

Dispersion Measurement of Femtosecond Pulses Through Photonic Band-Gap Edges of Cholesteric Liquid Crystals

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The cholesteric liquid crystal (CLC) phase exhibits a helical structure with a twist axis perpendicular to the local molecular director [1]. Because of the periodic change in refractive index, CLC exhibit 1-D photonic bandgap characteristics, through selective polarization-dependent Bragg reflection. These optical properties open some interesting prospects for dispersion management, for instance slow light or ultrafast laser modulation [2]. The experimental demonstration of experimental femtosecond pulse compression has been recently proposed, thanks to the combination of a thick and highly birefringent CLC with a strong nonlinearity [2].

Here, we propose an advanced optical characterization of CLC samples, using ultrashort pulses and a statistical approach to experimentally quantify the temporal changes undergone when a femtosecond pulse propagates in the linear regime through the edges of the photonic bandgap.

We fabricated a set of 11 samples, based on two substrates with a left-handed CLC layer in between. The CLC thicknesses were ranging from 14 to 56 μm . The sample Bragg reflection is different for each sample, so that the laser spectrum (700 nm - 840 nm) overlaps with the "red-edge bandgap" or "blue-edge bandgap" or does not overlap at all with the bandgap. We then used the Fourier-transform spectral interferometry (FTSI) [3,4] to study the changes of spectral intensity and phase of pulses transmitted through each liquid crystal. FTSI is based on a Mach-Zehnder interferometer composed of reference and sample arms with slightly different optical paths. The employed laser is a 80 MHz repetition rate femtosecond source, emitting nJ pulses, with a spectrum supporting 20 fs pulse duration and center at 775 nm. Left- and right-handed circularly polarized light was used. For statistical approach, 1000 to 2000 data points were collected for each sample.

The calculated FTSI parameters were: amplitude spectrum and spectral phase changes of pulses transmitted through the samples, and the central wavelength of the transmitted spectrum. The latter enables to quantify the relative position of photonic bandgap and laser spectrum. We also obtained group (time) delay, group delay dispersion (GDD) and third-order dispersion (TOD) as fitting coefficients of spectral phase. The cluster analysis technic allows us to identify from 1 to 4 areas per sample. The experimental results for GDD are plotted in Fig. 1.

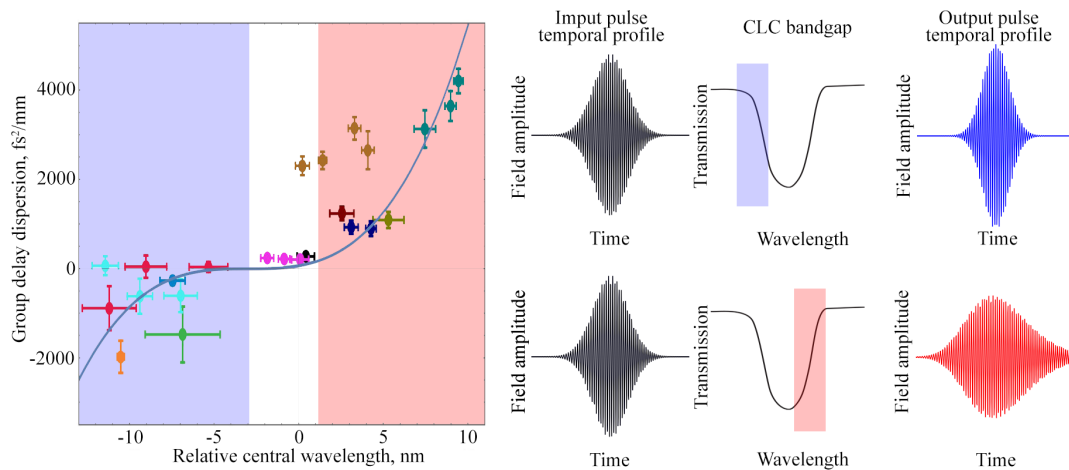


Fig. 1 (Left) Group delay dispersion dependency on relative central wavelength of the transmitted left-handed circularly polarized light pulses. Different colours refer to different samples. Blue line is only for eyes guiding. (Right) Illustration of 20-fs chirped pulse propagating through 100- μm -thick CLC with red- or blue-edge bandgap

The main conclusions of our study are the following. We identified a strong GDD undergone by the femtosecond pulses with a sign and amplitude depending on the relative position to the bandgap, opening the way to controlled pulse shaping. A critical amount of TOD has been measured as well. Finally, this method is also an innovative optical method to investigate the macroscopic homogeneity of chiral liquid crystals.

References

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