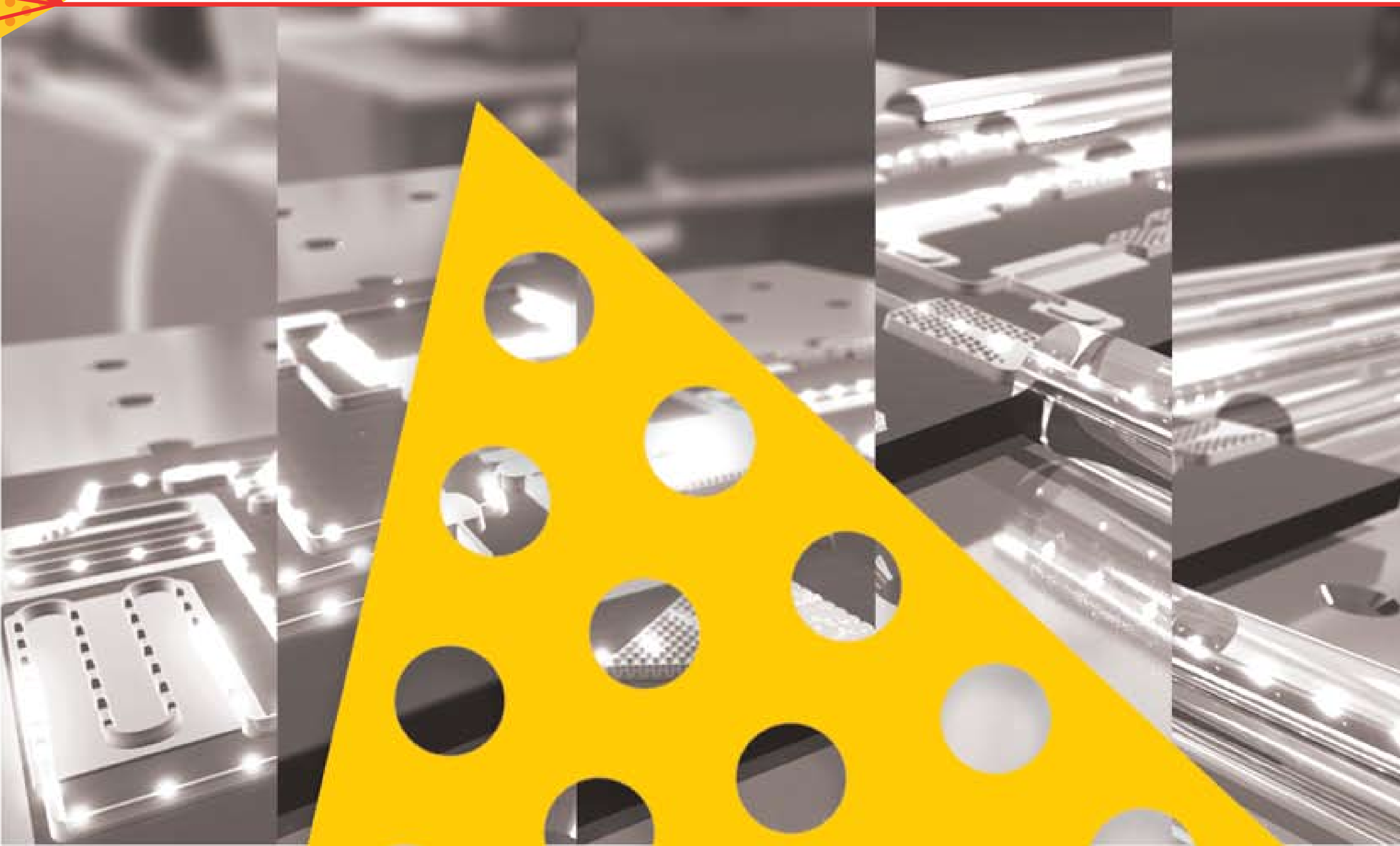
CUDOS The Centre for Ultrahigh bandwidth Devices for Optical Systems (CUDOS)

An Australian Research Council Centre of Excellence



Annual Report 2007

Wieslaw Krolikowski (3rd from right) and other members of the nonlinear optics experimental team.

Wieslaw Krolikowski received the Ph.D. degree in physics from the Institute of Physics, Polish Academy of Sciences, Warsaw, in 1987, and the D.Sc. (habilitation) degree in physics from the Warsaw University of Technology, Warsaw, Poland, in 2001. From 1988 to 1991, he was a Research Associate at Tufts University, Medford, Ma, USA where he was involved in the theoretical and experimental research on stationary properties and dynamics of optical phase conjugation in photorefractive media. Since 1992 he has been with the Laser Physics Centre, Australian National University, Canberra, where he is currently a Professor. His research interests include nonlinear optics, nonlinear dynamics, solitons, holography, fiber optics, and integrated optics. Prof. Krolikowski is an author and co-author of over 140 publications in technical journals. He is a member of the Australian Optical Society and Fellow of the Optical Society of America. He has served as a reviewer for major physical journals including Physical Review Letters, Physical Review, Optics Letters and Optics Express.

