Observation of two-dimensional superlattice solitons

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Lattice solitons have been investigated in a number of settings and in different nonlinear materials (see [1,2] for recent reviews). Particular attention has been paid to the precise tuning of the properties of such states. In this respect periodic systems with complicated transverse shapes, such as photonic superlattices, open new opportunities for soliton control. A variety of linear and nonlinear phenomena have been demonstrated in superlattices, but experimental investigation of superlattice solitons were limited to one-dimensional settings [3]. Thus, the properties of two-dimensional entities remained unobserved.

In this talk we report on the experimental observation of two-dimensional solitons in superlattices comprising alternating deep and shallow waveguides [4]. Our experiments were conducted in superlattices that were fabricated using the femtosecond-laser direct writing technique in a fused silica samples with a length of 105 mm. The relevant lattice sites were excited with a Ti: Sapphire laser, delivering 200 fs pulses at a wavelength of 800 nm with a repetition rate of 1 kHz, while output patterns were recorder with a CCD camera. The symmetry of the linear diffraction patterns, soliton shapes, and threshold powers for soliton excitation in superlattices largely differ for excitations centered on deep and shallow waveguides. This is illustrated in Figs. 1,2 showing the output intensity distributions at specific powers for excitation of deep (Fig. 1) and shallow (Fig. 2) guides located either in the center (first column), at the edge (second column), or in the corner (third column) of the superlattice. The first row in each figure corresponds to the almost linear regime of propagation for 200 kW excitation peak power. The second and third rows show different stages of localization for input peak powers of 1 MW and 2 MW, respectively. Figures 1 and 2 illustrate that the dynamical excitation of solitons centered on deep guides is achieved at substantially smaller input peak powers than excitation of solitons on shallow guides (compare the patterns in the same rows in Figs. 1 and 2). Moreover, while an increasing input power results in the monotonic contraction of the output pattern for excitation of deep guides, an abrupt intermediate spreading can be observed upon excitation of shallow guides because of the matching of the effective index of excited shallow guide due to nonlinear contribution with refractive index in deep neighboring guides. We found that in all cases corner solitons exhibit the smallest threshold for their excitation, while center solitons require the highest threshold.

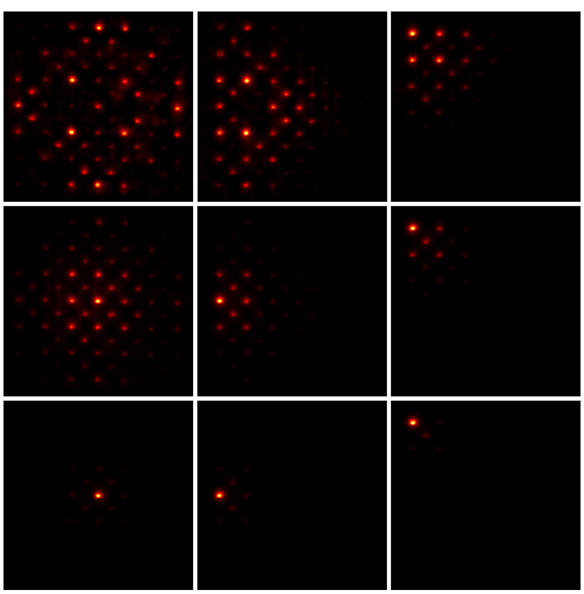

Fig. 1. Excitation of solitons centered on deep guides.

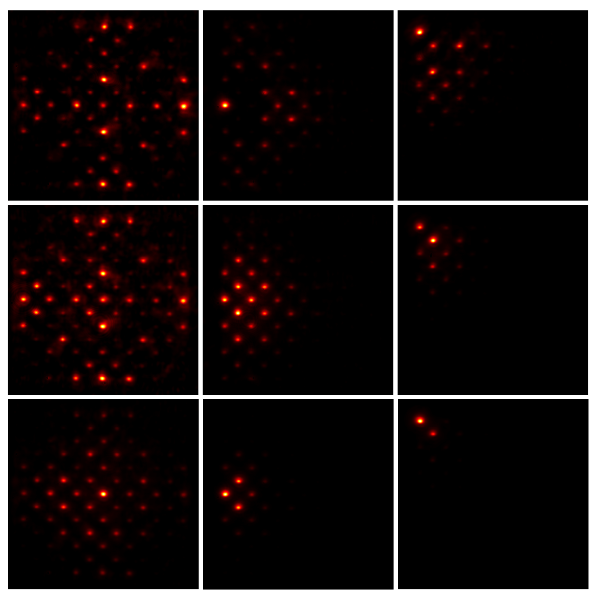

Fig. 2. Excitation of solitons centered on shallow guides.

References:

1. F. Lederer et al., Phys. Rep. **463**, 1 (2008).
2. Y. V. Kartashov et al., Prog. Opt. **52**, 63 (2009).
3. R. Morandotti et al., Opt. Lett. **29**, 2890 (2004).
4. M. Heinrich et al., Opt. Lett **34**, 3701 (2009); Phys. Rev. A **80**, 063832 (2009).