

Hyperspectral imaging of bio-inspired tilted cholesteric liquid crystal structures

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The cholesteric liquid crystal (CLC) phase exhibits a helical structure with a twist axis perpendicular to the local molecular director. When light propagates in the Bragg regime through a CLC slab with a planar texture, the medium gives rise to Bragg reflection, selective in wavelength and in polarization. The characteristics of the Bragg band are tunable by acting on the following structural parameters: the pitch, the helicity sense and the helix orientation. Tuning the latter parameter produces polygonal textures (Fig. 1, center). Such a texture is made of an array of micrometer-scale polygonal cells, acting a network of microlenses with wavelength-tunable focusing properties [1]. Polygonal textures can be found in biological CLCs (for instance, multiwavelength micromirrors the cuticle of scarab beetle *Chrysin gloriosa* [2]).

Here, we perform jointly spectral and spatial characterization of CLCs with oblique helicity through a liquid-crystal-based hyperspectral imaging (HSI), which is a compact and non-destructive technique ideally adapted to characterize mesoscopic samples, both in transmission and reflection [3]. Although liquid crystal have already been used to perform multispectral and hyperspectral imaging, they have not been, to date, the subject of an HSI study. The instrument output is an image with 512*128 pixels, each of them being spectrally resolved. Spectro-spatial properties of the polygonal texture are then measured with unprecedented spectral resolution for tilted CLCs, that is 6 nm over 400-1000nm, while conventional multispectral imaging is limited to a spectral resolution of a few tens of nanometers.

Our experimental results are summarized in Fig. 1. In transmission, the mesoscopic chromatic pattern of the studied sample is recovered, and its wavelength-tunable light shaping properties are emphasized with the reconstruction of the hyperspectral datacube of a quarter of polygon. In reflection (insert on the right), the hyperspectral analysis reveals the spatial tilt along y of the helical axis (θ) through the measurement of the spectral shift of the reflected bandgap.

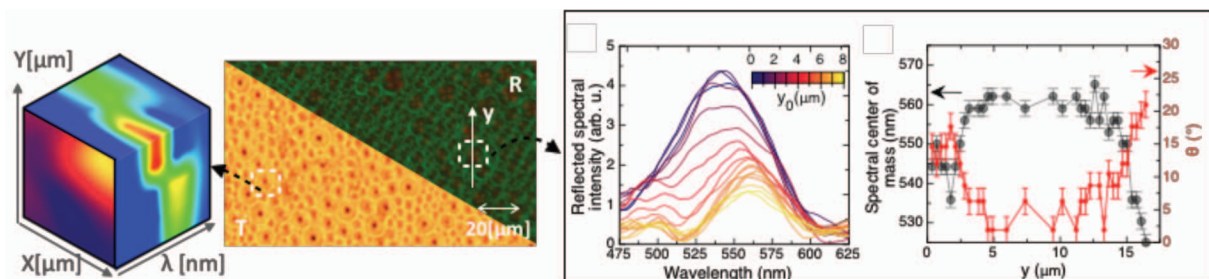


Fig. 1 Center : Polygonal textures observed in the cholesteric material of the present study by optical microscopy in transmission (unpolarized light) and reflection (crossed polarizers) modes. The micrographs reveal a mosaic of polygons with various sizes. On the left : transmitted hyperspectral data cube of a quarter of polygon. In reflection (insert on the right), the hyperspectral analysis reveals the spatial tilt along y of the helical axis (θ) through the measurement of the spectral shift of the reflected bandgap.

These results demonstrate the interest of hyperspectral imaging for the precise study of complex cholesteric components, also existing in biological samples. It thus opens many perspectives to enrich and deepen our knowledge on the fine structure of these materials. Additionally, it is found that polygonal textures may offer practical solutions in numerous applications, from secure authentication to information-enriched imaging, and, particularly, in the field of cryptography.

References

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