Professor Wieslaw Krolikowski

Key areas of research contribution within the Centre: Experimental and theoretical research on light propagation and localization in nonlinear photonic structures.

Roles and responsibilities within Centre

Within CUDOS Wieslaw Krolikowski is responsible for the experimental studies of linear and nonlinear aspects of localization and control of waves in periodic optical structures

Awards, honours, major international visits

Two articles describing our work on gap solitons and Second harmonic generation in random media have been included in the Optics & Photonics News “Optics in 2007” special issue.

Major international visits: COM Centre at the Technical University of Denmark, Department of Physics, Warsaw University of Technology, Beijing University of Technology, University of Massachusetts at Amherst.

Key areas of research activity

Professor Krolikowski conducts theoretical and experimental studies in linear and nonlinear optics. His research interests include fibre and integrated optics, optical phase conjugation, self-trapping of light and soliton formation and interaction. His earlier contributions include the discovery of the photorefractive effect in lead germanate and experimental observations of unstable dynamics and chaos in photorefractive optical phase conjugation. Prof. Krolikowski’s most important recent contributions include the observation of soliton birth and soliton annihilation in collision, prediction and experimental verification of anomalous interaction of incoherent solitons as well as demonstration of novel types of soliton, namely multipole vector solitons and nonlocal solitons. His current research activities within the CUDOS Flagship project

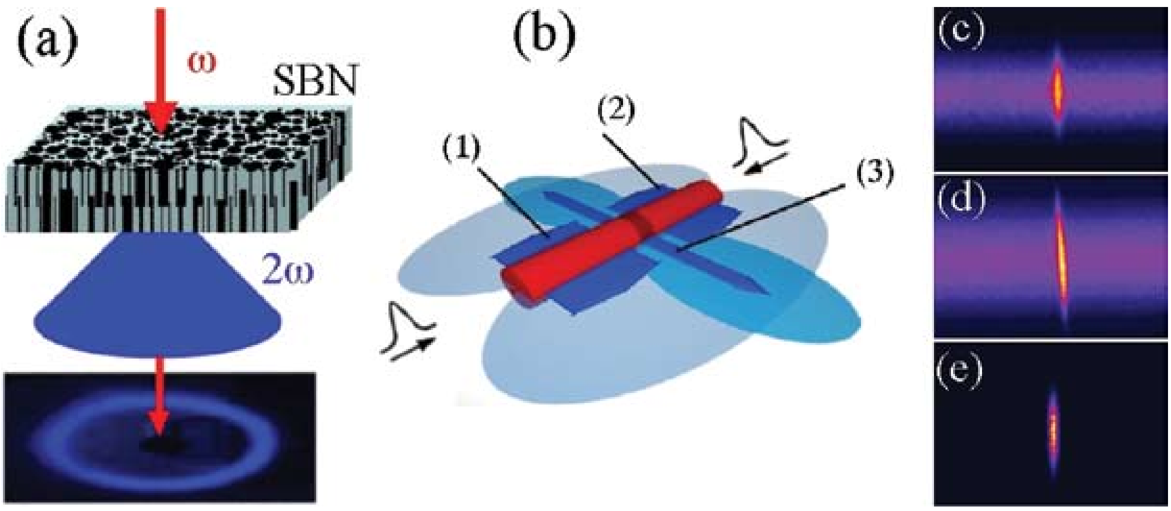


Fig 1: Monitoring ultrashort pulses by transverse frequency doubling of counterpropagating pulses in random media. (a) Conical emission of the second harmonic for the fundamental beam propagating along the optical axis of the SBN crystal with random ferroelectric domains. (b) Illustrating the concept of the pulse auto-correlator in disordered crystal - labels (1-3) denote the second harmonic emission by individual (1,2) and overlapping (3) pulses.(c-d) Autocorrelation traces of the femtosecond pulse with (c) straight and (d) tilted pulse front; as the pulses propagate perpendicular to the domains the background signal is clearly visible; (e) Background-free autocorrelation trace for pulses propagating along the domains.

