Reversible optical nonreciprocity in periodic structures with liquid crystals

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Abstract:

We demonstrate how to achieve reversible nonreciprocal optical response in a periodic photonic structure with a pair of defects, one of them being a nonlinear liquid crystal defect layer. We show that nonreciprocal effects can be reversed by changing the wavelength as a consequence of the light localization at the defect mode dependent inside the structure.

Optical nonreciprocity is usually associated with breaking of time-reversal symmetry [1]. A typical optical system with a nonreciprocal response employs the magneto-optical effect of gyrotropic materials. Nonreciprocity in nonlinear structures is employed in all-optical diodes and directional couplers. In all such systems the nonreciprocal response is characterized by the light propagating predominantly in one fixed direction, which cannot be changed afterwards.

In this study we suggest a novel approach for creating nonreciprocal tunable optical structures based on nematic liquid crystals (NLC) placed inside a periodic photonic structure. By analysing properties of one of such structures we show that changing the wavelength of the input light can reverse its nonreciprocal response. In general, the scattering setup implies that the field distribution inside the photonic structure is asymmetric. Above a certain threshold of the field intensity the NLC molecules start to reorient, this leads to a change of the effective refractive index [2]. This phenomenon is known as the optical Fréederickz transition (OFT). By placing a NLC defect layer asymmetrically inside the periodic structure, we may change the threshold for the light propagating from two different directions due to an asymmetric field distribution. By adding the second defect into the structure, we can reverse the nonreciprocal response by a proper choice of the wavelength. This makes the whole structure colour-sensitive with an unique possibility to invert the nonreciprocity of the response.

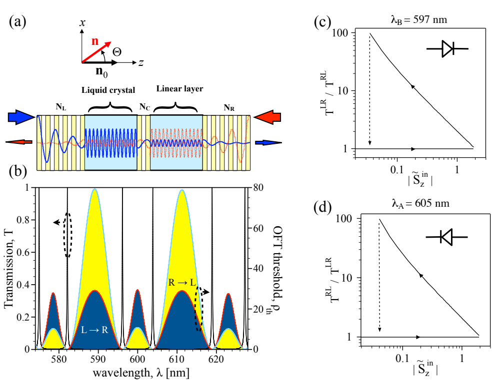

Fig.1 (a) Schematic view of the 1D photonic crystal with two defect layers, where one of them is nematic liquid crystal; (b) optical Fréedericksz threshold in opposite directions; (c) and (d) demonstrates reversible optical diode operation for different wavelengths.

References:

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