information about the search results.In nature the data owner creates a special encrypted index related to his files and stores the index among with the files in the cloud server. Later on the data owner will be able to send special search tokens corresponding to some keyword to the cloud and the cloud can search

and get all the files containing the keyword. Consequently, the cloud should not learn anything about the searched keyword itself.

Because of its practical significance a Searchable symmetric encryption (SSE) has been an active area of research and development during the last decade. Besides some results mostly theoretical in nature the main focus was concentrated on practical SSE schemes. Any practical scheme obviously should render a reasonable tradeoff between the following properties: search time, security, compact indexes and the ability to efficiently update the database i.e. add and delete files.

From the other hand, the emerging cloud technologies require more efficient and more functional cryptographic primitives for security management and particularly key exchanges between cloud applications, software as a service providers and end users. We are developing a special cryptographic primitive called white-box cryptography which comes to replace the standard public-key cryptography.

3. White-box cryptography (WBC) is a relatively new cryptographic discipline developed in last decade which allows transforming any block cipher to public key encryption scheme resulting to about 1000 times more efficient system compared with traditional public key schemes such as RSA or El-Gamal. WBC had found numerous applications in DRM systems widely used by Apple, IRDETO, NetFlix. Our own scientific research has shown its applicability in different security protocols including the secure pattern search application. The development of secure white-box scheme is a very challenging task. The major problem with WBC is its security. Up to date all publicly known WBC systems have been broken. We intend to develop a novel approach to the design of WBC systems with provable security,

Spectral Efficiency Improvement in Nonlinear Wireless Systems

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Nowadays the improvement of spectral efficiency (SE) in wireless system is one of the most important problems. Traditional method, allowing to improve SE, is the increasing of modulation order.On the other hand, the higher the modulation order, the sensitive the modulated signal against nonlinearities.

Another approach to increase the system effectiveness are techniques, allowing to improve the SE. Different methods to improve the system SE exist, examples of these methods are Faster-than-Nyquist (FTN) technique [1-3], Time-Frequency (TF) packing technique and so on. The improvement of SE can be also reached by using simpler methods such as reducing the roll-off factor of transmitter shaping filter and/or increasing the signal baud rate [4]. However, it should be noted that the using of above-mentioned simpler techniques increases the inter-symbol interference (ISI). To moderate the impacts of increased ISI, the more complicated receiver systems shall be used, including sophisticated equalizers. The improvement possibility of spectral efficiency (SE) in nonlinear wireless system, particularly in the DVS-S2(X) satellite systems, using time-frequency packing (TF-packing) technique is demonstrated.

The common method of calculating achievable spectral efficiency (ASE) as achievable information rate (AIR) per bandwidth is complicated from the engineering point of view, since the AIR shall include a complex Gaussian probability density function. Instead, a new less complicated calculation method of ASE based on bit error rate (BER) estimation is proposed. In addition, the ASE working bounds and calculation accuracy are clarified. To achieve the enhancement of SE, the equalizer is designed and applied on the receiver side. Based on numerical calculations of proposed method, ASE improvement is demonstrated for different nonlinearity scenarios in DVB-S2(X) systems. The obtained results show that the ASE reaches its maximum value at time packing factor-TPF≈0.7. As example, the ASE for 16APSK modulation is about 5.5 that exceeds the level, maximum achievable for orthogonal signaling by 1.5. For 32APSK modulation, the ASE at TPF≈0.7 exceeds the orthogonal signaling for at least by 0.5. It is also worth to mention that SE improvement is harder to achieve with increase of nonlinearity of the system, which is predictable, since the nonlinearity negatively affects the behavior of the overall system and, particularly, the operation of equalizer.

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Green Communication for GSM Network

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Power consumption is currently one of the major challenges faced by mobile operators. Recent explosive growth of smartphones market adoption and the consequent mobile internet traffic requirements have prompted waves of research and standard development activities to meet the expected future demands in an energy-efficient manner. Wireless access networks will be a major component of the communication infrastructure required by other "green" solutions for the efficient management of energy including remote monitoring, control and smart administration. In this paper we present the important issue to enhance the energy consumption efficiency of cellular network without compromising coverage and users perceived Quality of Service (QoS). The reason is twofold. First, mobile operators need to reduce their operational energy bill due to recent dramatic increase in energy costs. Second, there is a request of environmental protection to reduce CO_2 emissions. Today's mobile network have a strong potential for power saving. Most of consumed energy on the mobile networks (about 70%) is related to Radio Access Network (RAN) defining relation among power consumption, carried traffic and the coverage area. Therefore, power consumption in the RAN (BTS sites) is an important factor in the cellular network. Today's running cellular networks have been designed to maximize coverage area, traffic while energy consumption efficiency has not yet played a prime goal. Since about 65% of energy of cellular network is consumed by the BTS macrocells sites we consider three following components for power reduction:

- BTSs includes scheduler which operate according to the traffic load dynamically. BTS may turned on and off (soft sleep mode) according to the dynamic of traffic load.
- Cell zooming scalability as a function of traffic load, channel condition and required data rate.
- About half of energy in the Remote Radio Unit (RRU) consumes in the Power Amplifier (PA) while power consumption in 3G CDMA networks changes linearly as a function of bandwidth and signal quality which requires a high quality PA.

A significant amount of energy today is wasted by not having appropriate BTS site soft sleep mechanism in place. Regular approach, i.e. maximum load scenario is a rather rare case in typical network deployment. Most of the time the network infrastructure is operated with semi load efficiency leading to a significant waste of energy. It is essential to have optimal loads sizing, accurate data on BTS load pattern as well as potential renewable energy sources (basically PV solar and Wind) especially in rural area. We study these relations and algorithms to approach green communications in this paper. This study is based on the number of BTS, their configuration and topologies have been deployed in Orange Armenia GSM Network.

