

# Denis G. Baranov

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## Research summary

My research focuses on fundamental puzzles of nanophotonics and quantum optics. I am extremely interested in counter-intuitive and extraordinary effects of interaction between light and matter, both in the classical and quantum regimes. Those include the general aspects of the response theory, processes of perfect electromagnetic absorption and lasing, coherent control of propagation and scattering, ultrafast and nonlinear interaction of light with nanophotonic structures, nanostructures with tunable electromagnetic response, and behavior of coupled quantum emitter-cavity systems.

## Education

- May 2016 **PhD Degree in Physics**, *Moscow Institute of Physics and Technology*.
- June 2013 **Master's Degree in Applied Physics and Mathematics**, *Moscow Institute of Physics and Technology*, GPA: 4.9/5.
- June 2011 **Bachelor's Degree in Applied Physics and Mathematics**, *Moscow Institute of Physics and Technology*, GPA: 4.7/5.

## Professional Experience

- Sep 2016 - present **Postdoctoral Researcher**, *Chalmers University of Technology*, Gothenburg, Sweden.  
Theoretical research in nanophotonics
- Aug 2016 - Dec 2017 **Research Engineer**, *ITMO University*, St. Petersburg.  
Theoretical research in nanophotonics
- Aug 2013 - Jun 2016 **Research Fellow**, *All-Russia Research Institute of Automatics*, Moscow.  
Theoretical research in plasmonics and nanophotonics
- Sep 2009 - Jun 2013 **Junior Research Fellow**, *Institute for Theoretical and Applied Electromagnetics*, Moscow.  
Theoretical research in plasmonics and nanophotonics

## Bachelor's Thesis

- Title *Surface Plasmon Propagation Along a Surface of Indefinite Lossy Medium*
- Supervisor A. P. Vinogradov
- Description Theoretical analysis of SPP propagation along a surface of uniaxial nonpositively determined (indefinite) lossy medium. It is shown that a SPP mode guided by surface of indefinite lossy material may have arbitrarily large propagation length and at the cut-off frequency transforms to a homogenous plane wave, which is perfectly absorbed by surface without reflection.

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## Master's Thesis

- Title *Toy model of spaser. Magneto-optical spaser.*
- Supervisor A. P. Vinogradov
- Description We suggest a toy model for spaser which allows to describe its behavior in the framework of classical electrodynamics without quantum-mechanical dynamical equations. The model demonstrates phenomena, predicted by the quantum-mechanical approach, including lasing threshold, gain dependence of a laser mode, possibility of loss compensation and synchronization of spaser autooscillations by the external field. As a reasonable development of this model, we introduce a magneto-optical spaser, which has two lasing modes with circular polarization of dipole moment and different thresholds of the two lasing modes.

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## PhD Thesis

- Title *Perfect absorption and lasing in nanophotonic structures*
- Supervisor A. P. Vinogradov
- Description The development of novel approaches for advanced light manipulation at the nanoscale is the central problem of nanophotonics. In particular, efficient absorption of electromagnetic radiation is vital for a wide range of applications, including photovoltaics and photodetectors, RF cloaking, and others. Another goal is the development of nanolasers, optical devices enabling generation of coherent electromagnetic fields at the nanoscale. Such devices have promising applications in novel optical chips as a link between the electronic and optical components and in biophotonics. The recent advances in optical nanostructures fabrication open the way towards creation of completely novel electromagnetic absorbers and nanolasers. For that reason, the investigation of perfect absorption and lasing at the nanoscale is an extremely important issue.

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## Publications

in preparation

**Denis G. Baranov**, Battulga Munkhbat, Nils Odebo Lank, Ruggero Verre, Mikael Kall, and Timur Shegai, "Vacuum Rabi splitting in circular dichroism with cavity-plasmon-polaritons"

under review

Ekaterina Yu. Tiguntseva, Kirill L. Koshelev, Aleksandra D. Furasova, Vladimir Yu. Mikhailovskii, Elena V. Ushakova, **Denis G. Baranov**, Timur O. Shegai, Anvar A. Zakhidov, Yuri S. Kivshar, and Sergey V. Makarov, "Single-particle Mie-resonant all-dielectric nanolasers".

Andrew B. Yankovich, Battulga Munkhbat, **Denis G. Baranov**, Jorge Cuadra, Erik Olsen, Hugo Lourenco-Martins, Luiz H. G. Tizei, Mathieu Kociak, Eva Olsson, and Timur Shegai, "Visualizing plasmon-exciton hybridization at the nanoscale using electron microscopy".

