Group velocity dispersion in liquid crystal filled photonic crystal fibers

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We investigate the group velocity dispersion of liquid crystal (LC) filled solid core photonic crystal fibres (PCFs). These fibres are based on a 2D photonic crystal consisting of a periodic hexagonal arrangement of high index LC rods in a low index silica glass surrounding. The core is formed by removing one of the rods [Fig. 1(a)] which facilitates the guidance of light. The light is confined inside the core as long as there are no photonic cladding states available, which is equivalent to the presence of a photonic band gap. Consequently, these fibres are called photonic band gap fibres (PBGFs) [1]. However, wavelength regions exist, where light is not guided as no photonic band gap can be found. The leaking of light restricts transmission to certain spectral windows [2]. The regions of low transmission originate from coupling of the core mode to the leaky modes of the high index LC rods [3]. Thus the optical properties (refractive index, director orientation) of the rods are of high importance [Fig 1(b)] and offer the possibility of electrical addressing. The dispersion properties of such fibres are of high interest as each transmission window is expected to have a unique dispersion. This has already been shown for all-solid band gap fibers [2]. The dispersion is of high interest for applications related to frequency conversion where momentum conversation needs to be satisfied.

Fig. 1: (a) Schematic of the cross section of a PCF with pitch $\Lambda$ and inclusion diameter $d_{incl}$. (b) Cross section of a single inclusion filled with LC along fibre direction. (c) Two transmission windows (black) of PCF LMA10 filled with E7 and the corresponding measurements of dispersion (blue). The dotted blue line corresponds to zero dispersion.

The measurement of a LMA10 fiber with a uniaxial anchoring filled with E7 is shown in Fig. 1(c). The intensity (black line) clearly shows two transmission windows centred at 475 nm and 530 nm. The dispersion of these windows is strongly bent as one approaches the edges of the transmission windows. This is caused by the coupling of the core mode with the cladding modes, which influences the propagation constant and thus the dispersion. In fact, the effect is such pronounced that each window has a zero dispersion wavelength.

This somehow special dispersion behaviour may facilitate new possibilities to satisfy momentum conservation for the creation of entangled photon pairs or even triplets [4]. Furthermore, the use of liquid crystals provide the possibility of electrical tuning such sources.

References:

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