Renewable Hybrid Off-Grid Power Solution for GSM Network

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This paper gives an overview of existing power network of BTS sites of Orange Armenia and present technical and economical assessment for proper selection of technologies on Hybrid efficient power system as a backup DC power supply in the urban and rural areas.

Typical GSM network can be viewed as composed by three different sections:

• Mobile Switching Center (MSC)

• Base Transceiver Station (BTS)

• Mobile Terminals, normally limited to the hand-held devices.

The key elements are the BTSs because their contribution is the most relevant for the total energy consumption. The power consumption per function within the BTS site can be differentiated as follows: more than 60% of the power is consumed by the radio equipment and amplifiers, 11% is consumed by the DC power system and 25% by the cooling equipment (air conditioning unit). Therefore it is very important to consider BTS energy savings strategies applied both to the radio equipment, i.e. radio "standby" mode and to the cooling, i.e. passive cooling (free cooling) and advanced climate control. Hybrid Off-Grid systems are particularly well-suited for applications in rural remote areas, where electric utility service does not exist or unstable grid power supply. In comparison with the costs of High Voltage Line (HVL) extension or the high costs of fuel delivery to remote locations and site maintenance costs, hybrids can offer several benefits to telecommunication operators particularly: Decreased fuel consumption by 30–90%, decreased grid energy consumption by 30%, Save massive BTS outages (around 70%) due to Genset failures, environment friendly, extended maintenance and replacement intervals (diesel Genset typically accounts for 30% of the total OPEX of a BTS site). The Renewable Hybrid BTS site consist of Solar Photovoltaic Panels which converts the Sun light into electrical energy and charge the 48V Battery bank during the day time. An efficient MPPT solar charge controller is used to maximize the power output from the PV modules to charge the battery bank. Control logic developed to utilize the different energy resources in efficient techniques and keep the battery fully charged by providing priority to solar charging and using Utility power or Diesel Generator power in the absence of solar power. This study is based on the Eltek's high efficiency Hybrid Solution have been deployed in Orange Armenia GSM Network. The Benefits of Eltek's Hybrid Power Solution are as follows:

- Up to 75% OPEX reduction
- More than 96% rectifiers/solar chargers efficiency
- Reduced CO_2 emissions
- Reduced service maintenance
- Fully integrated of all energy sources: Grid, Solar, Wind, Diesel Genset

THz technique, spectroscopy and applications (TH)

Chairman: Prof. Sergey Vainshtein

From miniature, low-power-consumption sub-THz emitter based on collapsing domain phenomenon to mm-wave pulsed radars and transmission/reflection imagers with sub-ps time-of-flight precision

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Pulsed radars with sub-ps precision widely used in radio and optical frequencies do not exist in millimetre-wave range, despite penetration of this non-ionizing radiation through various dielectric objects (clothes, packages etc.) and spatial resolution of ~1 mm is interesting for non-destructive tests, security (narcotics, plastic explosives), biomedicine (cancer detection) and gives sometimes the contrast where X-ray fails. The reason is in lacking of miniature pulsed (ps -range) semiconductor (all-electronic) sources with simple construction, high efficiency and potentially low price.

We have suggested unique, pulsed, high-speed, miniature sub-THz emitter based on a phenomenon found in a bipolar GaAs structure. Powerfully avalanching and shrinking down to nanometer size "collapsing" field domains appear due to negative differential mobility at extreme electric fields and cause sub-THz emission [1]. Huge power density resolves main trade-off of solid-state sources, when maximum emission power is limited by shunting effect of the capacitance. Achieved sub-psstability of the generated sub-THz pulse has allowed us ~0.1 ps temporal radar precision to be achieved and prospective applications to be demonstrated in both propagation and reflection imaging modes.

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Waveguide transitions with various crossections for the terahertz range

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It is proposed that, in the terahertz wavelength range, waveguides of the class "hollow dielectric channel" be used as a guiding system. When constructing circuits for various purposes it is necessary to use various waveguide junctions with the cross-sectional dimensions of the inlet and outlet. In this wave of higher types emerge in the case of multi-wavelength waveguides. In such devices, the working mode conversion to the higher wave types should be minimal. Application of Velden Zakson method allows to calculate the level of transformation of the operating mode to higher wave types and basic dimensions of the proposed conversions.

Keywords - *terahertz range, a waveguides of a class "hollow dielectric channel", losses, self-filtration, working mode, higher types of waves, crossection*.

Photoconductive Antennas Based on Low Temperature Grown GaAs on Silicon Substrates for Broadband Terahertz Generation and Detection

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We present investigations of photoconductive antennas based on low temperature grown GaAs (LT GaAs) on silicon substrates for terahertz (THz) generation and detection. The antennas consist of 2 μm thick layers of LT GaAs bonded on a high resistivity silicon substrate in order to reduce the intrinsic absorption losses around 8 THz due to a strong phonon resonance in GaAs. Our test system for terahertz generation and detection consists of a typical time domain spectroscopy setup pumped with 20 fs long laser pulses around 800 nm and dipole antennas with dipole length between 20 μm and 60 μm. A full bandwidth up to 10 THz and a maximum dynamic range exceeding 90 dB at 0.5 THz have been obtained. It has also been shown that compared to regular PCAs fabricated on a GaAs wafer, a clear increase in bandwidth with a dynamic range of more than 50 dB at 5 THz have been obtained. The average terahertz output power as a function of the applied voltage and optical pump power has been measured with a calibrated detector. Saturation features and output powers up to 100 μW have been demonstrated for a repetition rate of the pump laser of 80 MHz.