2019

**Denis G. Baranov**<sup>†</sup>, Yuzhe Xiao<sup>†</sup>, Igor A. Nechepurenko, Alex Krasnok, Andrea Alù, and Mikhail A. Kats, "Nanophotonic engineering of far-field thermal emitters", *Nature Materials* 18, xxx (2019).

Ruggero Verre<sup>†</sup>, **Denis G. Baranov**<sup>†</sup>, Battulga Munkhbat, Jorge Cuadra, Timur Shegai, and Mikael Käll, "Transition metal dichalcogenide nanoantennas as a novel high-index platform for nanophotonics", *Nature Nanotechnology* 14, xxx (2019).

2018

Battulga Munkhbat<sup>†</sup>, **Denis G. Baranov**<sup>†</sup>, Michael Stuhrenberg, Martin Wersäll, Ankit Bisht, and Timur Shegai, "Self-hybridized exciton-polaritons in multilayers of transition metal dichalcogenides for efficient light absorption", *ACS Photonics* **6**, 139 (2018).

Michael Stuhrenberg, Battulga Munkhbat, **Denis G. Baranov**, Jorge Cuadra, Andrew B. Yankovich, Tomasz J. Antosiewicz, Eva Olsson, and Timur Shegai, "Strong light-matter coupling between plasmons in individual gold bipyramids and excitons in mono- and multilayers of WSe<sub>2</sub>", *Nano Lett.* **18**, 5938 (2018).

Ekaterina Y. Tiguntseva, **Denis G. Baranov**, Anatoly P. Pushkarev, Battulga Munkhbat, Filipp Komissarenko, Anvar A. Zakhidov, Timur Shegai, Sergey V. Makarov, and Yuri S. Kivshar, "Tunable Hybrid Fano Resonances in Halide Perovskite Nanoparticles", *Nano Lett.* **18**, 5522 (2018). [[Phys.org](#)]

Benjamin Rousseaux, **Denis G. Baranov**, Mikael Käll, Timur Shegai, and Göran Johansson, "Quantum description and emergence of non-linearities in strongly coupled single emitter-nanoantenna systems", *Phys. Rev. B* **98**, 045435 (2018).

Battulga Munkhbat, Martin Wersäll, **Denis G. Baranov**, Tomasz J. Antosiewicz, and Timur Shegai, "Suppression of photo-oxidation of organic chromophores by strong coupling to plasmonic nanoantennas", *Science Advances* **4**, eaas9552 (2018). [[Highlighted by Nature Nanotechnology](#)]

**Denis G. Baranov**, Ruggero Verre, Pawel Karpinski, and Mikael Käll, "Anapole-enhanced intrinsic Raman scattering from silicon nanodisks", *ACS Photonics* **5**, 2730 (2018).

Mikhail V. Zyuzin, **Denis G. Baranov**, Alberto Escudero, Indranath Chakraborty, Anton Tsympkin, Elena V. Ushakova, Florain Kraus, Wolfgang Parak, and Sergey V. Makarov, "Photoluminescence quenching of dye molecules near a resonant silicon nanoparticle", *Sci. Rep.* **8**, 6107 (2018).

Alex Krasnok, **Denis G. Baranov**, Andrey Generalov, Sergey Li, and Andrea Alù, "Coherently Enhanced Wireless Power Transfer", *Phys. Rev. Lett.* **120**, 143901 (2018). [[Focus in Physics](#)]

Jorge Cuadra, **Denis G. Baranov**, Martin Wersäll, Ruggero Verre, Tomasz J. Antosiewicz, and Timur Shegai, "Observation of tunable charged exciton polaritons in hybrid monolayer WS<sub>2</sub>-plasmonic nanoantenna system", *Nano Lett.* **18**, 1777 (2018).

**Denis G. Baranov**, Jorge Cuadra, Martin Wersäll, Tomasz J. Antosiewicz, and Timur Shegai, "Novel nanostructures and materials for strong light-matter interactions", *ACS Photonics* **5**, 24 (2018).

Alex Krasnok, Sergey Li, Sergey Lepeshov, Roman Savelev, **Denis G. Baranov**, and Andrea Alù, "All-optical switching and unidirectional plasmon launching with nonlinear dielectric nanoantennas", *Phys. Rev. Appl.* **9**, 014015 (2018).

