

# Ivan Lisenkov, PhD

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## Current Position

Director of Research and Development  
Winchester Technologies

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## Research Interests

*Theoretical condensed matter physics:*

Magnetization dynamics; Linear, nonlinear and topological phenomena in ferromagnets and antiferromagnets; Spin transfer and spin-Hall related effects; Magneto-elastic interactions;

*Experimental magnetism:*

Spin-transfer torque devices, spin-wave signal processing devices;

*Electromagnetism:*

Artificial magnetic materials; Electrodynamics of magnetic materials;

## Education

PhD in Physics and Mathematics    **Russian Academy of Sciences** (The Higher Attestation Commission of Russian Federation)  
Physics and Mathematics, 2010

Topic: **On the characteristics of acoustic waves in liquid and solid media with cylindrical inclusions**

Scientific Advisor: Prof. Sergey Nikitov

Area of examination: Radiophysics

Qualification work performed at Kotelnikov Institute of Radioengineering and Electronics

MSc and BSc    **Moscow Institute of Physics and Technology (State University)**, Moscow, Russia  
Department of Physical and Quantum Electronics  
Applied Mathematics and Physics, 2007

## Professional Experience

2018–    **Winchester Technologies**,  
Burlington, Massachusetts, USA  
*Director of Research and Development*

- Development and production of magneto-electromechanical ultra-compact antennas

2018–2018    **Department of Electrical and Computer Engineering, Northeastern University**,  
Boston, Massachusetts, USA  
*Postdoctoral Researcher*

- Developed a theory of sub-THz frequency zero-bias ferrimagnetic spin-transfer torque oscillators
- Developed a theory of a broad-class magneto-elastic sensors and antennas operating in the MHz–GHz frequency range

2016–2018    **School of Electrical Engineering and Computer Science, Oregon State University**,  
Corvallis, Oregon, USA  
*Postdoctoral Researcher*

- Established a general theoretical formalism for the parametric generation and amplification of localized dipolar-exchange spin-waves by a magneto-elastic interaction.
- Applied the developed theory to design of a magneto-acoustic analog correlator.
- Developed an experimental technique for magneto-elastic parameters characterization based on a linear response theory.

- Design of table-top RF experiments for thin magnetic film devices performance evaluation and characterization

2013–2016

**Department of Physics, Oakland University**, Rochester, Michigan, USA  
*Research Associate*

- Established a general theory of spin-wave excitations in confined arrays of magnetic nanodots with arbitrary dot shape and lattice symmetry. Formulated conditions of nonreciprocity of edge spin-wave modes in magnetic arrays. Developed an according computer code.
- Formulated a theory of electromagnetic field interactions with arrays of thin magnetic elements and designed according computer code.
- Explained experimental results of the nonlinear magnon interaction in the Bose-Einstein condensate of magnons
- Explained recent phenomena in pure spin current flow through antiferromagnets. Developed a theory of THz generation in antiferromagnetic materials

2010–2013

**Kotelnikov Institute for Radio-engineering and Electronics of RAS**, Moscow, Russia  
*Researcher* (on leave since 2013)

- Established a multiple scattering theory for spin-waves spectra in magnonic crystals. Explained distinguishing features of the locally resonant and Bragg-type band gaps in magnonic crystals.
- Developed a variation of a multipole expansion method for acoustic waves and applied the method to acoustic waves in microstructured optical fibers.
- Formulated an effective medium theory for bulk and surface acoustic waves in microstructured metamaterials. Formulated conditions for a complex Doppler effect in acoustic metamaterials.

### Visiting Research Positions

2010

**Adam Mickiewicz University in Poznan**, Poznan, Poland  
Host Professor: Maciej Krawczyk

- Developed a theory of spin-wave non-reciprocity in magnonic crystals.

