Curriculum Vitae
Professor Nikolay Zheludev, PhD, DSc
Deputy Director, Optoelectronics Research Centre
University of Southampton, UK

Personal Information

Surname: Zheludev
First Name: Nikolay
Business Address: Optoelectronics Research Centre, University of Southampton, Highfield, Southampton, SO17 1BJ, UK
e-mail: niz@orc.soton.ac.uk
Web: www.nanophotonics.org.uk/niz

Education & Research Career

- 1978: Graduated *summa cum laude* with a Master of Science degree in Physics from Russia's leading Moscow State University
- 1981: Awarded a PhD degree in Physics and Mathematics for his work on nonlinear polarization spectroscopy
- 1981: Appointed a faculty position at the Nonlinear Optics Laboratory at Moscow State University, group leader
- 1991: Appointed a Lecturer at the Physics Department of the University of Southampton
- 1992: Awarded the degree of Doctor of Science by MSU in recognition of his contribution to nonlinear polarization optics
- 1994: Promoted from a Lectureship directly to a Readership
- 2000: Appointed to a Chair (full Professorship) in Physics and Astronomy at the University of Southampton
- 2004: Became the Principal Investigator and Coordinator of the UK's EPSRC "NanoPhotonics Portfolio" Centre
- 2006: Appointed Deputy Director, Optoelectronics Research Centre, University of Southampton
- 2008: Appointed Editor-in-Chief of the *Journal of Optics* (IOP)
- 2009: Became the Director of the EPSRC UK Programme on "Nanostructured Photonic Metamaterials"

Personal Awards

- 1990: R.V.Khohlov award for young scientists
- 1994: Fellow of the IOP
- 2000: Leverhulme Senior Research Fellowship - the highest research fellowship awarded by the UK's main charity
- 2002: Senior Research Professorship of the Engineering and Physical Sciences Research Council in Nanophotonics - the highest research fellowship awarded by the UK's Research Council
- 2004: Fellow of the Optical Society of America for his contributions to nonlinear optics and nano-photonics
- 2009: The Royal Society Wolfson Research Merit Award

Prof Zheludev is Deputy Director (Physics) of the internationally famous, leading European Research Institution: The Optoelectronics Research Centre, University of Southampton. He leads a major research effort in the UK's photonics community. He coordinates the EPSRC (the UK's main funding body) Portfolio Programme on Nanophotonics and directs the EPSRC Programme on Nanostructured Photonic Materials. Since 2000, he has been awarded, as Principal Investigator, 19 National and European research grants totalling more than £17.5m.

Professor Zheludev's research reputation is derived from more than a hundred plenary and invited talks at major international conferences, held since 2005 (see: http://nanophotonics.org.uk/niz/talks), three research books and a constant stream of publications in high-impact journals (see: http://nanophotonics.org.uk/niz/publications/). As a highly influential scientist he has been elected to key committees and posts at the Optical Society of America, SPIE, the European Physical Society and the Institute of Physics (UK).

Since 2005 Prof Zheludev has sat or chaired the programme committees of 54 international conferences (see: http://nanophotonics.org.uk/niz/calendar/). This includes chairing the largest European conference in the discipline, CLEO/EQEC Europe, and the US and European SPIE Conferences on Metamaterials. He created a highly successful international meeting at the crossroads of nanophotonics and metamaterials (NANOMETA, now biennial, see: http://nanometa.org).

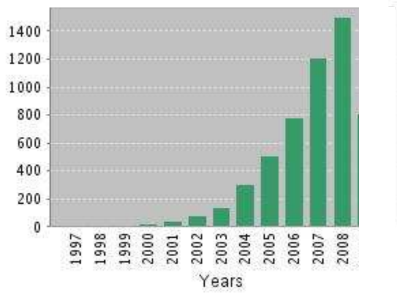
Professor Zheludev is the Editor-in-Chief Editor of the *Journal of Optics* (IOP), and has been appointed to several other editorial boards.

Achievements in Research

Professor Nikolay Zheludev is a world leader in the field of experimental nanophotonics and metamaterials.

