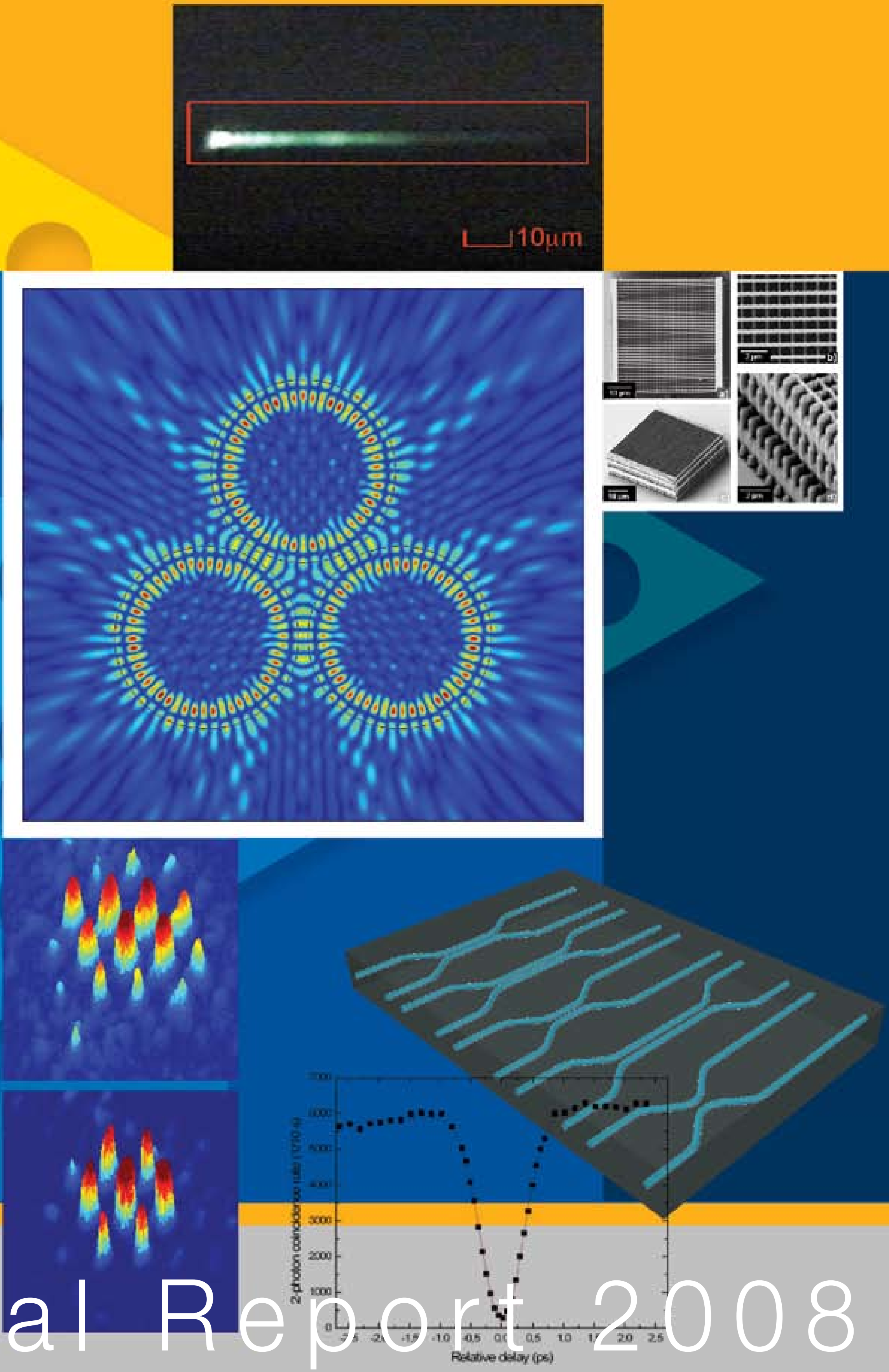
CUDOS

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



Annual Report 2008

Chief Investigator: Wieslaw Krolikowski

CI short biography

Wieslaw Królikowski 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 170 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, Optics Express.

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

In 2008 Wieslaw Krolikowski has been nominated Topical Editor of the Journal of the Optical Society of America B.

Major international visits

DTU Fotonik at the Technical University of Denmark, Department of Physics, Warsaw University of Technology, University of Muenster, Germany, Barcelona

Key areas of research activity

Professor Wieslaw 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 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, P.Rasmussen, B.Terhalle (visitor from the Institute of Applied Physics, University of Muenster)

Research achievements during 2008

1. Observation of multivortex solitons in photonic lattices. We reported on the first observation of topologically stable spatially localized multivortex solitons generated in optically induced hexagonal photonic lattices. We demonstrated that topological stabilization of such nonlinear localized states can be achieved through self-trapping of truncated two-dimensional Bloch waves and confirmed our experimental results by numerical simulations of the beam propagation in weakly deformed lattice potentials in anisotropic photorefractive media [1].