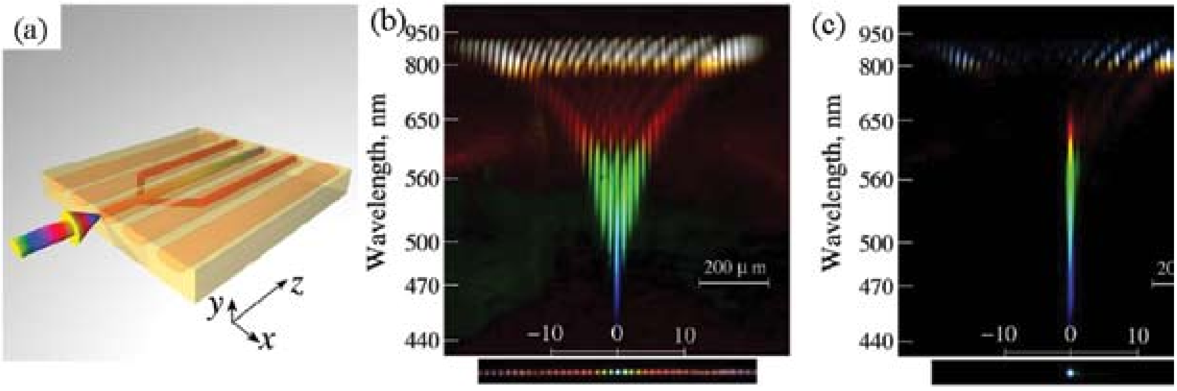


Fig 2: Nonlinear spectral-spatial control and localization of supercontinuum radiation. (a) Schematic of the experiment illustrating the dispersion of the colors inside the array of optical waveguides. (b) Spectrally resolved diffraction of the supercontinuum radiation (low input power of 17 μW). (c) Spectrally resolved localization of the supercontinuum inside the central waveguide at input power of 7.5 mW Bottom in (b-c): output color intensity profile.

Tunable microphotonics involve nonlinear interaction and control of of light in periodic photonic structures such as optical lattices and photonic fibres.

Researchers and students

Prof. W.Krolikowski, Prof. Y.Kivshar, Dr D. Neshev, Dr. A. Sukhorukov, F. Bennet, R. Fischer C. Rosberg, U.A. Laudyn (visitor from Warsaw University of Technology, Poland), S.Koke (visitor from the Institute of Applied Physics, University of Muenster, Germany), A.Szameit (visitor from the Institute of Applied Physics, University of Jena, Germany)

Research achievements during 2007

Nonlinear effects in optically induced photonic periodic structures:

1. Nonlinear spectral-spatial control and localization of supercontinuum radiation [1]. We present the first observation of spatiospectral control and localization of supercontinuum light through the nonlinear interaction of spectral components in extended periodic structures. We use an array of optical waveguides in a LiNbO3 crystal and employ the interplay between diffraction and nonlinearity to dynamically control the output spectrum of the supercontinuum radiation. This effect presents an efficient scheme for optically tunable spectral filtering of supercontinua.
2. Stabilization of counterpropagating solitons by photonic lattices [2]. We experimentally demonstrated the stabilization of inherently unstable counter-propagating photorefractive spatial solitons by the use of one- and two-dimensional photonic lattices in SBN crystal.
3. Observation of nonlinear self-trapping in triangular photonic lattices [3]. We experimentally studied light self-trapping in triangular photonic lattices induced optically in nonlinear photorefractive crystals. We observed the formation of two-dimensional discrete and gap spatial solitons originating from the first and second bands of the linear transmission spectrum.

Propagation of light in fabricated periodic structures.

1. Tunable diffraction and self-defocusing in liquid-filled photonic crystal fibers [4]. We suggest and demonstrate a novel platform for the study of tunable nonlinear light propagation in two-dimensional discrete systems, based on photonic crystal fibers filled with high index nonlinear liquids. Using the infiltrated cladding region of a photonic crystal fiber as a nonlinear waveguide array, we experimentally demonstrate highly tunable beam diffraction and thermal self-defocusing, and realize a compact all-optical power limiter based on a tunable nonlinear response.
2. Monitoring ultrashort pulses by transverse frequency doubling of counterpropagating pulses in random media [4]. A Strontium Barium Niobate ferroelectric crystal with randomly distributed antiparallel ferroelectric domains of various sizes can be used to realize broad-band second harmonic generation via the quasi-phase matching technique. We employed this property to create very simple optical autocorrellator and used it to characterize intensity profile and front tilt of femtosecond laser pulses.
3. Generation of Bessel beams by parametric frequency doubling in annular nonlinear periodic structures. We analyze the second-harmonic generation in two-dimensional photonic structures with radially periodic domains created by poling of a nonlinear quadratic crystal. We demonstrate that the parametric conversion of the Gaussian fundamental beam propagating along the axis of the annular structure leads to the axial emission of the second-harmonic field in the form of the radially polarized first-order Bessel beam.
4. Diffraction control in periodically curved two-dimensional waveguide arrays. We study propagation of light beams in two-dimensional photonic lattices created by periodically curved waveguide arrays. We demonstrate that by designing the waveguide bending, one can control not only the strength and sign of the beam diffraction, but also to engineer the effective geometry and even dimensionality of the two-dimensional photonic lattice. Our results suggest novel opportunities for efficient self-collimation, focusing, and reshaping of light beams in two-dimensional photonic structures.

[1] D. Neshev et al. Phys. Rev. Lett. 99, 123901 (2007).

[2] S. Koke et al. Opt. Express 15, 6279 (2007).

[3] C. Rosberg et al. Opt. Lett. 32, 397 (2007).

[4] C. Rosberg, et al. Opt. Express 15, 12145 (2007).

[5] R. Fischer, et al. Appl. Phys. Lett. 91, 031104 (2007).

[6] S. Saltiel, et al. Opt. Express 15, 4132 (2007).