

Workshop “QUASIOPTICS: BEAMS, SCATTERING, FOCUSING, AND RESONANCES”
within the framework of the ESF Activity entitled
“New Frontiers in Millimetre / Sub-Millimetre Waves Integrated Dielectric Focusing Systems”
incorporated into
**14-TH INTERNATIONAL CONFERENCE ON
MATHEMATICAL METHODS IN ELECTROMAGNETIC THEORY
(MMET*12)**
Kharkiv, Ukraine, August 28 – 30, 2012
<http://www.mmet.org>

Workshop Summary

ESF-Newfocus Workshop “Quasioptics: Beams, Scattering, Focusing, and Resonances” was organized as a one-day event in the framework of the 14-th International Conference on Mathematical Methods in Electromagnetic Theory in Kharkiv, Ukraine (August 28–30, 2012). The workshop celebrated the 90-th birthday of Dr. Yevgeny M. Kuleshov, father of the quasi-optical hollow-dielectric-channel beam waveguide and IEEE Microwave Pioneer Award winner 2000, and 50 years of initiated by him research into quasioptics at IRE NASU.

MMET series of conferences started in 1988 as a school-seminar for young scientists; in 1990 it was transformed into a regular symposium held in the major university and science cities of Ukraine: Kharkiv, Kiev, Dnipropetrovsk, Odesa, and Lviv. Today this is the only one conference in the Former Soviet Union in electromagnetics that has English as a single medium of presentation and discussion. It was hosted by the Institute of Radio-Physics and Electronics of the National Academy of Sciences of Ukraine and the Kharkiv National Academy of Municipal Engineering.



Alexander Schuchinsky (United Kingdom), Fadil Kuyucuoglu (Turkey), and Nikolaos Tsitsas (Greece) presenting their papers at the workshop; Sinisa Skokic (Croatia) and Stephen Shipman (USA) awarded by the prizes of the International Jury.

The Workshop included one plenary session of 30-minute invited talks and two regular sessions of 15-minute contributed papers. The co-chairs of the sessions were Dr. Oksana Shramkova, Kost Ilyenko, Sinisa Skokic, Valentin Borulko, Henri Benisty and Natalya Sakhnenko. Totally, 17 papers reviewed and selected by the MMET*12 Technical Program Committee were presented during the Workshop.

ESF visibility

The European Science Foundation was mentioned as a co-sponsor in the conference program, proceedings and at the conference web-site (<http://mmet.org/2012/>). ESF and Newfocus logos were published at the main and sponsors' pages of the conference web-site (<http://mmet.org/2012/sponsors.html>), on CD Proceedings and on the title page of the conference program. ESF-Newfocus was also acknowledged by some authors in their papers. One separate page of MMET*12 web-site was entitled "Newfocus workshop" (<http://mmet.org/2012/workshop.html>). ESF logo was posted on the tribune at the conference-hall, and the workshop description was displaying on the screen between the talks.

Scientific content, assessment of the results and impact of the event on the future directions of the field

MMET Conference is famous as efficient interface between the ex-USSR and Western scientists and engineers in the broad area of modeling and simulation of electromagnetic fields including wave propagation, radiation, scattering, guidance, and processing. This year MMET collected over 140 papers from 25 countries and over 160 participants registered at the conference. The Workshop reflected the general situation: 8 papers were presented by authors affiliated in the Western countries, and 9 presentations were made by researchers from Ukraine and Russia. Thus, the Workshop gave a good impetus for international scientific cooperation. In particular, young scientists had opportunity to arrange their future post-doc plans.

The highest level of the proposed talks was acknowledged by the MMET International Jury. Stephen Shipman (Louisiana, USA) was awarded the N.A. Khizhnyak Prize "For Contribution to the Electromagnetic Theory"; Alexander Schuchinsky (Belfast, UK) got the V.G. Sologub Award "For Contribution to the Analytical Regularization Theory", and Sinisa Skokic has become II Prize winner of the Young Scientists' Contest.

The breakthrough of contemporary research in the field were outlined by the workshop invited speakers: *Henri Benisty* (Palaiseau, France), *Stephen Shipman* (Baton Rouge, USA), *Trevor Benson* (Nottingham, UK), *Alexander Shishlov* (Moscow, Russia), *Maurizio Bozzi* (Pavia, Italy), *Alexander Schuchinsky* (Belfast, UK), and *Vitaly Bulygin* (Kharkiv, Ukraine).

Henri Benisty in his talk with the refined title "Littrow resonances in broad corrugated ribbons: quasi-optics in the no man's land between resonators and waveguides" presented the properties of «Littrow modes» in broad periodic waveguides. In the band picture they correspond to multimode slow light. In the resonator picture, they mainly behave as Fabry-Perot resonators. However, he notes that there are several subtleties in their quasi-optics behaviour from forbidden coupling to nonlinear conversion effects. He points out also that they represent a general wave phenomenon.