Integrated Nanoscale Thermoelectric Converters of Infrared and Terahertz Irradiation

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Long-wave infrared (LWIR) and THz detectors are of special interest due to the blackbody radiation of objects at room temperature. These detectors can be used for imaging applications such as hidden objects and defects identification and medical diagnostics. The operating principle of the thermoelectric electromagnetic irradiation detectors (TEID) is based on the absorption of the electromagnetic energy that is converted to heat, which is then converted to a measurable electrical signal. Antenna-coupled devices exploit the wave nature of the IR and THz radiation. The design of the antenna determines the spectral, polarization, and directional properties of the TEID. Unlike bolometers, which require read-out current for operation, thermocouples are active devices having a direct heat-to-electricity transfer function. In antenna-coupled thermocouples, the radiation-induced antenna currents heat the hot junction of the thermocouple, which is converted to a measurable electrical signal by the Seebeck effect. The thermoelectric converter is either thermally connected to the antenna, or the converter itself is a part of the resonant absorber. The downscaling of such devices enables a very short response time ($t < 100$ ns), and the ability to fabricate these devices from single-material nano- thermocouples with a cross-sectional discontinuity reduces the fabrication complexity. Moreover, by combining a thermocouple and a resonant absorber in one element, it is possible to fabricate a device with a symmetric, bipolar, polarization-dependent signal with maximal absolute values corresponding to two orthogonal polarizations of the incident irradiation. Experimental results of TEIDs operating at LWIR (10.6 μm) and THz (500-600 μm) frequencies are presented.

Progressive THz Spectrometric TechnologiesApplied for Non-Invasive Evaluation of Bio-Medical Tissues

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The generation of coherent terahertz (THz) radiation through the femtosecond pulse laser irradiation on a photoconductive antenna has been effectively utilized for the promising new far-infrared spectrometric technique of the terahertz time-domain spectroscopy (THz-TDS). The THz-TDS technique has the advantage of higher signal-to-noise-ratio than the conventional spectrometric techniques, and makes it possible to measure not only the transmission intensities $T(\omega)$ but also the intrinsic phase shifts $\Delta\varphi(\omega)$ of propagating THz radiations through within a sample specimen. The exact measurements of both $T(\omega)$ and $\Delta\varphi(\omega)$ make direct estimation of the real part $\varepsilon'(\omega)$ and the imaginary part $\varepsilon''(\omega)$ of complex dielectric constant $\varepsilon^*(\omega)$ free from the uncertainty caused by the Kramers-Kronig analysis. The intrinsic phase shifts $\Delta\varphi(\omega)$ also provide analytical estimations of the dispersion relations for various elementary excitations coupled with the propagating THz radiations. The THz-TDS technique has recently been in progress with a wide expansion of routine measurements on industrial products of dielectric functional materials, polymorphous organic compounds, bio-molecules, and crystalline morphology of pharmaceutical reagents. Here, we describe an overview of the newly developed advanced technologies of the polarization-sensitive THz-TDS, and of the fast-scan time domain spectrometry based on laser repetition frequency modulation, and also some of the latest results of novel applications focusing on the non-destructive evaluation of functional dielectric materials and of pharmaceutical products, and also non-invasive evaluation of bio-medical tissues.

What is the primary target of the action millimeter waves on biological objects?

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It has been experimentally shown that the low-intensity millimeter waves (MMWs) do not act directly on DNA molecules, and the influence takes place through a mediated influence of the MMWs on the water, stimulating structural change of the water shell surrounding the DNA. Thereby, it may conclude that the primary targets of the influence of the millimeter waves on the DNA water solutions are the water molecules.

The assumption that changes in the DNA melting parameters under the influence of low intensity non-ionizing millimeter (MM) waves stipulated by the structure of water, is based on the fact that the resonant absorption frequencies of DNA are in the region of 2 to 9 GHz [1]. Hence, we assume that at a frequency of 64.5 GHz the changes in the values of temperature melting T_m and melting interval ΔT can not be due to the resonance absorption of DNA, i.e. the radiation not directly influences on the DNA. Consequently, the increase in the thermostability of DNA during the irradiation by MM-waves with a frequency 64.5 GHz can be caused by their mediated influence through the water. DNA-samples were prepared in the irradiated only water-salt solution (buffer) for the confirmation of the mentioned fact. Melting curves obtained for them do not practically differ from the curves obtained by irradiation of DNA solutions within the experimental error. Therefore, it can be assumed that the observed changes in the parameters of DNA-denaturation are caused just by changes in the structure of water arising due to exposure. This is also indicated by the results on the measurement of the density of aqueous salt solutions of DNA in the case of irradiating by MM-waves. For a control the densities of bidistilled water and water-salt solution were also measured before and after irradiation. The studies have shown that in the case of irradiation by pure water with a frequency of 64.5 GHz, its density does not practically change, while the density of the buffer and the DNA-solution increases. This indicates that the structural state of pure water does not change due to irradiation, since under these medium conditions the water molecules form a most stable, from a thermodynamic point of view, structure, and an increase in ordering after exposure becomes thermodynamically non-profit. Therefore, the density of water under these conditions should not be changed. In contrast, in the case of irradiation of the buffer and the DNA-solution by non-ionizing millimeter electromagnetic waves the dehydration of DNA and being present in solution ions of Na^+ occurs. Moreover, most probably, the water molecules are involved in the formation of additional bonds with the salt ions or with functional and atomic groups of macromolecules, which leads to an increase in size of the ions or macromolecules, and the latter is the cause of density increase. The results of measurements of the density buffer and the DNA-solution are summarized in Table 1. As it can be seen from the table, there is almost the same dynamics of changing of the buffer and the DNA-solution densities. And the obtained data are in a good agreement with the results of DNA-melting. For irradiation G4-142 generator (Russian made) was used [2], the incident power density (IPD) at the location of object was about 50 $\mu W/cm^2$.

