Yuri Kivshar received his PhD in 1984 from the USSR Academy of Science and was at the Institute for Low Temperature Physics and Engineering (Kharkov, Ukraine). From 1988 to 1993 he worked at different research centers in USA, France, Spain, and Germany. In 1993 he accepted an appointment at the Research School of Physical Sciences and Engineering of the Australian National University where presently he is Professor and Head of the Nonlinear Physics Center. Yuri Kivshar published more than 350 research papers in peer-reviewed journals including more than 15 book chapters and review articles and 2 books published in 2003 (Academic Press) and 2004 (Springer-Verlag), both translated to Russian. His interests include nonlinear guided waves, optical solitons, nonlinear atom optics, photonic crystals, and stability of nonlinear waves. Professor Yuri Kivshar was a recipient of the Medal and Award of the Ukrainian Academy of Science (1989), the International Pnevmatikos Prize in Nonlinear Physics (1995), the Pawsey Medal of the Australian Academy of Science (1998). In 1999 he was appointed as an (first Australian) Associate Editor of the Physical Review, and in 2002 he was elected to the Australian Academy of Science. He is Fellow of Optical Society of America and American Physical Society.

His recent awards include the Lyle Medal of the Australian Academy of Sciences ((the highest award of the AAS in physics), The Peter Baum Award of the Australian National University (the most distinguished award of ANU), Carl Zeiss Visiting Professor Award from the University of Jena and the Carl Zeiss Foundation, and Distinguish Professor Award from the Wenner-Gren Foundation in Sweden.

Key areas of research contribution within the Centre

Nonlinear optics, nanophotonics, photonic crystals, parametric processes and frequency conversion, all-optical devices and technologies, left-handed metamaterials, physics of graphene and carbon nanotubes

Researchers and students

Dr. Dragomir Neshev, Dr. Andrey Sukhorukov, Dr. Andrey Miroshnichenko, Dr. Zhiyong Xu, Dr. Ivan Garanovich, Dr. Ilya Shadrivov, Mr. Francis Bennet, Mr. Arthur Davoyan, Mr. Sangwoo Ha, Mr. Alexander Minovich, Mr Alexander Solntsev

Awards, honours, major international visits

His recent awards include the The Peter Baum Award of the Australian National University, Carl Zeiss Visiting Professor Award from the University of Jena and the Carl Zeiss Foundation, and Distinguished Award from the Wenner-Gren Foundation in Sweden. In 2010 he was awarded by the title Distinguished Professor of the Australian National University.

In 2010 he visited more than 15 research laboratories (where presented colloquia or invited seminars) including University of Cape Town (South Africa), University of Santiago de Chile (Chile), University of Concepcion (Chile), Sun Sen-Yat University (China), Los Alamos National Laboratory (USA), University of Odessa (Ukraine), Sandia Laboratories (USA), Texas A&M University of Qatar (Doha, Qatar), Institute for Low Temperature Physics (Kharkov, Ukraine), Institute for Radio-Electronics (Kharkov, Ukraine), St Petersburg State University (Russia).

He was invited to organize a mini-symposium at the PIERS Meeting in Xian (March 2010), and also a symposium on Nonlinear optics and nanophotonics in the framework of the second international conference: "Nonlinear waves – Theory and Applications" (Beijing, June 26-29, 2010)

In 2010, Yuri Kivshar presented 12 invited and keynote talks including Photonic localization and band gaps (ICPBG) (Guangzhou, China), International Workshop on Complexity in Periodically Structured Systems (Dresden, Germany), International Conference in Advanced Optoelectronics and Lasers (Sevastopol, Ukraine), 2nd International Conference on Metamaterials, Photonic crystals and Plasmonics META'10 (Cairo, Egypt), and others.