The new research fields of nanophotonics and metamaterials are closely interlinked. The term **Nanophotonics** was coined only a few years ago and is now a major research direction in optical physics and engineering. Driven by the dream of untapped device functionality, nanophotonics studies the exciting science of the interaction of light with nanostructures, at the size scale where optical, electronic, structural, thermal and mechanical properties are deeply interdependent. The aim is to control light in a minute device containing only a few layers of atoms using signals carried by only a few photons and to do it very fast, within only a few oscillation cycles of the light wave.

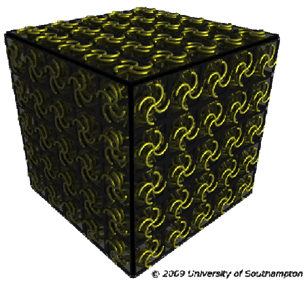
Nanophotonics and metamaterials.
Published items in each year worldwide

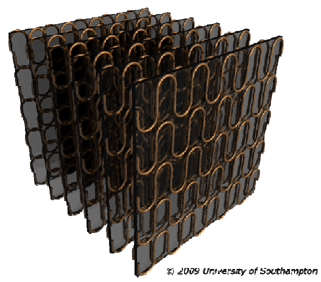


Metamaterials are artificial electromagnetic media achieved by structuring on a sub-wavelength scale. This field of research was catalyzed a few years ago by the intriguing opportunity to develop media that refract light in the opposite direction to that of normal media. The term 'metamaterial' quickly came into widespread use. Now its meaning encompasses linear, nonlinear and gain artificial media with all sorts of unusual functionalities, achieved by artificially structuring at sizes smaller than the length scale of the external stimulus.

Today nanophotonics and metamaterials are the most dynamic areas of physics, engineering and material science development which have been facilitated by the recent proliferation of nano-fabrication techniques such as high-resolution optical and electron beam lithography, focused ion milling and nanoimprint. Research centers and national programmes on nanophotonics and metamaterials are created all around the world as a core part of the nanotechnology revolution. The numbers of publications increase dramatically year-by-year (see figure). We're witnessing here *the new photonic revolution*.

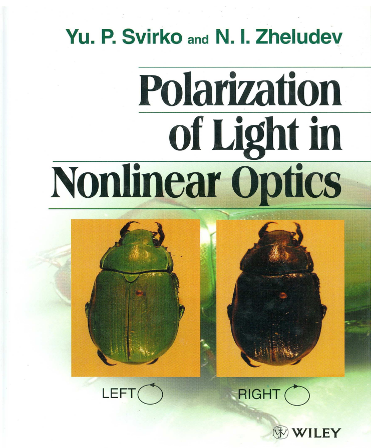
Indeed, in the last twenty years photonics has played a key role in creating the world as we know it today, with enormous beneficial worldwide social impact. Today it is impossible to imagine modern society without globe-spanning broadband internet and mobile telephony made possible by the implementation of optical fibre core networks, optical disc data storage (underpinned by the development of compact semiconductor lasers), modern image display technologies, and laser-assisted manufacturing.





Artistic impression of chiral photonic metamaterial (left) following: **Physical Review Letters.** 97, 177401 (2006) & **Physical Review B**. 79, 035407 (2009); and "slow light" photonic meta-material (right), following **Physical Review Letters**. 101, 253903 (2008)

The *next photonic revolution* will be explosively fuelled by a new dependence on active and switchable photonic metamaterials and nanophotonic devices. This significant revolution will lead to dramatic new science and applications on a global scale in all technologies using light, from data storage to optical processing of information; from sensing to energy conversion and defense.