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Dielectric Anizotropy of Human Bone in Spectral Range 0.2 to 2.5 THz

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Terahertz time domain spectroscopy (THz-TDS) was applied to study anisotropic properties of a human jawbone in transmission geometry. The time scale of vibrational motion of biological molecules has the order of picoseconds, and therefore, the frequency of collective vibrations as well as crystal lattice vibrations is within the terahertz frequency range. Intermolecular interactions are usually weaker than the intramolecular ones and only the THz time-domain spectroscopy is sensitive to resolve their spectrum in the THz range. Non-invasive and contactless by nature, a THz wave can penetrate into non-conductive materials to provide additional spectroscopic data for the accurate diagnosis and analysis of the material.

The fiber femtosecond laser (Fx-100, IMRA) with a pulse width of 113 fs, a central wavelength of 800 nm and a repetition rate of 75 MHz and an average power of 120 mW was used as a laser source for pumping and detecting terahertz pulses. The polarization of the pulsed terahertz wave is linear. The experimental results indicate that the refractive indices n (ω) and the absorption coefficients α (ω) of a human jawbone are changing with the alteration of the direction of the vector of the linearly polarized electric field of the THz pulse relative to the axis of the plate of the human jawbone.

Terahertz pulses generation via optical rectification in $LiNbO_3$crystal by step-wise phase mask

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The temporal and spectral characteristics of broadband terahertz (THz) radiation generated via optical rectification of femtosecond laser pulses in the single-domain $LiNbO_3$ crystal were investigated.

The application of step-wise phase mask (PM) to achieve phase-matched THz generation is studied. The radiation pattern of Thz generation for different numbers of the step of PM is analysed. The spectral width and THz-pulse duration are calculated.

Optical Properties of Human Bone and CERABONE® in the Terahertz Range

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The refractive indices $n(\omega)$ and absorption coefficients $\alpha(\omega)$ of the human jawbone and bone substitute Cerabone® were determined in vitro by the THz Time-Domain Spectroscopy (TDS) in a wide frequency range from 0.2 to 2.5 THz. It is shown that the refractive index of the human jawbone changes between the values of 2.075 and 2.157, and Cerabone® between 2.4 and 2.65. The absorption coefficient of the human jawbone depending on frequency increases from zero to 210 cm^{-1}, showing several resonance absorption lines after 1.6 THz. The absorption coefficient of Cerabone® increases from zero to 80 cm^{-1}, and the resonance absorption occurs at 1.7 THz.

The obtained results allowed us to determine the proximity of the physical properties of the Cerabone® with the natural bone matrix.

THz waves propagation in a $LiNbO_3$ wedge antenna

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The THz wave propagation in $LiNbO_3$ wedge crystal was investigated. To simulate the THz modes propagation in the crystal placed in free space, the finite-element method was used. The THz pulses were generated via optical rectification of femtosecond pulses of a Ti: Sapphire laser in a wedge crystal. In order to analyze experimental results the propagation of the most intense spectral lines of THz pulse at 290 GHz, 330 GHz, 409 GHz, 451 GHz, 500 GHz, 644 GHz, 760 GHz, 802 GHz, 1000 GHz and 1016 GHz were studied by using COMSOL Multiphysics interface.

The distribution of THz electric field component along the *z* axis for the corresponding lengths of $LiNbO_3$ wedge crystal 2.5 mm, 8 mm, 12 mm, 14 mm, 18 mm, 22 mm were analyzed. It was shown that the mode structure and phase velocity of the THz radiation are changing during its propagation through the wedge crystal. The simulation results demonstrate the ability of the spatial focusing of the THz waves which opens a promising way to the using of wedge antenna in wide range of applications, such as in THz microscopy and imaging systems.

Ferromagnetic detector of infrared radiation

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The detection of laser radiation in the magnetized transparent ferromagnetic yttrium iron garnet (YIG) at room temperature was experimentally obtained.

Under the influence of linearly polarized light in a magnetized YIG crystal changes the magnetic momentum. Magnetic sensor (a horseshoe ferrite body with a coil inductor wound around it) was used to register changes in the magnetic moment of the magnetized YIG sample. The sensor was attached to the sample. A change in the magnetic moment of the YIG crystal leads to a change in the magnetic flux in the magnetic sensor, and this induces a voltage in the inductor coil.

It is shown that the efficiency of detection strongly depends on the shape of the magnetization curve of the ferromagnetic, and on the magnitude of the magnetizing field.

For the different forms of the magnetization curve the detected signal on the magnetizing field was measured. It is shown that without external magnetizing field detected signal is absent.

To use the coil of the magnetic sensor for the magnetizing of the ferromagnetic sample was proposed, instead of the external electromagnet (see. [1]).

The results of this study may find applications for the registration and conversion of laser radiation, for optical recording of information and so on.

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Alternative semiconductor materials, electronic devices (EL)

Chairman: Prof. Alexei Orlov

Silicon quantum dots for future electronics and photonics

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Quantum dot structures, where electrons are confined three-dimensionally in the below 10 nm scale, show characteristics quite different from conventional bulk structures. Recent progress in the fabrication technology of silicon nanostructures has made possible observations of novel electrical and optical properties of silicon quantum dots, such as single electron tunneling, ballistic transport, visible photoluminescence and photovoltaic devices and quantum information processing devices. Silicon quantum dots are fabricated either by bottom-up or top-down processes. Fabrication and electrical/opto-electrical characterization of Nanocrystalline Si films by plasma processes and coupled Si quantum dots by electron beam lithography processes are described.

