Supercontinuum spatial gap solitons

Sukhorukov, Andrey; Neshev, Dragomir; Dreishuh, Alexander; Fischer, Robert; Ha, Sangwoo; Bolger, Jeremy; Bui, Lam

https://researchrepository.rmit.edu.au/esploro/outputs/9921863392201341/filesAndLinks?institution=61RMIT_INST&index=null

Sukhorukov, A., Neshev, D., Dreishuh, A., Fischer, R., Ha, S., Bolger, J., Bui, L., Krolikowski, W., Eggleton, B., Mitchell, A., Austin, M., & Kivshar, Y. (2007). Supercontinuum spatial gap solitons. European Conference on Lasers and Electro-Optics, 2007 and the International Quantum Electronics Conference. CLEOE-IQEC 2007., 1-1. <https://doi.org/10.1109/CLEOE-IQEC.2007.4386096>

Published Version: <https://doi.org/10.1109/CLEOE-IQEC.2007.4386096>

Repository homepage: <https://researchrepository.rmit.edu.au>

© 2007 IEEE

Downloaded On 2023/04/26 19:38:49 +1000

Supercontinuum spatial gap solitons

Andrey A. Sukhorukov¹, Dragomir N. Neshev¹, Alexander Dreischuh^{1,2},
Robert Fischer¹, Sangwoo Ha¹, Jeremy Bolger³, Lam Bui⁴, Wieslaw Krolikowski¹,
Benjamin J. Eggleton³, Arnan Mitchell⁴, Michael W. Austin⁴, and Yuri S. Kivshar¹

Centre for Ultra-high bandwidth Devices for Optical Systems (CUDOS),

¹Nonlinear Physics Centre and Laser Physics Centre,

RSPHysSE, Australian National University, Canberra, Australia

²Department of Quantum Electronics, Faculty of Physics, Sofia University, Bulgaria

³School of Physics, University of Sydney, Sydney NSW 2006, Australia

⁴School of Electrical and Computer Engineering, RMIT University, Melbourne, Australia

Advances in the generation of light with supercontinuum spectra in photonic-crystal fibers (PCFs) open new possibilities for a wide range of applications. PCFs allow for engineering of the spectral dispersion and confinement of light through the underlying periodicity of their structure. Periodic photonic structures also find applications for spatial beam control, however their use is primarily optimized for beam shaping and deflection in a narrow-frequency range. In this work, we predict theoretically and demonstrate experimentally novel possibilities for active control of supercontinuum light beams in nonlinear waveguide arrays. Whereas different colors are separated in the linear regime due to the strong spectral dispersion, we show that nonlinear interactions enable collective manipulation of amplitude and phase states of all spectral components through the formation of *supercontinuum spatial gap solitons*.

Fig. 1. (a-c) Calculated real-color intensity plots of supercontinuum light beams: (a) linear diffraction inside the waveguide array; (b) output beam profile vs. the input power; (c) soliton formation at high input power. (d) Output phase structure of individual frequency components corresponding to (c).

In the linear regime (at low optical powers), each spectral component exhibits typical discrete diffraction where most of the light is concentrated into the wings of the beam rather than in its center. Spectral dispersion leads to the separation of various colors among different channels of the waveguide array, as shown in Figs. 1(a) and 2(a). We demonstrate that collective manipulation of all colors becomes possible when spectral dispersion is compensated by nonlinear incoherent interactions between spectral components in photorefractive media through the optically-induced decrease of the optical refractive index. Although such a negative nonlinear response would result in self-defocusing and accelerated beam broadening in bulk media, the supercontinuum beam experiences sharp transition to self-trapping in a periodic waveguide array above a critical power level [Fig. 1(b)]. The formation of such self-localized *gap solitons* [Fig. 1(c) and 2(c)] becomes possible due to localization in the photonic bandgap¹, when the dominating spectral components in the adjacent waveguides are out-of-phase [Fig. 1(d) and 2(d)], demonstrating nontrivial phase control of supercontinuum radiation. This represents a uniquely different phenomenon compared to the theoretically studied white-light lattice solitons in self-focusing media².

References

1. K. Motzek, A. A. Sukhorukov, and Yu. S. Kivshar, Opt. Express **14**, 9873 (2006).
2. R. Pezer, H. Buljan, G. Bartal, M. Segev, and J. W. Fleischer, Phys. Rev. E **73**, 056608 (2006).

Fig. 2. Experimental observation of supercontinuum gap solitons in the nonlinear waveguide array fabricated in LiNbO₃: (a-c) Real-color CCD camera images of the output beam intensity profile: (a) diffraction profile at low power; (b) non-linear localization with increasing optical power and (c) formation of a supercontinuum gap soliton. (d) Interferogram of the output beam profile (c) and a reference supercontinuum beam, integrated over all spectral components.