### Teaching Experience

#### **Oregon State University**

2018 ECE 390 “Electric and Magnetic Fields” (hybrid on-line/classroom) (26 students, instructor)

2017 ECE 411 “Engineering Magnetism” (25 students, guest instructor)

#### **Oakland University**

2016 PHY 380 “Electricity and Magnetism” (3 students, guest instructor)

#### **Moscow Institute for Physics and Technology (State University)**

2013 Level 4 “Electrodynamics of Metamaterials” (15 students, instructor, new course)

### Student Mentoring

2017–2018

A graduate student at Oregon State University  
Project: Signal Processing using parametric non-linear interactions of spin-waves

- 2015–2016 A graduate student at Oakland University  
Project: Signal processing with spin-waves in re-configurable magnetic arrays
- 2014–2015 An undergraduate student at the Oakland University  
Project: Scattering of electromagnetic waves by magnetic metasurfaces
- 2010–2013 An undergraduate student at the Moscow Institute of Physics and Technology  
Project: Acoustic waves in wedge-shaped metamaterials

### **Honors and Awards**

- 2017 Professional Development award from the Oregon State University (\$1000)
- 2015 Medal from the Russian Academy of Sciences for young scientists in the category “General Physics and Astronomy” for excellence in research
- 2009 Prize for the excellence in research among young scientists at the Kotelnikov Institute of Radioelectronics and Engineering, Moscow, Russia
- 2007, 2005 Moscow Institute for Physics and Technology: graduated with honors in Applied Physics and Mathematics, Moscow

### **Service to Profession**

- Outstanding reviewer for Journal of Magnetism and Magnetic Materials
- Ad-hoc reviewer for: IEEE Transactions on Magnetics, Scientific Reports, Applied Physics Letters, Journal of Applied Physics
- Invited panelist for the National Scientific Foundation, USA (Panel “Magnetic and Memory Devices”)
- Session chair for 2016 and 2017 International Conferences on Magnetism and Magnetic Materials
- Member of the NextGen Magneticians 2017 Advisory Board of the IEEE Magnetics Society

### **Research Grants & Contracts**

- 2016–2018 **DARPA HR0011-17-2-2005**  
*Title:* Signal Processing at RF (SPAR)  
*Objective:* To develop and demonstrate an analog correlator and a spin-waves amplifier based on parametric magneto-elastic interaction  
*PI:* Prof. Albrecht Jander (Oregon State University)  
*Award amount:* \$1,000,000 per year  
*Role:* Development of physical models of the magneto-acoustic correlator and parametric amplifier, spin-wave and acoustic waves transducer design, overall correlator design.
- 2016–2018 **NSF EFMA-1641989**  
*Title:* Non-Reciprocal Magneto-Acoustic Waves in Chiral Magnetic Systems  
*Objective:* Development of chiral materials and meta-materials supporting strongly non-reciprocal spin waves and magneto-acoustic waves and demonstration of acoustic signal circulators and reconfigurable microwave circulators, which are based on the non-reciprocal waves  
*PI:* Prof. Ilya Krivorotov (University of California, Irvine)  
*co-PI:* Prof. Andrei Slavin (Oakland University)  
*Award amount:* \$2,000,000  
*Role:* Developed of a new theoretical formalism for spin-waves and acoustic waves in topological and chiral materials. Contributed to the proposal and the first year interim report. Left Oakland University before the project completed.

- 2016 **US Army TARDEC**  
*Title:* Design of conformal ground vehicle antenna based on a magnetic metamaterial  
*Objective:* Development of a comprehensive theory of magnetic-metamaterial-based microwave antennas. Deliver a computer program for US Army TARDEC enabling time efficient electromagnetic simulations of magnetic metalaterials  
*PI:* Prof. Andrei Slavin (Oakland University)  
*Award amount:* \$77,000  
*Role:* Proposed the idea of the metamaterial-based antennas for ground vehicles, developed a new theoretical formalism and efficient numerical scheme for magnetic metamaterial electromagnetic simulations. Wrote a computer program delivered to TARDEC for an internal use. Contributed to the research proposal and the final report. Project completed.
- 2010–2016 **NSF DMR-1015175**  
*Title:* Dynamically Controlled Artificial Magnonic Materials Based on Arrays of Nano-Sized Magnetic Dots  
*Objective:* Theoretical investigation of spin-wave properties of man-made materials based on dipolary interacting island of magnetic materials  
*PI:* Prof. Andrei Slavin (Oakland University)  
*Award amount:* \$440,000  
*Role:* Formulated a new theoretical formalism for localized spin-wave modes in magnetic arrays, conceptualized spin-wave signal processing devices based on the magnetic arrays, established a theoretical formalism for electromagnetic waves interactions with magnetic arrays. Delivered an open-source computer program for spin-wave modeling in magnetic arrays. Contributed to the interim and final reports. Project completed.