Nanomagnet Logic

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We present a review of Nanomagnet Logic (NML), which is a proposed technology of realizing logic devices using arrays of physically-coupled nanomagnets. The binary state of a bit is represented by the magnetization state of a single-domain nanomagnet element, and logic is accomplished through direct physical interactions between them. NML is based on patterned arrays of elongated nanomagnets that are sufficiently small to contain only a single magnetic domain. The magnetization state of a device – i.e. whether it is magnetized along one direction or another, commonly referred to as "up or down" – can be used to represent binary information in the same way that magnetic islands are used to store information in magnetoresistive random access memory (MRAM). Elongated single-domain magnets are essentially tiny bar magnets with poles on each end, that generate strong stray fields that can be used to couple to other nearby magnets. While such magnetic interactions between neighboring nanomagnets are undesirable for data-storage applications, we have demonstrated that these interactions can be exploited to perform logic operations. We have demonstrated that NML satisfies the requirements for digital logic, and offers performance advantages, primarily low power and non-volatility, as a potential post-CMOS technology. This talk will summarize both the basics and most recent work in several areas of NML development.

Large Diffusion Lengths of Excitons in Perovskite and TiO_2 Heterojunction

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Solar cells based on organometal halide perovskites have recently become very promising among other materials because of their cost-effective character and improvements in efficiency. Such performance is primarily associated with effective light absorption and large diffusion length of charge carriers. Our paper is devoted to the explanation of large diffusion lengths in these systems. The transport mean free path of charged carriers in a perovskite/TiO_2 heterojunction that is an important constituent of the solar cells have been analyzed. Large transport length is explained by the planar diffusion of indirect excitons. Diffusion length of the coupled system increases by several orders compared to single carrier length due to the correlated character of the effective field acting on the exciton.

On electron holographic phase imaging of threading dislocations

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Electron holography (EH) in a transmission electron microscope is an interferometric technique that can be used for phase imaging of electrically active crystallographic defects with nanometer-scale resolution. Several groups have employed the EH method for obtaining quantative information on the electronic structure of threading dislocations (TDs) in wide bandgap materials, such as *n*-doped GaN [1,2], ZnO [2], and SiC [3]. In this contribution, we study the features of the phase shift of the electron wave passing through the barrier of a charged TD. Our calculation scheme relies on the short-wavelength approximation and the Read scenario of line charge screening. We find that the functional form of the phase shift becomes useful for (i) estimating the magnitude of the trapped charge per unit length of the TD and (ii) reconstructing the profile of the electric field surrounding an unscreened [1] or effectively screened [2,3] TD.

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Pre-annealing effects on a pentacene organic thin film transistor with a polymer dielectric interface

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A pentacene organic thin film transistor (OTFT) with polymethylmethacrylate (PMMA) gate dielectric layer was fabricated at 25 ^{o}C (RT), 90 ^{o}C, and 120 ^{o}C in situ substrate temperatures. In order to study the effect of pre-annealing treatment on the crystal structure, we observed the fabricated pentacene thin films by scanning electron microscope, atomic force microscope, and X-ray diffraction. The pentacene film remains in the bulk phase and the carrier's mobility decreases only with 120 ^{o}C substrate temperature compared with RT preparation. A pentacene OTFT with PMMA as a gate insulator layer exhibited enhanced electric characteristics, including hole mobility of 0.21 cm^2/Vs, current on/off ratio of order of 10^5, and a threshold voltage less than -4 V.

The Effect of Interface Traps on Electrical Characteristics of Nanowires and Nanowire Junctionless FETs

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The recombination through surface traps plays an important role in electronic properties of semiconductor nanowires (NW) and NW based devices. It was experimentally demonstrated that the conduction type of NW changes due to the surface traps at certain wire diameters [1]. We performed theoretical studies and analyzed the influence of surface traps on semiconductor nanowire conductivity [2]. Different semiconductor materials have been considered. For Silicon NWs with doping densities less than 10^{18} cm^{-3}, we observed the conduction type switching when decreasing the NW radius due to high density of surface traps (10^{12} cm^{-2}). However, as already reported in our previous work [3], the impact of interface traps on NW electrical characteristics is apparent also at high doping densities which are common in NW junctionless FETs (JL FET). The effect of interface traps have been accurately included in the existing analytical compact model for NW JL FET. Different trap energies and densities were considered.

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Two dimensional coordinate-sensitive photodetectors based on (p)InSb - (n)CdTe heterojunction

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In the present work we study the photosensitivity of locally irradiated (n)CdTe-(p)InSb heterojunction formed by laser-pulsed deposition of thin CdTe layer. Using such heterojunction two-coordinate sensitive IR photo-detectors have been fabricated and it was shown, that they have linear output characteristics and the measured value of coordinate sensitivity is about 30nA/μm.

Influence of surface recombination on the open circiut voltage of the nanowire solar cells with radial p-n junction

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Radial nanowire (NW) structure shows excellent photovoltaic effect and thus it can be used as an ultra low power source for various nanoscale electronics and optoelectronic devices. The radial p-n junction NW geometry produce significant improvements in the efficiency of cells made from material that have diffusion length at least two order of magnitude less than their optical thickness and low recombination in the depletion region.

However all the experimental realizations of Si NW solar cells show a very low open circuit voltage (Voc< 0.3 V under standard conditions of 1-sun AM1.5 G illumination) in comparison to conventional single or policrystalline Si planar devices with typical Voc= 0.6-0.7 V.

Such low Voc can be caused by large surface recombination at the NW sidewall the role of which is increased as the diameters become smaller and the ratio of surface to volume of NW increases.