Key areas of research activity

Yuri Kivshar leads several research projects within the CUDOS program. His main research activity aims to develop innovative concepts of all-optical communication and information technologies and to carry out both theoretical and experimental studies on the photonic-crystal physics and engineering, optical solitons, and microphotonic nonlinear switching devices in order to promote the new field of photonic crystals, to enhance its development in Australia and provide linkages between leading edge R&D and industry in an important emerging technology. In particular, his current research activities fits at least two CUDOS Flagship projects **Slow Light** and **Tunable Microphotonics**, and it involve the studies of spatiotemporal dynamics of light propagation, nonlinear interaction and control of light in periodic photonic structures, and theoretical studies of photonic crystals and related devises.

Research achievements during 2009

Observation of two-dimensional dynamic localization of light

We have reported on the first experimental observation of dynamic localization of light in two-dimensional photonic lattices. We have demonstrated suppression of beam diffraction in hexagonal lattices created by weakly coupled waveguides with axis bending. We also reveal that this effect is strongly related to dynamic localization in zigzag waveguide arrays with next-nearest neighboring interactions (A. Szameit et al, Phys. Rev. Lett, 2010)

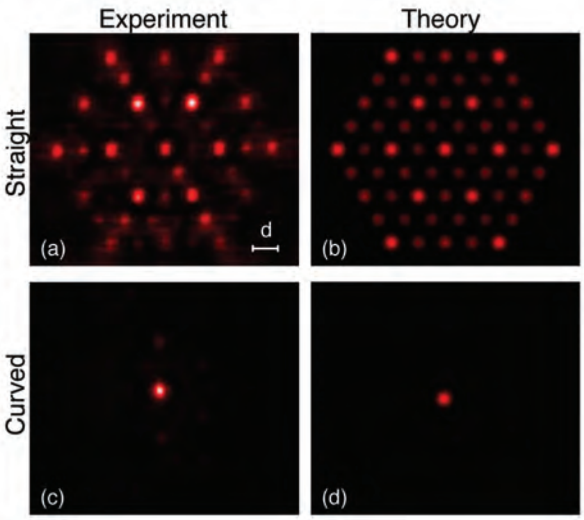

Fig 1: (a) Experimentally measured and (b) numerically calculated output beam profiles for the hexagonal lattice created by straight waveguides. (c) Experimentally measured and (d) numerically calculated output beam profiles for the hexagonal lattice created by periodically curved waveguides.

Observation of nonlinear modes in band-gap microcavities

In collaboration with the group of A/Prof. R.-K Lee from Hsinchu (Taiwan), we have studied experimentally an electrically pumped GaAs-based band-gap microcavity based on a vertical cavity surface emitting laser (VCSEL). We have demonstrated that such a band-gap structure in VCSEL supports the generation of self-organized optical patterns and dissipative solitons without using any holding beams. We have proposed a model of surface-structured VCSELs based on the coupled equations for the electric field and carrier density in semiconductor cavities, and analyzed a crossove between linear cavity modes and nonlinear clusters of dissipative band-gap solitons

(W.-X. Yang et al., Opt. Lett, 2010).

Prediction of optical bistability in disordered structures

We have studied wave transmission through one-dimensional random nonlinear structures and predict a novel type of optical bistability resulting from an interplay of nonlinearity and disorder. We reveal that, while weak nonlinearity does not change the typical exponentially small transmission in the regime of the Anderson localization, it affects dramatically the disorder-induced localized states excited inside the medium leading to bistable and nonreciprocal resonant transmission. Our numerical modeling shows an excellent agreement with theoretical predictions based on the concept of a high-Q resonator associated with each localized state. This offers a new way for all-optical light control employing statistically homogeneous random media without regular cavities [I. Shadrivov et al., Phys. Rev. Lett. **104**, 123902 (2010)]