Valentin A. Milichko, Dmitry A. Zuev, **Denis G. Baranov**, George P. Zograf, Katerina Volodina, Andrei A. Krasilin, Ivan Mukhin, Pavel A. Dmitriev, Vladimir V. Vinogradov, Sergey V. Makarov, and Pavel A. Belov, "Metal-dielectric nanocavity for real-time tracing molecular events with temperature feedback", *Laser Photon. Rev.* **12**, 1700227 (2018).

2017

**Denis G. Baranov**, Alex Krasnok, and Andrea Alù, "Coherent Virtual Absorption Based on Complex Zero Excitation for Ideal Light Capturing", *Optica* **4**, 1457 (2017). [[Phys.org](#)]

**Denis G. Baranov**, Alexander E. Krasnok, Timur Shegai, Andrea Alù, and Y. D. Chong, "Coherent perfect absorbers: linear control of light with light", *Nature Reviews Materials* **2**, 17064 (2017).

**Denis G. Baranov**, Dmitry A. Zuev, Sergey I. Lepeshov, Oleg V. Kotov, and Alexander E. Krasnok, Andrey B. Evlyukhin, and Boris N. Chichkov, "All-dielectric nanophotonics: the quest for better materials and fabrication techniques", *Optica* **4**, 814 (2017). [[Phys.org](#)]

Roman S. Savelev, Olga N. Sergaeva, **Denis G. Baranov**, Alexander E. Krasnok, and Andrea Alù, "Dynamically Reconfigurable Metal-Semiconductor Yagi-Uda Nanoantenna", *Phys. Rev. B* **95**, 235409 (2017).

**Denis G. Baranov**, Roman S. Savelev, Sergey V. Li, Alexander E. Krasnok, and Andrea Alù, "Modifying magnetic dipole spontaneous emission with nanophotonic structures", *Laser Photon. Rev.* **11**, 1600268 (2017).

2016

**Denis G. Baranov**, Sergey V. Makarov, Alexander E. Krasnok, Pavel A. Belov, and Andrea Alù, "Tuning of Near- and Far-Field Properties of All-dielectric Dimer Nanoantennas via Ultrafast Electron-Hole Plasma Photoexcitation", *Laser Photon. Rev.* **10**, 1009 (2016) [[IEEE Spectrum](#)]

**Denis G. Baranov**, Sergey V. Makarov, Valentin A. Milichko, Sergey I. Kudryashov, Alexander E. Krasnok, and Pavel A. Belov, "Nonlinear Transient Dynamics of Photoexcited Resonant Silicon Nanostructures", *ACS Photonics* **3**, 1546 (2016) [[Materials Today](#)]

**Denis G. Baranov**, Mihail I. Petrov, and Alexander E. Krasnok, arxiv: "Decoupling of light and matter: permanent dipole moment induced collapse of Rabi oscillations"

Anton I. Ignatov, Igor A. Nechepurenko, and **Denis G. Baranov**, "Anisotropy-assisted non-scattering coherent absorption of surface plasmon-polaritons", *Annalen der Physik* **528**, 537 (2016)

Pavel A. Dmitriev, **Denis G. Baranov**, Valentin A. Milichko, Sergey V. Makarov, Ivan S. Mukhin, Anton K. Samusev, Alexander E. Krasnok, Pavel A. Belov, and Yuri S. Kivshar, "Resonant Raman Scattering from Silicon Nanoparticles Enhanced by Magnetic Response", *Nanoscale* **8**, 9721 (2016) [[IEEE Spectrum](#)]

2015

**D. G. Baranov**, J. H. Edgar, Tim Hoffman, Nabil Bassim, and Joshua D. Caldwell, "Perfect interferenceless absorption at infrared frequencies by a van der Waals crystal", *Physical Review B* **92**, 201405(R) (2015) [[Phys.org](#)]

Sergey V. Li, **Denis G. Baranov**, Alexander E. Krasnok, and Pavel A. Belov, "All-dielectric nanoantennas for unidirectional excitation of electromagnetic guided modes", *Applied Physics Letters* **107**, 171101 (2015)

**D. G. Baranov**, A. P. Vinogradov, A. A. Lisyansky, "Superoscillating response of a nonlinear system on a harmonic signal", *Applied Physics B: Lasers and Optics* **21**, 209 (2015)

I. A. Nechepurenko, **D. G. Baranov**, and A. V. Dorofeenko, "Lasing induced by resonant absorption", *Optics Express* **23**, 20394 (2015)