Our aim here will be to analyze the influence of surface recombination velocity on Jsc ,Voc and efficiency of NW solar cells with different core and shell radii and will show that the surface recombination with velocity as high as 105 cm s-1 can lead to a very low open circuit voltage for Si NW solar cells.

Capacitance of MOS Structures Based on Inhomogeneously Doped Semiconductor Nanowires and Nanospheres

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Semiconductor nanostructures such as nanowires and nanospheres are promising building blocks for near future nanoelectronic devices since they provide a new route to continuing miniaturization and new applications in field effect transistors, sensors, solar cells and thermoelectric systems.

Formation of depletion regions at different interfaces in semiconductor homo and hetero-structures plays an essential role in the physics of most electron devices. Therefore the understanding of surface band bending and dopant distribution effects is critical for the fabrication of high-quality electrical devices based on semiconductor nanostructures.

Caused by the features of synthesis and doping methods of semiconductor nanostructures the distribution of dopants in semiconductor nanostructures, particularly in semiconductor nanowires is usually radially inhomogeneous with a heavily doped shell surrounding a core of much lower dopant concentration with a change of almost 2 orders of magnitude and the profile of dopant distribution can be different: from linear to exponential.

In this presentation we will study the influence of dopant distribution on the depletion length and surface potential for semiconductor nanowires and nanospheres and on the capacitance-voltage characteristics of MOS structures based on such nanostructures.

Critical radius of full depletion in semiconductor nanowires

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Among other nanostructures semiconductor nanowires with a diameter of several hundred *nm* and aspect ratios as high as 10^2, even without quantum size effects, offer exciting possibilities as building blocks for different photovoltaic devices, in particular, for photosensitive elements in highly integrated optoelectronic devices and for third generation of solar cells. When the radius of nanowire becomes comparable with the Debye screening length there is a certain radius of nanowire, so called as a critical radius, when the nanowire is totally depleted from free charge carriers. This causes the radical changes in equilibrium and nonequilibrium properties of nanowires.

Poission`s equation is solved to find potential distribution in nanowires as a result of surface depletion for different parameters of surface states. The dependence of critical radius on doping level, surface states density and their ionization energy was examined.

Preparation technology and optical properties of $CH_3NH_3PbI_{3-x}Cl_x$ perovskite thin films

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Optical properties of $CH_3NH_3PbI_{3-x}Cl_x$ thin films obtained by vapor-processing of thermal deposited PbJ_2 films via CH_3NH_3Cl are presented in this paper. Optical absorption edge (1.6 eV for as-deposited and annealed $CH_3NH_3PbI_{3-x}Cl_x$ film) has been estimated by using of absorption coefficient spectra curves. It is shown that the annealing of as-deposited $CH_3NH_3PbI_{3-x}Cl_x$ film leads to a sharp edge of the optical absorption and an increase of absorption coefficient in several times.

The research is supported by SCS MES RA, within the frames of joint Armenian - Belarusian research project №13РБ-031

Microwave devices, antennas, propagations and remote sensing (MT)

Chairman: Prof. Kiejin Lee

Principles of Earth Microwave Radiometry from Space

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Peculiarities of microwave radiometer method of Earth remote sensing are considered. It is based on measurement method of brightness temperature of the system "atmosphere-surface" from satellites and on determination of geophysical parameters by inverse problem solution. The merit of microwave radiometry is the possibility to obtain information on environment under any weather conditions at various time of twenty four hours period independently on the illumination, clouds and precipitations. The necessity of multichannel (spectral and polarization) measurements of Earth microwave radiation is shown for reliable data interpretation. Effectiveness of global monitoring of atmosphere and surface was shown in 1968 when first time in World practice 4 microwave radiometers were installed on satellite "Cosmos-243". Techniques of microwave images obtaining as well as problems of internal and external calibration of satellite SHF radiometers and methods of initial and subject data processing are discussed. Analysis of measurements inaccuracy of microwave radiometers is given. Measurement results of bright temperature of the system "atmosphere - surface" obtained by means of modern techniques of microwave sensing SSM/I, TMI, AMSR, MTB3A are presented. Estimates of accuracy of atmosphere geophysical parameters determination are given. Examples of utilization of data on scanning multichannel polarization radiometer for investigation of mesoscale and synoptic dynamic processes of moisture and energy transfer in atmosphere are shown.

A new approach in local and global anti-hail protection technique

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Each year hail and shower cause great and severe damage to agriculture and human properties and to minimize or to prevent economic disruption and downturn in agriculture various kind of anti-hail protection methods and stations are used to reduce the material damage in size. At present several anti-hail protection methods and stations are known in the art. It is known a wide-ranging anti-hail protection method with an active effect (impact) on hail clouds by shells or rockets which spread reagents or aerosol in clouds. It is known as well an anti-hail protection method with an active effect on hail clouds by significant shock waves directed upwardly to the sky.

Known anti-hail protection methods have some limitations related to the absence of automatic operation and self-management capabilities. Known anti-hail protection methods are operated only when corresponding commands come from the service operator, which includes subjective factor, or when corresponding commands came from an anti-hail radar station, which is a very expensive one and needs specific exploitation conditions, besides it is not always possible to receive the commands from the anti-hail radar station, or these commands are not always contained correct information about hail situation and stage regarding the protected area.

In this paper we will represent a new method for realization of local or global anti-hail protection network which protection efficiency is higher than all known methods. Presented method and the network of anti-hail protection are already patented in Armenia by ECOSERV Remote Observation Centre Co. Ltd., as well as they are patenting in various countries of the World, namely: in the USA, in Canada, in the EU, in Russian Federation, in India and in China.