Stephen Shipman's talk was dedicated to resonances in anisotropic layered media. When it is interrupted by a slab of contrasting material, electromagnetic resonance can be manifest in a variety of ways. In one scenario, anisotropy allows for frequency intervals in which waves propagating perpendicular to the layers coexist with evanescent waves. This permits energy to be trapped within the slab at frequencies embedded in the continuous spectrum. These are unstable

states that result in resonance under small perturbations. In another scenario, a stationary inflection point in the dispersion relation of an ambient magnetic anisotropic layered medium leads to unidirectional propagation and resonant interaction between Bloch waves and the contrasting layer. Analysis of energetic interactions between waves allows for a detailed understanding of these resonances.

Computer simulations are critical for the rapid and accurate design of innovative photonic components and systems. This increasingly calls for the development of efficient ways of describing sub-wavelength features in numerical codes. Motivated by this, *Trevor Benson* discussed and presented techniques for embedding such features into the Transmission Line Modeling Method.

Alexander Shishlov presented a method of antenna pattern reconstruction using sampling field data in sparse grid of points in Fresnel zone. According to this method, antenna far field pattern in a desired section is reconstructed from several sections of the field in Fresnel region. Fresnel field to far field transformation is based on two-dimensional Fourier series expansion. The main features of the method were discussed, and computer simulation results were also given.

The next plenary talk of *Maurizio Bozzi* was dedicated to Substrate Integrated Waveguide (SIW) technology, which represents the new paradigm for the low-cost and efficient implementation of microwave and mm-wave components and subsystems. SIW structures permit to implement in planar form a variety of waveguide components and antennas, and they also allow for complete system integration in a single substrate, thus avoiding interconnects and packaging issues. This talk presented an overview of the modeling of waveguide interconnects and components by the Boundary Integral-Resonant Mode Expansion (BI-RME) method and its application to the derivation of equivalent circuit models of SIW discontinuities. Design techniques based on the combined use of equivalent circuit models and space-mapping optimization techniques were also addressed.

Much interest has been attracted by the invited talk of *Vitaly Bulygin*. At first, he presented a detailed review of Body of Revolution method for electrodynamic problems. The special attention in his review was given to Nystrom method and description of its advantages for numerical solving of integral equations (IEs) in scattering problems. *Bulygin's* own pioneer research achievement is in expanding 2D method of discrete singularities to 3D unclosed infinitely thin screens. Unlike famous Rao-Wilton-Glisson theory and other Method of Moments methods, the presented method is mathematically strict and allows to solve diffraction problem for open surfaces rapidly. The mentioned theory of solving hypersingular integral equations was almost unknown in the international scientific literature.

Alexander Schuchinsky discussed the features of artificial surfaces composed of doubly periodic patterns of interwoven planar conductors. The free-standing intertwined quadrifilar spirals and modified Brigid's crosses were presented as illustrative examples to demonstrate the highly stable angular reflection and transmittance response with low cross-polarisation and a broad fractional bandwidth. The main mechanisms contributing to the substantially sub-wavelength response of these arrays were discussed showing that interweaving their conductor patterns provides concurrent control of both the equivalent capacitance and inductance of the unit cell. The effects of dielectric substrate and conductor thickness on the properties of intertwined spiral

and modified Brigid's cross arrays were discussed to provide insight in the effect of the structure parameters on array performance.

Quite a few papers presented at the Workshop (*Fadil Kuyucuoglu, Nikolaos Tsitsas, Sinisa Skokic, Nikolay Mikhailychev, Natalya Sakhmenko, Oleg Yeliseyev, Tatyana Zinenko, Sergey Nechitaylo*) were dedicated to the excitation of reflectors and dielectric slabs or lenses by complex sources and Gaussian beams that are more realistic alternative of conventional plane-wave considerations. The common scientific interest allowed the authors to hold a consonant discussion on their topic.

Oleg Sukharevsky demonstrated the efficiency of the short-wave asymptotic calculation method for transient electromagnetic scattering by objects coated with radar absorbing materials. The comparison of the results with the data obtained via solver FEKO for simple shape objects was convincing. The main discussion was about the limitations of various methods used for the considered scattering problems.

Vladislav Senyuta presented the numerical method for diffraction mirror in the form of a radial or circular diaphragms placed inside a metal circular waveguide.

Another paper presented by *Sergey Nechitaylo* considered the reflectivity properties of precipitations and their influence on antenna performance.

The friendly atmosphere of the workshop and high scientific level of the papers selected led to fruitful discussions of speakers and participants.

The success of MMET*12 conference and the ESF-Newfocus Workshop allows us to organize the next conference on Mathematical Methods in Electromagnetic Theory – 2014 in the beautiful city of Uzhgorod situated close to the Western borders of Ukraine.