**D. G. Baranov**, A. A. Zyablovsky, A. V. Dorofeenko, A. P. Vinogradov, and A. A. Lisyansky, "Comment on "Counterintuitive Dispersion Violating Kramers-Kronig Relations in Gain Slabs" ", *Physical Review Letters* **114**, 089301 (2015)

**D. G. Baranov**, A. P. Vinogradov, A. A. Lisyansky, "Magneto-optics enhancement with gain-assisted plasmonic subdiffraction chains", *J. Opt. Soc. Am. B* **32**, 281 (2015)

2014

**D. G. Baranov**, A. P. Vinogradov, A. A. Lisyansky, "Abrupt Rabi oscillations in a superoscillating electric field", *Optics Letters* **39**, 6316 (2014)

**D. G. Baranov**, A. P. Vinogradov, A. A. Lisyansky, "All-dielectric nanolaser", arXiv:1408.5164 (2014)

2013

**D. G. Baranov**, A. P. Vinogradov, A. A. Lisyansky, Yakov M. Strel'nik, and David J. Bergman, "Magneto-optical spaser", *Optics Letters* **38**, 2002 (2013)

E. S. Andrianov, **D. G. Baranov**, A. P. Vinogradov, A. A. Lisyansky, "Loss compensation by spasers in plasmonic systems", *Optics Express* **21**, 13467 (2013)

**D. G. Baranov**, E. S. Andrianov, A. P. Vinogradov, A. A. Lisyansky, "Exactly solvable toy model for surface plasmon amplification by stimulated emission of radiation", *Optics Express* **21**, 10779 (2013)

2012

**D. G. Baranov**, A. P. Vinogradov, C. R. Simovski, "Perfect absorption at Zenneck wave to plane wave transition", *Metamaterials* **6**, 70-75 (2012)

**D. G. Baranov**, A. P. Vinogradov, C. R. Simovskii, I. S. Nefedov, and S. A. Tret'yakov, "On the electrodynamics of an absorbing uniaxial nonpositive determined (indefinite) medium", *Journal of Experimental and Theoretical Physics* **114**, 568-574 (2012)

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## Book chapters

Alexander E. Krasnok, Roman S. Savelev, **Denis G. Baranov**, and Pavel A. Belov, "All-dielectric nanophotonics: fundamentals, fabrication, and applications", in *A Handbook of Metamaterials and Nanophotonics* (World Scientific, 2017).

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## Conference Publications

**D. G. Baranov**, S. V. Makarov, A. E. Krasnok, and P. A. Belov, "Nonlinear all-dielectric nanoantenna reconfigured by electron-hole plasma", *Proceedings of 10th International Congress on Advanced Electromagnetic Materials in Microwaves and Optics* p. 217 (2016)

Alexander Krasnok, Sergey Makarov, Pavel Belov, and **Denis Baranov**, "Ultrafast Magnetic Light", *Proceedings of 2016 IEEE International Symposium on Antennas and Propagation* p. 19 (2016)

Pavel A. Dmitriev, **Denis G. Baranov**, Valentin A. Milichko, Sergey V. Makarov, Ivan S. Mukhin, Anton K. Samusev, Alexander E. Krasnok, and Pavel A. Belov, "Femtosecond laser transfer of silicon nanoparticles with enhanced Raman response", *AIP Conference Proceedings* 1748, 030001 (2016)

**D. G. Baranov**, A. P. Vinogradov, C. R. Simovski, "Perfect Absorption by Semi-infinite Indefinite Medium", *Proceedings of the International Conference Days on Diffraction 2012*, p. 32 (2012)

**D. G. Baranov**, A. P. Vinogradov, A. A. Lisyansky, "Exactly Solvable Toy Model for Spaser", *AIP Conference Proceedings* **1475**, 110-112 (2012)

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## Oral presentations

**Denis G. Baranov**, "Effects of strong coupling at the single nanoparticle level", *49th Winter Colloquium on the Physics of Quantum Electronics*, Snowbird, USA, 2019 [Invited]

**Denis G. Baranov**, "Coupling multilayer and bulk transition metal dichalcogenides to optical cavities", *Near-Field Optics 15*, Troyes, France, 2018

**Denis G. Baranov**, "Enhanced Raman emission by non-scattering anapole mode of a silicon nanodisk", *Days on Diffraction'2018*, St. Petersburg, Russia, 2018