The automated global anti-hail protection method comprises continuous or periodically receiving in $K >> 1$ points signals of the anti-hail protected area's adjacent land corresponding sky intrinsic emission in radiofrequencies all around the anti-hail protected area of $M >> 1$ sites, squaring of the received signals of the adjacent land's corresponding sky intrinsic emission in radiofrequencies, accumulation of the squared signals of the adjacent land, comparison of the accumulated signals of the adjacent land with a minimum threshold, generation in any site of K points an alert code-signal on gathering hail danger from the adjacent land if the accumulated signal of the adjacent land exceeds a minimum threshold, transmission on the air by radio waves the alert code-signal on gathering hail danger, and reception of the transmitted alert code-signal on gathering hail danger in each site of the anti-hail protected area of M sites. Reception of sky intrinsic emission in radiofrequencies in each of M sites, squaring of the received signals, accumulation of the squared signals, comparison with corresponding thresholds, generation command signals to detonate combustible gas and to direct shock waves upwardly to the sky, generation and transmission alert signals, reception of transmitted alert signals in each M sites, comparison with proper code-signals of that site and setting alert operational mode of sonic generator. For local anti-hail protection method it is necessary to take $K=1$ and $M=1$.

Represented invention allows realize fully autonomous and automate operating local or global anti-hail protection network.

The New Dual-Reflector Axisymmetric Antenna with Circular Generatrix. The Main Reflector

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Dual-reflector axisymmetric antenna consisting of the main reflector with circular generatrix, displaced in relation to the axis of rotation, and subreflector with curvilinear generatrix, with sharpening on a symmetry axis directed towards a feed which phase centre is combined with focus of system is offered. The polar parametrical equations generatrix a subreflector and obvious expression for the transforming function which, by simple multiplication by the directional pattern of a feed, transfers the last to inphase amplitude distribution of a field in an antenna aperture are given. Are noted, without analyzing, two features of the antenna which are advantageously distinguishing its from know analog with parabolic generatrix the main reflector and elliptic generatrix a subreflector.

1.6-Kilowatt GaN-Based L-Band Pallet Amplifier

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A GaN-based pallet amplifier optimized for avionics applications is presented. The pallet combines two Integra GaN HEMT transistors in parallel to produce 1.6 kilowatts output power, 15.5dB gain, and 55% efficiency operating at 100uS pulse duration and 2% duty cycle over the 1.03GHz to 1.09GHz band.

For high power handling at the output, this pallet uses a Gysel RF combiner; the design and layout of the Gysel combiner have been modified to reduce its normally large size. At the input, the pallet achieves greater than 20dB input return loss using a conventional Wilkinson power divider.

This paper will describe transistor and pallet design, along with test results on a prototype pallet amplifier.

Features of radar cross-section determination using near-field measurements

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An algorithm for determine radar cross section (RCS) of object, based on near-field measurements, developed earlier, is improved. The algorithm has two components: the process of measurement and mathematical processing of the measured data. The illuminator and probe (electric or magnetic dipoles) are located on concentric scanning spheres (exterior and interior), covering the object. The measurements are carried out for each fixed mutual arrangement of emitting and measuring probes, moving with a certain increments. Data processing is carried out using the method of spherical harmonics and of the reciprocity principle. The problem is to exclude the direct fixation of the illuminator radiation by the measuring probe. The traditional way to eliminate this effect is to measure the electric and magnetic components of the scattering field of object for each of four different orientations of emitters: for two orthogonal tangential orientations of the electric and magnetic dipole radiators). In this report the generalized method of spherical harmonics is used. The method allows to exclude a direct effect of the radiator on the measuring probe by measuring only electrical components of the scattered field, and, in addition, to obtain the absolute value of RCS using relative measurements.

Estimation of Phase Noise Impact on MTI Performance in FM-CW Radars

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The ideal design of short-range FM-CW radar implies fully coherent architecture with common main clock oscillator, and a complex forked clock distribution system, consisting of many PLL-ed oscillators required for digital signal synthesis. Most often such systems are utilized in Doppler radars which are highly sensitive to the level of oscillators' phase noise from the viewpoint of moving target indication (MTI) performance required for maximum attainable distance.

However, the complexity of such systems also determines their proportional high cost that does not always satisfy the requirements for such systems. In this paper we analyze the phase noise of the Doppler radar having frequency double-conversion architecture with three independent oscillators (carrier frequency, IF and MTI) [1,2]. It is shown that in such system, the overall power spectral density (PSD) of phase noise is determined by the contribution of all three oscillators [3]

$$L(\omega) = 4\left(L_c(\omega) + L_{IF}(\omega) + L_{MTI}(\omega)\right)\frac{R^2\omega^2}{c^2}, \quad (1)$$

where $L_c(\omega)$, $L_{IF}(\omega)$, $L_{MTI}(\omega)$ are PSD of phase noise of carrier oscillator, IF oscillator and MTI oscillator respectively, R is the distance to the target, ω is angular frequency offset, and c is speed of light.

The method for direct estimation of oscillators' phase noise by degradation of MTI performance is proposed. Estimated additional reduction of detection range, caused by contribution of MTI oscillator's phase noise is about 10 percent.

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Pedestrian Caused Doppler Signal Detection by Bispectrum Processing in Ku-Band Coherent CW Radar

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Receiving signals from moving objects, especially from pedestrian, are classified in special group. The pedestrian global motion consists of several micro-motions. He has center of gravity and his hands and legs are moving concerning that center. Pedestrian hands and legs are moving opposite sides. The speed of pedestrian hands and legs are allocated between null and double of pedestrian body moving speed. So we have mathematical pendulums with opposite phases but with the same frequencies. This means that we have Doppler shifts to different sides. In general, they are micro-Doppler shifts, because the pedestrian motion includes different body parts with different motion structure. In power spectrum the phase relations between micro-Doppler spectral components are lost. Therefore, it is impossible to recover phase coupled components by energy spectrum estimation. So to keep phase information is essential. Under those circumstances using in-phase (I) and quadrature (Q) components is sufficient for keeping phase information to retain useful maxima in bi-spectrum graph.