### Skills

- Fundamental methods of linear and nonlinear theoretical physics: Hamiltonian approach, Green functions theory, linear response theory, effective media homogenization techniques, Fourier methods.
- Programming Languages and Tools: Wolfram Mathematica, MuMax3 micromagnetic simulations package, C++ (including C++11), OpenMP for high performance parallel computing, Python with NumPy and cython,  $\LaTeX$ , git version control, bash for script wring.
- Operating Systems: Good knowledge of GNU/Linux in an application to scientific computing
- On-line and hybrid teaching using Canvas

### Publications & Talks

21 refereed publications (1 review), 21 conference talks (3 invited), 3 invited colloquia  
 322 citations, h-index  $h = 9$

#### INVITED REVIEWS

- 2017 **1. Magnonics: a new research area in spintronics and spin wave electronics**  
 Sergej Nikitov, Dmitry Kalyabin, Ivan Lisenkov, Andrei Slavin, Yu N Barabanenkov, Sergey Osokin, Alexandr Sadovnikov, Evgeniy Beginin, Mariya Morozova, Yu A Filimonov, Yu V Khivintsev, Sergei Vysotsky, Valentin Sakharov, Evgeniy Pavlov  
*Physics Uspekhi* 58, 1002 (2015)

REFEREED PUBLICATIONS

- 2018
- 20. Ultra-fast logic devices using artificial “neurons” based on antiferromagnetic pulse generators**  
Roman Khymyn, Ivan Lisenkov, James Voorheis, Olga Sulymenko, Oleksandr Prokopenko, Vasil Tiberkevich, Johan Akerman, Andrei Slavin  
*Journal of Applied Physics* 124, 152115 (2018) (Featured Article)
- 19. Nonreciprocal surface acoustic waves in multilayers with magneto-elastic and interfacial Dzyaloshinskii-Moriya interactions**  
Roman Verba, Ivan Lisenkov, Ilya Krivorotov, Vasil Tiberkevich, and Andrei Slavin  
*Phys. Rev. Applied* 9, 064014 (2018)
- 2017
- 18. Magnon-magnon interactions in a room-temperature magnonic Bose-Einstein condensate**  
Oleksandr Dzyapko, Ivan Lisenkov, Patrik Nowik-Boltyk, Vladislav E. Demidov, Sergej O. Demokritov, Benny Koene, Andrei Kirilyuk, Theo Rasing, Vasil Tiberkevich, Andrei Slavin  
*Phys. Rev. B* 96, 064438 (2017)
- 17. Antiferromagnetic THz-frequency Josephson-like Oscillator Driven by Spin Current**  
Roman Khymyn, Ivan Lisenkov, Vasil Tiberkevich, Boris A. Ivanov, Andrei Slavin  
*Scientific Reports* 7, 43705 (2017)
- 16. Low Power Microwave Signal Detection With a Spin-Torque Nano-Oscillator in the Active Self-Oscillating Regime**  
Steven Louis, Vasil Tyberkevych, Jia Li, Ivan Lisenkov, Roman Khymyn, Elena Bankowski, Thomas Meitzler, Ilya Krivorotov, Andrei Slavin  
*IEEE Transactions on Magnetics* VOL. 53, NO. 11, NOVEMBER 2017 1400804
- 2016
- 15. Interaction of microwave photons with nanostructured magnetic metasurfaces**  
Ivan Lisenkov, Vasil Tyberkevych, Luke Levin-Pompetski, Elena Bankowski, Thomas Meitzler, Sergey Nikitov, Andrei Slavin  
*Phys. Rev. Applied* 5, 064005 (2016)
- 14. Theoretical formalism for collective spin-wave edge excitations in arrays of dipolarly interacting magnetic nanodots**  
Ivan Lisenkov, Vasil Tyberkevych, Sergey Nikitov, Andrei Slavin  
*Phys. Rev. B* 93, 214441 (2016)
- 13. Transformation of spin current by antiferromagnetic insulators**  
Roman Khymyn, Ivan Lisenkov, Vasil S. Tiberkevich, Andrei N. Slavin, Boris Ivanov  
*Phys. Rev. B* 93, 224421 (2016)
- 12. Bias-free spin-wave phase shifter for magnonic logic**  
Steven Louis, Ivan Lisenkov, Sergey Nikitov, Vasil Tyberkevych and Andrei Slavin  
*AIP Advances* 6, 065103 (2016)
- 2015
- 11. Electrodynamic boundary conditions for planar arrays of thin magnetic elements**  
Ivan V. Lisenkov, Vasil Tyberkevych, Sergei Nikitov and Andrei Slavin  
*Appl. Phys. Lett.* 107, 082405 (2015)
- 10. Nonreciprocity of edge modes in 1D magnonic crystal**  
I. Lisenkov, D. Kalyabin, S. Osokin, J.W. Klos, M. Krawczyk, S. Nikitov  
*Journal of Magnetism and Magnetic Materials* 378, 313–319 (2015)