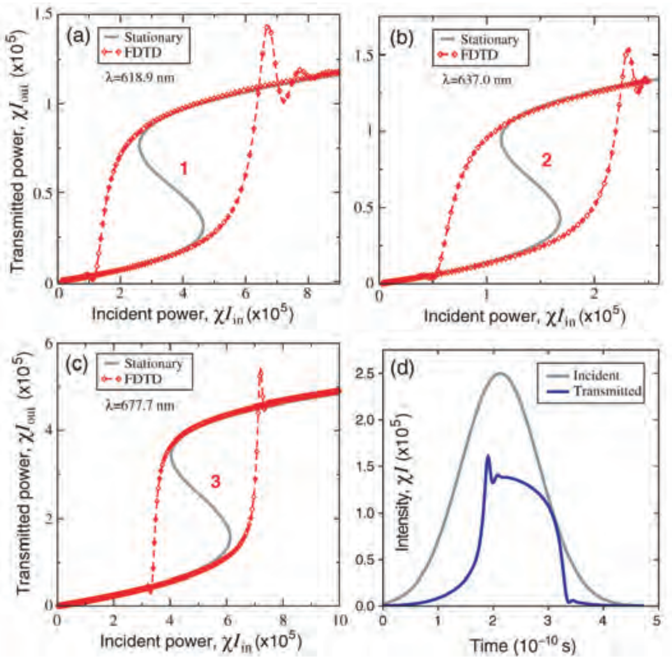

Fig 3: Stationary and FDTD simulations showing hysteresis loops in the output versus input power dependence for three selected resonances. Panel (d) shows deformation of the transmitted Gaussian pulse corresponding to the hysteresis switching.

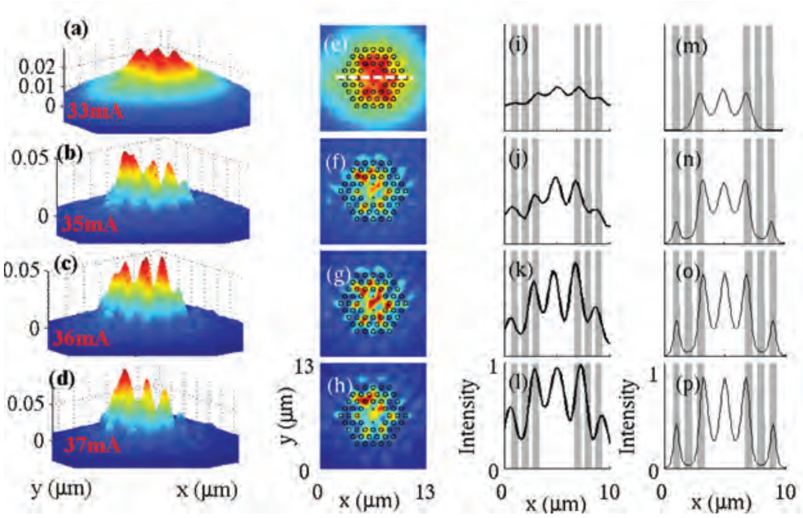

Fig 2: Experimental demonstration of soliton lattices with three-dimensional and two-dimensional NSOM images (first and second rows). The injection currents are (from top to bottom): 33, 35, 36, and 37mA, respectively. The third row shows the mode profiles along the horizontal direction, i.e., along the dashed line in (e). The shaded areas mark a periodic lattice.

A new type of nonlinear diffraction revealed

We have studied theoretically and observed experimentally a novel type of nonlinear diffraction in the process of two-wave mixing on a nonlinear quadratic grating. We demonstrate that when the nonlinear grating is illuminated simultaneously by two noncollinear beams, a second-harmonic diffraction pattern is generated by a virtual beam propagating along the bisector of the two pump beams. The observed diffraction phenomena is a purely nonlinear effect that has no analogue in linear diffraction.

[S. Saltiel et al., Phys. Rev. Lett. **104**, 083902 (2010)]

A short summary of this work has been included in the APS special online publication: "Physics: spotlighting exceptional research".