**Denis G. Baranov**, "Coherent control of light for virtual absorption and wireless power transfer", *Days on Diffraction'2018*, St. Petersburg, Russia, 2018

**Denis G. Baranov**, "Raman Scattering from Silicon Nanoparticles Enhanced by Dipole Mie Resonances", ICEM16, Singapore, July, 2016

**D. G. Baranov**, A. P. Vinogradov, and A. A. Lisyansky, "Plasmonic and Quantum Plasmonic Enhancement of Magneto-optics", *Days on Diffraction 2012*, St. Petersburg, Russia, May 27 - June 1, 2012

**D. G. Baranov**, A. P. Vinogradov, and C. R. Simovskii, "Coherent Plasmonic Perfect Absorber", *Days on Diffraction 2012*, St. Petersburg, Russia, May 27 - June 1, 2012

**D. G. Baranov**, A. P. Vinogradov, C. R. Simovskii, I. S. Nefedov, and S. A. Tret'yakov, "Zero reflection from uniaxial indefinite lossy medium", *5th Russian Conference on Radars and Communications*, Moscow, Russia, November 21-25, 2011

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## Poster presentations

**Denis G. Baranov**, "Ideal light capturing by a Hermitian system", SPP8, Taiwan, June, 2017

**D. G. Baranov**, "Perfect absorption without interference at infrared frequencies in hexagonal boron nitride", ICEM16, Singapore, July, 2016

**D. G. Baranov**, "Lasing induced by resonant absorption", SPP7, Jerusalem, Israel, June, 2015

**D. G. Baranov**, A. P. Vinogradov, and A. A. Lisyansky, "Non-resonant excitation of a quantum emitter by a superoscillating electric field", Photon14, London, UK, September 1-4, 2014

**D. G. Baranov**, A. P. Vinogradov, and A. A. Lisyansky, "Magneto-optical effect in passive and gain-assisted plasmonic chains", META'14, Singapore, May 20-23, 2014

**D. G. Baranov**, A. P. Vinogradov, and A. A. Lisyansky, "Subdiffraction Plasmonic Chain for Magneto-Optics Enhancement", 10th All-Russian Conference "Young scientists" - 2014, Moscow, Russia, April 9-11, 2014

**D. G. Baranov**, A. P. Vinogradov, and A. A. Lisyansky, "Subdiffraction Plasmonic Chain for Magneto-Optics Enhancement", The 14th Trends in Nanotechnology International Conference, Seville, Spain, September 9 - 13, 2013

**D. G. Baranov**, A. P. Vinogradov, and A. A. Lisyansky, "Toy model for spaser", 9th All-Russian Conference "Young scientists" - 2013, Moscow, Russia, April 14-17, 2013

**D. G. Baranov**, E. S. Andrianov, A. P. Vinogradov, and A. A. Lisyansky, "Exactly solvable toy model for spaser", *The Fifth International Workshop on Theoretical and Computational Nano-photonics*, Bad Honnef, Germany, October 24-26, 2012

**D. G. Baranov**, A. P. Vinogradov, and A. A. Lisyansky, "Electrodynamical Description of Nanolaser", *Nanomaterials and Nanotechnologies: Issues and Perspectives*, Moscow, Russia, October 1-2, 2012

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## Teaching Experience

2013-2014 Teaching at the correspondence school at Moscow Institute of Physics and Technology

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## Scientific Awards and Recognitions

- 2008 Abramov Foundation Scholarship
- 2012 Russian Federation President Scholarship
- 2012 State Academic Scholarship
- 2012 TaCoNa-Photonics 2012 Grant
- 2013, 2014 Dynasty Foundation Scholarship

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## Peer Reviewer

ACS Photonics, Optica, Laser & Photonics Reviews, Scientific Reports, Optics Express, Optics Letters, Materials Today, Advanced Optical Materials, Nanophotonics, Applied Physics Letters, Journal of Applied Physics, Advanced Photonics, IEEE Journal of Quantum Electronics, Photonics and Nanostructures - Fundamentals and Applications, Plasmonics, Applied Optics, Journal of Optical Society of America B, Applied Sciences, Journal of Electromagnetic Waves and Applications.

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## Computer skills

- OS Windows, UNIX
- Scientific Software Wolfram Mathematica, Lumerical FDTD,  $\LaTeX$ , Blender, Inkscape, Illustrator
- Programming C/C++, SQL

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## Certificates

- IELTS 7.5/9.0, Sep 2011, Portsmouth, UK