2014

- 9. Spin-wave edge modes in finite arrays of dipolarly coupled magnetic nanopillars**  
Ivan Lisenkov, Vasyl Tyberkevych, Andrei Slavin, Pavel Bondarenko, Boris A Ivanov, Elena Bankowski, Thomas Meitzler, Sergey Nikitov  
*Phys. Rev. B* 90, 104417 (2014)
- 8. Frequency separation of surface acoustic waves in layered structures with acoustic metamaterials**  
D. Kalyabin, I. Lisenkov, Y.P. Lee, S. Nikitov  
*Photonics and Nanostructures — Fundamentals and Applications* 12, 239–251 (2014)
- 2013
- 7. Edge rotational magnons in magnonic crystals**  
Ivan Lisenkov, Dmitriy Kalyabin and Sergey Nikitov  
*Appl Phys Lett.* 103, 202402 (2013)
- 6. Nonreciprocity of spin waves in metallized magnonic crystal**  
M Mruczkiewicz, M Krawczyk, G Gubbiotti, S Tacchi, Yu A Filimonov, D V Kalyabin, I V Lisenkov and S A Nikitov  
*New J. Phys.* 15 113023 (2013)
- 2011
- 5. The Complex Doppler Effect in Double Negative Media**  
I. V. Lisenkov and S. A. Nikitov  
*Journal of Communications Technology and Electronics*, 56, 687–689 (2011)
- 4. Acoustic wave propagation in fluid metamaterial with solid inclusions**  
I.V. Lisenkov, R.S. Popov, S.A. Nikitov  
*Appl. Phys. A* 103, 921–925 (2011)
- 2008
- 3. Elastic Wave Propagation in a Microstructured Acoustic Fiber**  
Sergey A. Nikitov, Roman S. Popov, Ivan V. Lisenkov, and Chul Koo Kim  
*IEEE Proc. of Ultrason. Ferr. and Freq. Control*, 55, 1831–1839 (2008)
- 2. Elastic waves in periodic and non-periodic sets of hollow cylinders**  
S. A. Nikitov, Yu. V. Gulyaev, I. V. Lisenkov, R. S. Popov, A. V. Grigorievskii and V. I. Grigorievskii  
*AIP Conf. Proc.*, 1022, 287 (2008)
- 2007
- 1. Propagation of Elastic Waves in Phononic Crystals**  
I. V. Lisenkov, S. A. Nikitov, R. S. Popov, and Chul Koo Kim  
*Journal of Communications Technology and Electronics*, 52, 1122–1134. (2007)
- INVITED PRESENTATIONS
- 2017
- 4. Acoustically pumped magnonics**  
Ivan Lisenkov, Mikkel Hansen, Albrecht Jander, and Pallavi Dhagat  
*2017 SPIE Optics + Photonics*, San Diego, CA August, 6–10 2017
- 2016
- 3. Mechanism of spin current transfer through antiferromagnetic dielectrics**  
Roman Khymyn, Boris Ivanov, Ivan Lisenkov, Vasyl Tyberkevych and Andrei Slavin  
*2016 Joint Intermag-MMM Conference*, San Diego, CA January, 11–15 2016
- 2015
- 2. Transfer of a pure spin through an antiferromagnetic insulator**  
R. Khymyn, B. Ivanov, I. Lisenkov, V. Tyberkevych and A. Slavin  
*The 13th RIEC International Workshop on Spintronics*, Sendai, Japan, November 18–20 2015.
- 2007
- 1. Review of Phononic Crystals, nonlinear processes, devices and prospects**  
S. Nikitov, Y. Gulaev V. Grigorevsky, A. Grigorevsky, I. Lisenkov, R. Popov  
*2007 IEEE International Ultrasonics Symposium, Oct 28-31, New York*

