OPTICAL COMMUNICATIONS

Photonic Lattices Induced by Partially Coherent Light

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Optical waveguide arrays are of particular interest because of their potential applications and because of their collective behavior during nonlinear wave propagation. They exhibit many intriguing phenomena also found in other nonlinear discrete systems.[1] Yet it has always been a challenge to create or fabricate two-dimensional waveguide arrays in bulk media. Here we report the first demonstration of 2D waveguide lattices induced by pixel-like spatial solitons of partially coherent light. Our experiment brings about the possibility of optically inducing reconfigurable photonic lattices with low-power incoherent light.

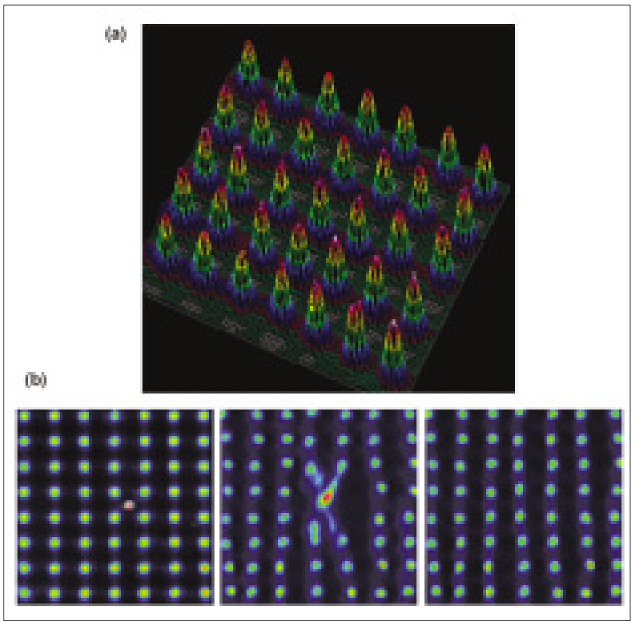

Figure 1. Generation and control of spatial soliton lattices of partially coherent light. (a) The 3D intensity pattern of solitons taken at crystal output face. (b) Lattices manipulated by a control beam. Shown are transverse intensity patterns from input (*left*), nonlinear output with control beam on (*middle*), and nonlinear output with control beam off (*right*).

In our experiment, an array of as many as 56 x 56 waveguide channels is established in a biased photorefractive crystal with a diffused laser source. Nonlinear propagation of a spatially modulated, partially coherent beam leads to the formation of stable soliton pixels, provided that the coherence of the beam and the strength of nonlinearity are set at appropriate values. In general, a broad incoherent beam tends to break up into many disordered filaments due to incoherent modulation instability (MI).[2] However, under certain conditions, we have observed not only clusters of quasi-solitons in incoherent (weakly-correlated) wavefronts,[3] but also robust 2D pixel-like spatial solitons of partially coherent light.[4] Such a pixel-like soliton formation creates a 2D waveguide lattice in steady state, as tested by a probe beam. Figure 1 shows a typical example. At the input to the crystal, the incoherent beam (with a coherence length of 20 μm) has a grid-like intensity pattern, as spatially modulated by an amplitude mask. Without the bias field, each incoherent intensity spot diffracts dramatically, and the diffraction washes out the fine structures in the beam after 20-mm of propagation through the crystal. When an electric field of 2400 V/cm is applied, the input intensity pattern is restored in steady state, forming a nice array of spatial solitons as shown in the 3D intensity plot in Fig. 1a. In this experiment, each soliton has a FWHM of about 30 μm, and the spacing between solitons is 70 μm. The soliton lattices are so formed because the induced incoherent MI experiences a maximum growth rate at a spatial frequency related to the input perturbation period.[5] In separate experiments, lattices with a much smaller spacing have also been generated.

Once the spatial solitons are formed, they are perfect waveguides for other coherent or incoherent light. By launching a probe beam of a longer wavelength (either a focused beam into one of the waveguide channels or a broad beam into the whole waveguide lattice), we observe strong guidance of the probe beam into the incoherent soliton-induced waveguides.[3] In addition, we have successfully demonstrated local coupling in the lattice by introducing another control beam between adjacent solitons (Fig. 1b). Interaction between a light beam and such a lattice may lead to observation of a host of new phenomena, such as incoherent 2D discrete solitons and optical polarons.

In summary, we have observed for the first time optically induced nonlinear waveguide arrays from partially coherent light. Apart from applications in optical switching and information encoding, these waveguide arrays open the door for studying the fascinating behavior of light in 2D photonic lattices.

References

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