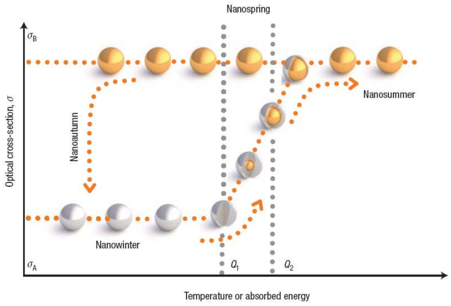


Front page of the research monograph on nonlinear phenomena in polarization optics. John Wiley & Sons (1998)

Research Overview. Professor Zheludev started his academic career at the leading Russian research institute, the International Laser Centre at Moscow state University. He moved to the UK in 1991 where he is now Deputy Director (Physics) of the internationally-famous Optoelectronics Research Centre (ORC) at the University of Southampton. He now leads major research efforts in the photonics community of the UK (see: www.nanophotonics.org.uk/niz). Since 2004 he has coordinated the EPSRC Portfolio Programme on "Nanophotonics" and from 2009 has directed the EPSRC interdisciplinary Programme on "Nanostructured Photonic Materials". Since 2000, he has been awarded, as Principal Investigator, 19 National and European research grants totaling more than £17.5M.

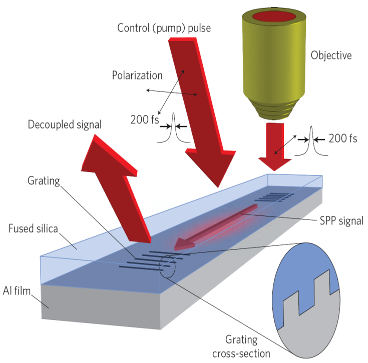
Professor Zheludev held the prestigious post of Senior Research Professor with the Science and Engineering Research Council UK (EPSRC) which is "awarded to outstanding academic scientists and engineers of international repute". His personal awards include the Wolfson Research Merit Award of the Royal Society and the Senior Leverhulme Research Award.

With more than 500 referred publications and more than a hundred keynote, plenary and invited talks at major conferences in recent years, Professor Zheludev has made seminal contributions to various branches of optics, nonlinear optics, nanophotonics and metamaterials.



Nano-photonics functionality through structural phase change in nano-particles, see: **Nature Photonics.** 1, 625 (2007)

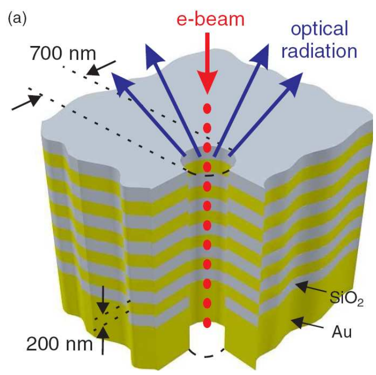
His early research was into the optics of intense laser fields, now widely known as nonlinear optics, the cornerstone science of today's optical data storage and telecommunication technologies. His particular interests were in the fundamental aspects of the subject, such as nonlinear phenomena involving changes in the vectorial properties of light. Professor Zheludev's interest in fundamental effects of light-matter interaction has led him to the fields of nanophotonics and metamaterials. In these fields he works on the development of radically new optical concepts suitable for all optical data processing tasks, management of optical and plasmonic signals in nanophotonic devices and artificially engineered photonic metamaterials that show characteristics not available in natural materials, thus permitting new functionalities.



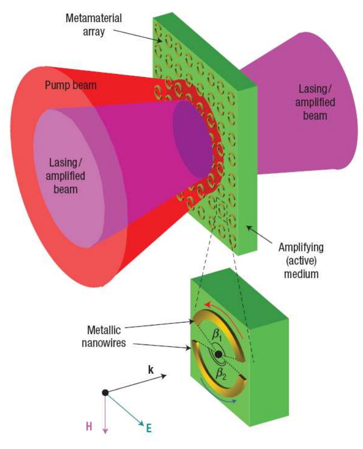
Ultrafast modulator of Plasmon signals. See: **Nature Photonics 3**, 55, (2008)

Polarization Optics. Professor Zheludev started his career researching nonlinear polarization phenomena in optics. This body of work, published in three books including the highly acclaimed "Polarization of light in Nonlinear Optics" (jointly with Yu.Svirko, see front cover [1]*)) and in more than eighty researches papers has made a profound contribution to the field. This includes fundamental discoveries in linear and nonlinear polarization optics of crystals including the nonlinear optical activity effect and the first observation of other fundamental transmissive and reflective nonlinear polarization phenomena. He has developed original mathematical methods for describing nonlinear polarization phenomena in media with spatial dispersion. Zheludev also developed methods for computing the symmetry of high-order material tensors used for the description of complex nonlinear optical phenomena [2]. He introduced an array of highly sensitive transient polarization measurement techniques with femtosecond resolutions for the study of nonlinear responses of semiconductors, superconductors and metals.