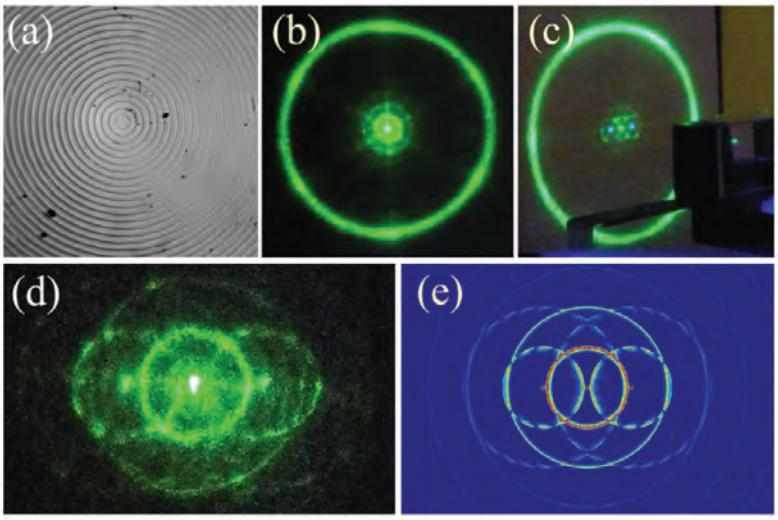

Fig 4: (a) Microphotograph of the Z surface of the annularly periodically poled structure. (b) Experimental image of nonlinear diffraction with a single fundamental beam and (c) with two beams crossing in the center of the structure. (d) Magnified central part of the pattern (c). (e) Numerically calculated second harmonics emission from the virtual-beam nonlinear diffraction process.

Backward second-harmonic generation with slow light in photonic crystals

We have studied theoretically forward and backward second-harmonic generation in a two-dimensional photonic crystal structure made of lithium niobate. The aim of this study was twofold: First, we proposed a reliable modal algorithm for describing the light propagation taking into account the vectorial character of the interacting fields as well as the tensorial character of the nonlinearity and verify it by means of the nonlinear finite-difference time-domain method. Second, we proposed a photonic crystal where we obtain a giant efficiency increase for backward second-harmonic generation with slow light [R. Iliew et al, Phys. Rev A **81**, 023820 (2010)].

Theory and experiment for cavity mode control in periodic waveguides

In collaboration with the group of Prof. A. Lavrinenko (DTU Fotonik, Denmark), we have demonstrated that the modes of coupled cavities created in periodic wave-guides can depend critically on the longitudinal shift between the cavities. In the absence of such shift, the modes feature symmetric or antisymmetric profiles, and their frequency splitting generally increases as the cavities are brought closer. We have shown that the longitudinal shift enables flexible control over the fundamental modes, whose frequency detuning can be reduced down to zero. Our coupled-mode theory analysis reveals an intrinsic link between the mode tuning and the transformation of slow-light dispersion at the pho- tonic band-edge. We have illustrate our approach through numerical modeling of cavities created in arrays of dielectric rods, and confirmed our predictions with experimental observations for microwave structures.

Observation of localized modes at phase slips in photonic lattices

In collaboration with Dr. Alex Szameit (Technion, Israel) and Prof. Mario Molina (Chile), we have studied light localization at phase-slip waveguides and at the intersection of phase-slips in two-dimensional square photonic lattices. Such system allows to observe a variety of effects, including the existence of spatially localized modes for low powers, the generation of strongly localized states in the form of discrete bulk and surface solitons, as well as a crossover between one-dimensional and two-dimensional localization. Using the facilities of laser-written waveguides in Jena, we have studied experimentally the generation of spatially localized modes at phase-slip waveguides and their intersections. We have generated both discrete bulk and surface solitons near the lattice structural defects, in a qualitative agreement with earlier theoretical predictions. We have also observed an interplay between the effectively one- and two-dimensional dynamics (A. Szameit et al, Optics Letters, 2010)

Demonstration of a novel types of phase transitions of nonlinear waves

In collaboration with the group of Prof. Th. Pertsch from Jena (Germany) and Prof. Roland Schiek from Regensburg (Germany), we have studied two-colour parametric nonlinear modes in waveguide arrays with quadratic nonlinear response. We have predicted theoretically and observed experimentally a new type of phase transition in nonlinear lattices accompanied by an abrupt power-controlled change of the staggered mode structure due to an interplay of localization and synchronization in parametrically driven discrete systems (F. Setzpfandt, Phys. Rev. Lett. 105, 233905 (2010)]