Nonlinear control of directed emissions from photonic crystal waveguides

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The beaming effect of light is of great practical importance for achieving the efficient emission of light from subwavelength apertures. In this case, light exiting the aperture is focused into a narrow directed beam in front of the aperture, via coherent interference of radiated surface modes. This effect, enhanced through the periodic corrugation of the exit surfaces in metallic thin films and photonic crystals, can be employed to produce nanofocusing of light which may provide great benefits for near-field optical devices working below the diffraction limit. Here, we extend the theory of the beaming effect in photonic crystals to include dynamic, all-optical control of the directed emission, leading to an effective free-space switching of light. We illustrate this effect using the transmission from a photonic crystal waveguide formed in a truncated crystal, and incorporating a nonlinear surface structure that provides intensity dependent control over the directed emission of light. We show that the dynamic control over the transmitted light can be achieved at moderate power levels as a result of the slow group velocity of the light within the surface modes combined with a strong localization of light within the photonic crystal structure near the waveguide exit.