Workshop Program

Wednesday, 29th of August 2012

Plenary Session

Chairs: O.V. Shramkova and K.V. Ilyenko

9.00-9.30	LITTROW RESONANCES IN BROAD CORRUGATED RIBBONS: QUASI-OPTICS IN THE NO MAN'S LAND BETWEEN RESONATORS AND WAVEGUIDES H. Benisty , N. Piskunov, L.A. Golovan, <i>Palaiseau, France – Moscow, Russia (invited)</i>
9.30-10.00	RESONANCE IN ANISOTROPIC LAYERED MEDIA S.P. Shipman , A. Welters, <i>Baton Rouge, USA (invited)</i>
10.00-10.30	SUB-WAVELENGTH DIELECTRIC FEATURES IN NUMERICAL CODES T.M. Benson , V. Meng, A. Vukovic, P. Sewell, <i>Nottingham, UK (invited)</i>
10.30-11.00	FRESNEL FIELD TO FAR FIELD TRANSFORMATION USING SPARSE FIELD SAMPLES Y.V. Krivosheev, A.V. Shishlov , A.K. Tobolev, I.L. Vilenko, <i>Moscow, Russia (invited)</i>
11.00-11.30	NUMERICAL MODELING AND DESIGN OF SUBSTRATE INTEGRATED WAVEGUIDES (SIW) COMPONENTS M. Bozzi , <i>Pavia, Italy (invited)</i>
11.30-12.00	Coffee-break

Session QO-I – Quasioptics

Chairs: S. Škokić and V.F. Borulko

12.00-12.30	NYSTROM METHOD ANALYSIS OF THREE-DIMENSIONAL ROTATIONALLY SYMMETRIC REFLECTORS AND LENSES V.S. Bulygin , <i>Kharkiv, Ukraine (invited)</i>
12.30-12.45	APPLICATION OF COMPLEX CONICAL BEAMS IN REFLECTOR SYSTEM ANALYSIS S. Škokić , Z. Sipus, S. Maci, M. Bosiljevac, M. Casaletti, <i>Zagreb, Croatia – Siena, Italy</i>
12.45-13.00	PARTICULARS OF FOCUSING OF HIGH-BANDWIDTH TERAHERTZ PULSES S.N. Zhukov, N.E. Mihailychiev , <i>Nizhni Novgorod, Russia</i>
13.00-13.15	TRANSIENT ELECTROMAGNETIC SCATTERING BY SIMPLE SHAPE OBJECTS WITH RADIOABSORBING COATING O. Sukharevsky , V. Vasilets , <i>Kharkiv, Ukraine</i>
13.15-13.30	TIME VARYING CYLINDRICAL LENS FOR DYNAMIC CONTROL OF SUBWAVELENGTH FIELD CONFINEMENT AND BEAM STEERING N.K. Sakhnenko , <i>Kharkiv, Ukraine</i>
13.30-14.30	Lunch

Session QO-II – Quasioptics

Chairs: H. Benisty and N.K. Sakhnenko

14.30-14.45	ANALYSIS OF AN ARBITRARY CONIC SECTION PROFILE THIN
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	DIELECTRIC CYLINDRICAL REFLECTOR ILLUMINATED BY AN E-POLARIZED COMPLEX SOURCE POINT BEAM T. Oğuzer, F. Kuyucuoğlu , I. Avgin, A. Altıntaş, <i>Izmir-Ankara, Turkey</i>
14.45-15.00	GAUSSIAN WAVE BEAM SCATTERING ON REFLECT PHASED ANTENNA ARRAY WITH SHORTED RECTANGULAR CROSS-SECTION WAVEGUIDES A. Gribovsky, O. Yeliseyev , <i>Kharkiv, Ukraine</i>
15.00-15.15	SCATTERING OF A THREE- DIMENSIONAL GAUSSIAN BEAM WITH CIRCULAR CROSS SECTION FROM A GYROTROPIC SLAB T.L. Zinenko , V.V. Yachin, M. Marciniak, V.K. Kiseliyov, <i>Kharkiv, Ukraine –Warsaw, Kielce, Poland</i>
15.15-15.30	CONCENTRATING THE ELECTROMAGNETIC POWER IN A GROUNDED DIELECTRIC SLAB EXCITED BY AN EXTERNAL GAUSSIAN BEAM N.L. Tsitsas , C.A. Valagiannopoulos, <i>Thessaloniki, Greece –Espoo, Finland</i>
15.30-15.45	METHOD OF PATTERN CALCULATION FOR REFLECTOR ANTENNA WITH SURFACE PARTLY COVERED BY SNOW S. Nechitaylo , O. Sukharevsky, G. Khlopov, O. Voitovich, <i>Kharkiv, Ukraine</i>
15.45-16.00	FORMATION OF TRANSVERSE MODES WITH SPATIALLYINHOMOGENEOUS POLARIZATION IN THE WAVEGUIDE QUASI-OPTICAL RESONATORS OF TERAHERTZ RANGE O.V. Gurin, A.V. Degtyarev, V.V. Khardikov, V.A. Maslov, V.A. Svich, V.S. Senyuta , A.N. Topkov, <i>Kharkiv, Ukraine</i>

Due to the technical reasons the talk of Alexander Schuchinsky was scheduled the next day, on the 30th of August, in the Plenary Session:

Thursday, 30 August 2012

Plenary Session

Chairs: E.I. Veliev and R.S. Zaridze

9.00-9.30	ARTIFICIAL SURFACES WITH INTERWOVEN AND TESSELLATED PATTERNED CONDUCTORS: PROPERTIES AND PHENOMENOLOGY A. Vallecchi, A.G. Schuchinsky , <i>Siena, Italy – Belfast, United Kingdom (invited)</i>
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