INVITED COLLOQUIA

- 2018      **5. Ultrafast antiferromagnetic dynamics under spin-transfer torque. Current state and outlook**  
Ivan Lisenkov  
Department of Physics, Southern Georgia University, Stateboro, CA. October 01, 2018.
- 4. Ultrafast antiferromagnetic dynamics under spin-transfer torque. Current state and outlook**  
Ivan Lisenkov  
Department of Physics, UCLA, Los Angeles, CA. January 29, 2018.
- 2017      **3. Spin current and THz frequency range generation in antiferromagnets**  
Ivan Lisenkov  
Department of Physics, Oregon State University, Corvallis, OR. February 01, 2017.
- 2016      **2. Arrays of magnetic nanoelements as a new reconfigurable magnetic material for magnonic signal processing and digital logic applications**  
Ivan Lisenkov  
The Materials Sciences Division at the Lawrence Berkeley National Laboratory, Berkeley, CA. January 20, 2016.
- 2014      **1. Arrays of magnetic nanodots as a new reconfigurable magnetic material for magnonic applications**  
Ivan Lisenkov  
Northeastern University of Boston, Boston MA. September 2014

CONTRIBUTED PRESENTATIONS

- 2018      **Dipole-exchange spin-wave spectrum in ferromagnetic films calculated using the method of geometrical optics**  
Ivan Lisenkov, Vasyl Tyberkevych, and Andrei Slavin  
ICM 2018, Jul 15–20, San Francisco, CA
- Parametric amplification of spin-waves by surface acoustic waves in nano-scale devices**  
Ivan Lisenkov  
TANMS 2018 Annual Research Strategy Meeting, Jan 30–31, Los Angeles, CA
- 2017      **Surface-acoustic-wave-pumped parametric amplification of forward volume spin waves**  
Ivan Lisenkov, Joe Davies, Albrecht Jander, Pallavi Dhagat  
2017 MMM Conference, Nov 06–10, Pittsburgh, PA
- Nonreciprocal magneto-elastic waves in magnetic/non-magnetic bilayers with interfacial Dzyaloshinskii-Moriya interaction**  
Roman Verba, Ivan Lisenkov, Roman Khymyn, Vasyl Tyberkevych, Andrei Slavin  
2017 MMM Conference, Nov 06–10, Pittsburgh, PA
- Control of the antiferromagnetic resonance frequency by spin-current**  
Ivan Lisenkov, Vasyl Tyberkevych, Andrei Slavin  
2017 MMM Conference, Nov 06–10, Pittsburgh, PA
- Determination of magnetoelastic constants in ferrite films using strain-dependent FMR measurements and a linear perturbation theory**  
Khalid Masood, Ivan Lisenkov, Brandon Howe, Benjamin Gray, Hyung-Min Jeon, Albrecht Jander, Pallavi Dhagat  
2017 MMM Conference, Nov 06–10, Pittsburgh, PA

**Spintronic generator of ultrashort pulses based on an antiferromagnetic film**

Ivan Lisenkov, Roman Khymyn, Vasyl Tyberkevych and Andrei Slavin  
2017 Intermag, Apr 24th-28th 2017, Dublin, Ireland

**Inhomogeneous parametric pumping of spin-waves by acoustic waves in an yttrium-iron-garnet film**

Ivan Lisenkov, Albrecht Jander and Pallavi Dhagat  
2017 Intermag, Apr 24th-28th 2017, Dublin, Ireland

2016

**Self-sustained Oscillations of a Biaxial Antiferromagnet Under a Spin-transfer Torque**

Ivan Lisenkov, Roman Khymyn, Vasyl Tyberkevych and Andrei Slavin  
2016 MMM Conference, Oct 31- Nov 04, New Orleans, LA

**Stabilization of a Bose-Einstein condensate of magnons through interaction of two condensates with opposite wave vectors**

Oleksandr Dzyapko, Patrik Nowik-Boltyk, Vladislav E. Demidov, Sergej O. Demokritov, Benny Koene, Andrei Kirilyuk, Theo Rasing, Ivan Lisenkov, Vasyl Tyberkevych, Andrei N. Slavin  
2016 MMM Conference, Oct 31- Nov 04, New Orleans, LA