In the field of **nanophotonics**, Professor Zheludev invented and developed the revolutionary concept of reversible and irreversible switching of optical properties of materials confined to the nanoscale (nanoparticles, films) through induced changes to their structure. The main benefits of this approach are low energy switching energies, good operating speeds (ranging from picosecond to microsecond depending on the regime), and the ability to operate in a broad spectral domain, thus making it a prime solution for nanophotonics [5]. In 2001 these works led him to becoming EPSRC's Senior Research Professor on the topic of "Nanophotonics of structural transformations". Using the new phase change paradigm of nanoscale optical functionality he demonstrated the first single-nanoparticle phase change optical gate and memory element operated at unprecedented energy and power levels [13,18].



The "light-well": nanoscale tunable free electron light source, see: **Physical Review Letters**. 103, 113901 (2009)



The concept of the plasmonic & metamaterial "Lasing Spaser", see: ***Nature Photonics***, 2 351 (2008)

Professor Zheludev is the inventor of the original concept of "active plasmonics" using nanoscale phase change in the plasmon waveguide material [19]. This work was the first in a wide international research effort on controlling signals in nanophotonic plasmonic devices. He then demonstrated the fastest active plasmonic device ever that offers a terahertz bandwidth of operation and exploits the ultrafast nonlinearity of metal [3]. He recently started highly innovative work on sub-wavelength light concentration and optical super-resolution using the concept of super-oscillations [6,11].

Professor Zheludev was the first to show that a nanoscale source of plasmon signals can be created by the injection of free electrons into the metal surface [16] and demonstrated the first nanoscale tunable light source on a chip driven by free electrons [7].

In the field of **metamaterials** Professor Zheludev achieved a number of pioneering results. He is the world leading authority on artificial chiral photonic metamaterials. In particular, he was first to observe negative refraction due to chirality [15] and for the first time observed optical activity in achiral metamaterials proving that in regular structures chirality may be derived from the mutual arrangement of the metamaterial and the beam of light [9]. He introduced *planar chiral* photonic metamaterials and provided the first observations of the two-dimensional analog of the optical activity effect in a metamaterial thus extending the historic 18th century work of Arago to planar structures [20]. He discovered and studied the asymmetric transmission effect in planar chiral metamaterials that takes place in the pantheon of fundamental phenomena alongside the optical activity effect and the Faraday effect [17]. Zheludev introduced the concept of the enantiomeric sensitive plasmon in metamaterials. He provided the first demonstration of "invisible" metallic meta-materials and optical "magnetic wall". He introduced a new class of coherent metamaterials [14,10] showing sharp resonances of a collective nature – a prime class of media for active and switchable metamaterial devices. He introduced the "Lasing Spaser" device [4] – a new type of source that generates coherent light, drawing energy from plasmonic excitations of artificial metamolecules. Promoting metamaterials as a powerful platform for modeling fundamental physics phenomena Zheludev demonstrated that essential features of atomic electromagnetically induced transparency can be achieved in metamaterials, allowing for the creation of slow light and delay optical devices [12]. He pioneered the field of toroidal metamaterials supporting excitation of unusual symmetries and other exotic properties [8].