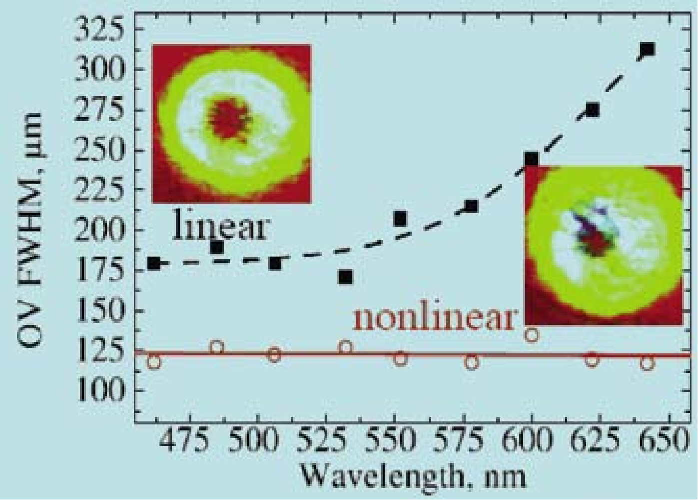


Fig 1. Polychromatic vortex in nonlinear defocusing media. Plots depict width of each spectral component of optical vortex in linear regime (solid squares; dashed curve) and nonlinear regime when polychromatic double-charged optical vortex soliton is formed. Insets output intensity distributions in the two regimes.

2. Generation of second-harmonic conical waves via nonlinear Bragg diffraction. We reported on the observation of second-harmonic conical waves generated in a novel geometry of the transverse excitation of an annular periodically poled nonlinear photonic structure by a fundamental Gaussian beam. We showed that the conical beams are formed as a result of the higher-order nonlinear Bragg diffraction involving two parametric processes in which an ordinary fundamental wave is converted

simultaneously into ordinary and extraordinary polarized second harmonics. [2]

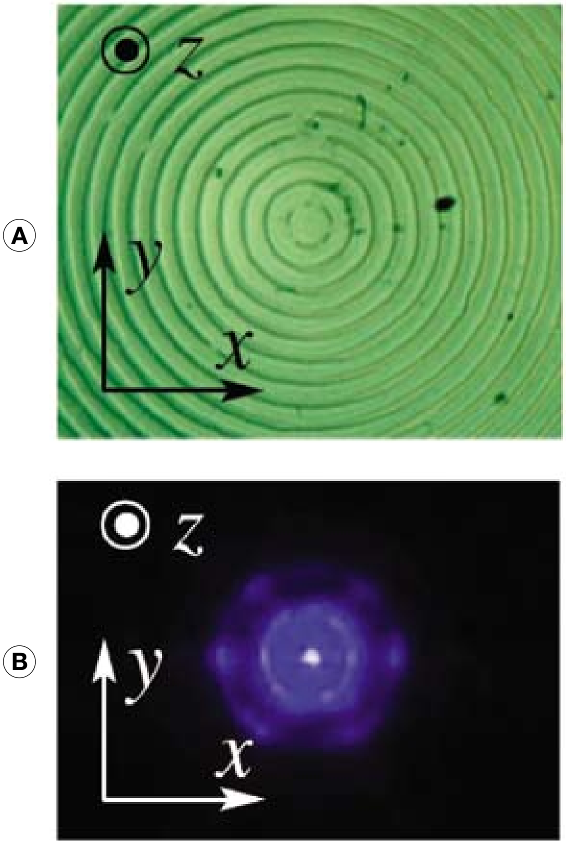


Fig 2. Illustrating the effect of second harmonic generation via the nonlinear Bragg diffraction. (a) annular periodically poled structure of lithium tantalite; (b) far field pattern of second harmonic emission.

3. Observation of polychromatic vortex solitons. We demonstrated experimentally the formation of polychromatic single- and double-charge optical vortex solitons by employing a lithium niobate crystal as a nonlinear medium with defocusing nonlinearity. We studied the wavelength dependence of the vortex core localization and observed self-trapping of polychromatic vortices with a bandwidth spanning over more than 70 nm for single-charge and 180 nm for double-charge vortex solitons. [3]

4. Spatiotemporal control of light in multi-core fibers. We studied theoretically the dispersion properties of Bloch modes and nonlinearly-induced defect states in two-dimensional waveguide arrays. We defined the conditions for achieving anomalous group-velocity dispersion and discussed possibilities for generation of spatiotemporal solitons [4]

5. Observation of polychromatic gap solitons. We studied theoretically and observed experimentally polychromatic gap solitons generated by supercontinuum light in an array of optical waveguides. The solitons are formed through a sharp transition from diffraction-induced broadening and color separation to the simultaneous spatio-spectral localization of supercontinuum light inside the photonic bandgap with the formation of the characteristic staggered phase structure for all colours [5].

6. Observation of diffraction-managed discrete solitons in curved waveguide arrays. We observed the formation of discrete diffraction-managed optical solitons in arrays of periodically curved coupled waveguides for two types of modulated structures: laser-written arrays in silica glass with self-focusing nonlinearity and lithium niobate waveguide arrays with self-defocusing photorefractive nonlinearity. Our results demonstrated that, for both types of nonlinear response, soliton formation occurs after transitional self-induced beam broadening, being fundamentally different from nonlinear self-focusing and defocusing in a bulk medium or discrete self-trapping in straight waveguides [6].

References

[1] B. Terhalle et al. Physical Review Letters **101** 013903 (2008)

[2] S. Saltiel et al., Phys. Rev. Lett. **100,** 103902 (2008).

[3] D.N. Neshev et al., Opt. Lett. **33,** 1851 (2008).

[4] P.D. Rasmussen et al., Opt. Express **16** 5878-5891 (2008)

[5] A. Sukhorukov, et al., Opt. Express **16** 5991-5996 (2008).

[6] A. Szameit, et al., Phys. Rev. A **78**, 031801 (2008)