**Ultrafast Spectrum Analyzer Based on the Injection Locking of a Spin-Torque Nano-Oscillator**

Steven Louis, Ivan Lisenkov, Vasyl Tyberkevych, Jia Li, Roman Khymyn, Elena Bankowski, Thomas Meitzler, Ilya Krivorotov and Andrei Slavin  
2016 MMM Conference, Oct 31- Nov 04, New Orleans, LA

**Giant frequency splitting of dipolar azimuthal modes caused by Berry phase in magnetic nanorings**

Ivan Lisenkov, Vasyl Tyberkevych and Andrei Slavin  
2016 The Joint European Magnetic Symposia, Aug 21- 26 Glasgow, UK

**Manipulation of Electromagnetic Waves Using Arrays of Magnetic Nano-Elements**

Ivan Lisenkov, Luke Levin-Pompetzki, Vasyl Tyberkevych, Sergey Nikitov and Andrei N. Slavin  
2016 Joint Intermag-MMM Conference, Jan 11-15, San Diego, CA

**Vector Hamiltonian Formalism in the Theory of Nonlinear Magnetization Dynamics**

Vasyl Tyberkevych, Ivan Lisenkov, Anatoly D. Belanovsky and Andrei N. Slavin  
2016 Joint Intermag-MMM Conference, Jan 11-15, San Diego, CA

2015

**Reconfigurable microwave metamaterial based on arrays of magnetic nanowires**

Ivan Lisenkov, Anatoly Belanovsky, Vasyl Tyberkevych, Sergey Nikitov, Andrei Slavin  
META'15, the 6th International Conference on Metamaterials, Photonic Crystals and Plasmonics, New York; 07/2015

**Dynamic reconfigurable magnonic circuits based on domain walls in arrays of dipolarly coupled magnetic nanodots**

S. Louis, I. Lisenkov, M. Morozova, S. Nikitov, V. Tyberkevych and A. Slavin  
International Symposium Spin Waves 2015, June 7 - 13, Saint Petersburg, Russia

**Mechanism of a pure spin transfer through an antiferromagnetic insulator**

R. Khymyn, B. Ivanov, I. Lisenkov, V. Tyberkevych and A. Slavin  
INTERMAG 2015 May 11-15, 2015 Beijing, China

**Reflection of electromagnetic waves from an array of thin magnetic nanoelements**

Ivan Lisenkov, Vasyl Tyberkevych, Sergey Nikitov, Andrei Slavin  
INTERMAG 2015 May 11-15, 2015 Beijing, China

**Spin-wave Waveguides Formed by Domain Walls in Arrays of Dipolarly Coupled Magnetic Nanodots**

Ivan Lisenkov, Steven Louis, Sergey Nikitov, Vasyl Tyberkevych and Andrei Slavin  
INTERMAG 2015 May 11-15, 2015 Beijing, China



- 2014 **Unidirectional spin wave edge mode in an array of magnetic nanopillars with antiferromagnetic order**  
Ivan Lisenkov, Vasyl Tyberkevych, Sergey Nikitov and Andrei Slavin  
2014 Annual Conference on Magnetism and Magnetic Materials 03-07 Nov, Honolulu, HI
- Magnonic metamaterial with reconfigurable anisotropy based on a magnetic nanodot array with triangular lattice**  
Roman Khymyn, Ivan Lisenkov, Elena Bankowski, Thomas Meitzler, Vasyl Tyberkevych, Andrei Slavin  
2014 Annual Conference on Magnetism and Magnetic Materials 03-07 Nov, Honolulu, HI
- 2013 **Surface acoustic waves control with external magnetic field in TbCo<sub>2</sub>/FeCo films**  
Ivan V. Lisenkov, A. Klimov, V. Onoprienko, V. Preobrajenski, Philippe Pernod and S. A. Nikitov  
2013 IEEE International Ultrasonics Symposium, 21-25 Jul, Prague, Czech Republic
- 2012 **Local resonance band gaps in ferromagnetic nanostructured composites**  
Ivan Lisenkov and Sergey Nikitov  
Days on Diffraction 2012 28 May - 01 June, Saint Petersburg, Russia
- 2011 **Complex Acoustic Doppler Effect in Double Negative Resonance Metamaterials**  
I. V. Lisenkov and S. A. Nikitov  
2011 IEEE International Ultrasonics Symposium, Oct 18-21 Orlando, FL