Optically Induced PCF-Like Structures

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Optically Induced PCF-Like Structures

Xiaosheng Wang, Igor Makasyuk, Jianke Yang and Zhigang Chen

One of the most fascinating features of photonic band-gap (PBG) structures is that they provide a fundamentally different way of waveguiding by defects in otherwise uniformly periodic structures, as opposed to guidance by total internal reflection (TIR).[1] Such band-gap guidance has been demonstrated in two-dimensional (2D) arrays of dielectric cylinders with an isolated defect for microwaves, and in holey-core photonic crystal fibers (PCF) or in all-solid PCF with a lower-index core for optical waves, where the PBG refers to time-domain frequency modes. In fact, laser emission based on photonic defect modes has been realized for a wide range of spectra.

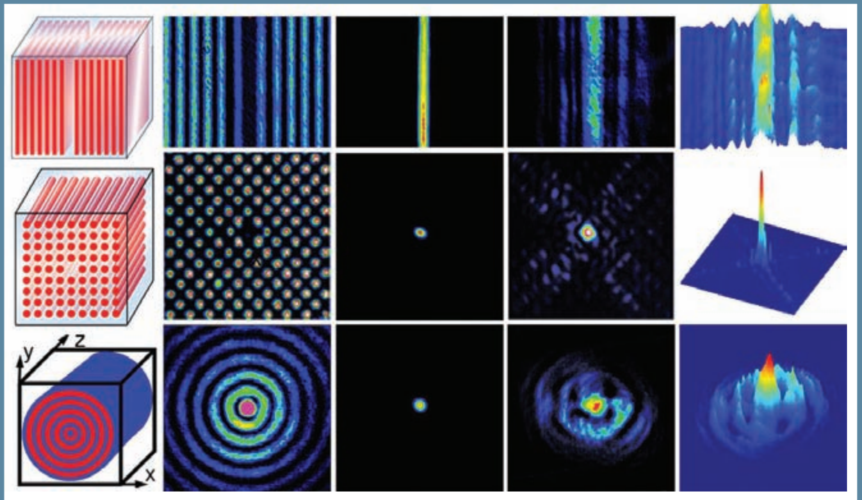
On the other hand, the PBG of spatial frequency modes (propagation constant vs. transverse wave vector) in waveguide lattices[2] represents another possibility for unconventional guidance of light, especially in periodic waveguides with structured defects. For instance, in optically induced lattices containing a negative defect, a probe beam tends to diffuse away from the defect site where the induced index is lower than that in neighboring sites.

However, within the PBG, the probe beam can be localized by defects, forming an evanescent defect mode.[3] In a number of recent experiments, we have demonstrated novel spatial confinement of light in optically induced PCF-like structures, including those with a negative defect embedded in 1D stripe waveguide lattices, 2D square lattices, and 2D ring lattices akin to PBG fibers.[4,5] In these settings, the guidance of light is distinctively different from traditional guidance by TIR or soliton-induced nonlinear self-guidance.

Typical experimental results are summarized in the figure. The refractive index structures (lattices) with a single-site negative defect are optically induced in a nonlinear photorefractive crystal by spatial modulation of an optical beam with an amplitude mask. Such structures (in *x*-*y* plane) remain nearly invariant after 10 to 20 mm of propagation through the crystal (along *z*-direction) under appropriate conditions.

The lattice potential or the index change is controlled by parameters such as the lattice beam intensity, polarization, coherence, as well as the bias field across the crystal. The lattice spacing is typically between 20 and 30 µm. To test the "guiding" property of the defect, a focused probe beam of about 16 µm FWHM is aimed into the defect site or the central low-index core, propagating collinearly with the lattice beam. The intensity or the wavelength of the probe beam is so chosen such that it does not experience any nonlinear self-action.

Without the lattice, the probe beam diffracts dramatically. However, with the lattice, it exhibits good confinement by the defect channel. Such guidance is not attributed to TIR because the defect forms an anti-guide with self-focusing nonlinearity (top two rows) while the center of the Bessel-like lattice also forms an anti-guide with self-defocusing nonlinearity (bottom row). Instead, this arises from the formation of photonic defect modes, or the anti-resonance effect in the ring PCF-like waveguides.[4,5] Our results bring about the possibility to control light in a new type of reconfigurable PBG structure.



Guiding light in optically induced PCF-like structures. The first two rows are 1D and 2D lattices with a single-site negative defect induced with self-focusing nonlinearity. The bottom row shows the ring lattices with a central low-index core induced with self-defocusing nonlinearity. From left to right, shown are schematic illustration of induced lattice structures (red indicates high index), experimentally created lattice patterns, the probe beam at input, and its 2D and 3D intensity patterns exiting the defect or low-index channel, respectively.

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