Dynamics of Buneman instability in plasma-filled devices for microwave generations

E.Rostomyan

Plasma filled devices for microwave generation nave many advantages as compared to vacuum ones (high power of emitted radiation and other). They cover wide range of frequencies: from comparatively low-frequency devices (for medical and biological needs) up to very high (terahertz). Usually movement of plasma ions is not accounted in high-frequency range. But strictly speaking it should be accounted if the ion Lengmuire frequency is of order emitted frequency. Usual plasma density in plasma assisted microwave generators is $n_p \approx 10^{13} \mathrm{sm}^{-3}$ that corresponds to ion Lengmuire frequency $\omega_{Li} \approx 4.1 \times 10^9 \ \mathrm{sec}^{-1}$

Account of ions leads to many new and important features of theory microwave devices and gives raise to new tasks and new applications of the existing tasks in other areas. Most important of them are

1. Development of new instabilities e.g Buneman instability that is due to motion of electrons against ions
2. Electron ion collisions with all ensuing effects (dissipation and change of instability properties)

In addition passage to higher (terahertz) frequencies demands increasing of plasma density. In its turn this leads to increasing of the plasma collisions' role as well as the role of Buneman instability.

My investigation is devoted to investigation of Buneman instability with collisions. In spite of importance of Buneman instability (too many applications in space and laboratory plasma this task has not been considered yet. Absence of investigations on the problem along with its importance may be explained by its complexity only. Correct solution of the problem should be based on solution of transport equation with collisional term. In fully ionized plasma the term is nothing else as Landau collision integral (LCI). It is very complex formation. LCI greatly complicates transport equation. Actually since 1936, when LCI was formulated there is very little literature on solution of the transport equation with LCI Almost all successful attempts to accommodate influence of collisions on various processes in plasma are based on other model – model of Bhatnagar, Gross and Krook (BGK). The model is based on conservation laws (mass, momentum) and is appropriate, when specific interaction law of colliding particles isn't specified or it is very complicate (collisions of charged particles with neutrals). This model is semiphenomenological and is **much simpler**. It properly works in partially ionized plasma.

I managed to sole kinetic equation in some limiting cases.

A radio frequency spiral scanning deflector for keV electrons

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In this paper, we describe a new sensitive deflector to perform spiral sweeps of keV electrons by means of radio frequency, RF, fields in a frequency range of 500-1000 MHz. By converting the time dependence of incident electrons to a hit position dependence on a spiral, this device forms a basis for THz bandwidth timing processor with extended dynamic range. The deflection system can be adjusted to the velocity of the electrons to exclude the reduction of deflection sensitivity due to finite transit time effects. The deflection electrodes form a resonant circuit, with quality factor Q in excess of 100. Thanks to this resonance, the sensitivity of this new and compact RF deflector is about 1~mm per V of applied RF input, which is an order of magnitude higher than the sensitivities of other RF deflectors used previously. Potentially it has a number of applications in fixed-frequency cathode-ray-tube based instruments, for example opto-electronic devices such as RF Streak Cameras or the RF photomultiplier tubes. Both techniques provide 1 ps resolution and could find application in different fields of science and technology. Results of current theoretical and experimental studies will be presented.

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Practically Interesting Subreflector for the Spherical Reflector Located under Caustic

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The plane curve with a cusp which local elements can serve generatrixed the subreflectors located under caustic of spherical reflector and providing focusing is shown. The curve element at which rotation round a symmetry axis, there is practically interesting subreflector, with sharpening on a symmetry axis, providing also high matching with a feed, is selected. The formulas defining end points generatrix a subreflector which are necessary at radio physical design of the corresponding dual-reflector spherical antenna are given.

On Radio Physical Design of The Dual-Reflector Radio Telescope with a Fixed Main Spherical Reflector and Movable Subreflector Type Gregory

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It is revealed, earlier unnoticed, relationship between the radius of a spherical reflector, diameter of a movable aperture of the radio telescope and location of focus of system on an axis of symmetry which limit generatrix a movable subreflector type Gregory and excludes possibility of deep subreflector with a feed located inside. The simple ratio connecting the key controlled constants of optical scheme, thereby, providing to the designer a freedom of choice of an order of radio physical design of the radio telescope is received.

Change of flux density Characteristic of the radio source Cassiopeia A for the period 2008-2015 years

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On the basis of results of regular radio-astronomical observations (2008-2015 years) which was done on Saravandsky scientific experimental site IRPhE the National Academy of Sciences of the Republic of Armenia. In work are discussed nature of average annual change of intensity of a radio emission, and also veracity (authenticity) of frequency of change of a stream of a radio source of Cassiopeia A. It is shown that in mentioned period intensity of a radio emission of Cassiopeia A decreased approximately with an average annual speed of 0,6%, and from results of average annual values of the period 2008-2015 years a curve was constructed with low 2.7 -3 years period of change.

Conical Bessel beam radial line slot antenna

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The conical beam planar ring-slot antenna on radial transmission line has been designed and investigated. Resonance conditions for shorted and open end radial line has been evaluated. Using of resonance-type radial line for feeding the ring-slot antenna increases the antenna emission efficiency. The radius of ring slot is chosen from the maximum condition of first kind Bessel function $J_1(kr)$. The directivity pattern has been measured for emission to free space, after diffraction on metallic disk, and, after transmission thru dielectric thick layer.