N.I.Zheludev: Key recent publication

Books

1. **"Polarization of Light in Nonlinear Optics".** Y.P. Svirko and N.I. Zheludev. John Wiley & Sons. Chichester, New York, Weinheim, Brisbane, Singapore, Toronto, 1998 (ISBN 0-471-97640-7)
2. **"Susceptibility Tensors for Nonlinear Optics".** S.V.Popov, Y.P. Svirko and N.I. Zheludev. Institute of Physics Publishers, Bristol and Philadelphia, 1995 (ISBN 0-7503-0253-4)

Papers

3. Ultrafast active plasmonics. K. F. MacDonald, Z. L. Sámson, M. I. Stockman, and N. I. Zheludev. **Nature Photonics 3**, 55, (2008)
4. Lasing spaser. N. I. Zheludev, S. L. Prosvirnin, N. Papasimakis, and V. A. Fedotov**. Nature Photonics,** 2 351-354 (2008)
5. All Change, please. N.I.Zheludev. **Nature Photonics.** 1, 625-628 (2007)
6. What diffraction limit? N. I. Zheludev. **Nature Materials** 7, 420-422 (2008)
7. Light well: a tunable free-electron light source on a chip. G. Adamo, K. F. MacDonald, Y. H. Fu, C-M. Wang, D. P. Tsai, F. J. García de Abajo, and N. I. Zheludev. **Physical Review Letters**. 103, 113901 (2009)
8. Gyrotropy of a metamolecule: wire on a torus. Papasimakis, V. A. Fedotov, K. Marinov, and N. I. Zheludev. **Physical Review Letters.** 103, 093901 (2009)
9. Metamaterials: optical activity without chirality. E. Plum, X.-X. Liu, V. A. Fedotov, Y. Chen, D. P. Tsai, and N. I. Zheludev. **Physical Review Letters**. 102, 113902 (2009)
10. Coherent and incoherent metamaterials and order-disorder transitions. N. Papasimakis, V. A. Fedotov, Y. H. Fu, D. P. Tsai, and N. I. Zheludev. **Physical Review B.** 80, 041102(R) (2009)
11. Super-resolution without evanescent waves. F. M. Huang and N. I. Zheludev. **Nano Letters**. 9, 1249 (2009)
12. Metamaterial analog of electromagnetically induced transparency. N. Papasimakis, V. A. Fedotov, N. I. Zheludev, and S. L. Prosvirnin. **Physical Review Letters**. 101, 253903 (2008)
13. All-optical phase-change memory in a single gallium nanoparticle. B. F. Soares, F. Jonsson, and N. I. Zheludev. **Physical Review Letters**. 98, 153905 (2007)
14. Sharp trapped-mode resonances in planar metamaterials with broken structural Symmetry. V. A. Fedotov, M. Rose, S. L. Prosvirnin, N. Papasimakis, and N. I. Zheludev. **Physical Review Letters.** 99, 147401 (2007)
15. Giant gyrotropy due to electromagnetic-field coupling in a bilayered chiral structure. A. V. Rogacheva, V. A. Fedotov, A. S. Schwanecke, and N. I. Zheludev. **Physical Review Letters.** 97, 177401 (2006)
16. Generation of traveling surface plasmon waves by free-electron impact. M. V. Bashevoy, F. Jonsson, A. V. Krasavin, N. I. Zheludev, Y. Chen, and M. I. Stockman. **Nano Letters. 6**, 1113 (2006)
17. Asymmetric propagation of electromagnetic waves through a planar chiral structure. V. A. Fedotov, P. L. Mladyonov, S. L. Prosvirnin, A. V. Rogacheva, Y. Chen, and N. I. Zheludev. **Physical Review Letters.** 97, 167401 (2006)
18. Phase coexistence in gallium nanoparticles controlled by electron excitation. Pochon S, MacDonald KF, Knize RJ, Zheludev NI. **Physical Review Letters.** 92, 145702 (2004)
19. Active plasmonics: Controlling signals in Au/Ga waveguide using nanoscale structural transformations. Krasavin AV, Zheludev NI, **Applied Physics Letters**. 84, 1416 -1418 (2004)
20. Optical manifestations of planar chirality. Papakostas A, Potts A, Bagnall DM, Prosvirnin SL, Coles HJ, Zheludev NI. **Physical Review Letters.** 107404 (2003).