# Selected Papers On Liquid Crystals For Optics

## Investigation of the electro-optical properties of 270° chiral nematic layers in the birefringence mode

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Numerical results are presented on transmission, reflection, and color of the recently described, supertwisted birefringence effect for highly multiplexed liquid-crystal displays. The electro-optical properties, which are investigated for normal and oblique incidence of light assuming a multiplexed duty cycle of 1/100, are compared to those of a 270° layer operating in the Mauguin mode and to 270° twisted Heilmeier and White–Taylor guest-host schemes.

### I. INTRODUCTION

The majority of the liquid-crystal displays in use today are of the conventional twisted nematic (TN) type[1] having a twist angle of about 90°. Since their electro-optic characteristic (brightness versus voltage curve) is rather flat and strongly dependent on viewing angle, TN displays are not very well suited for application in high information density displays where matrix addressing (multiplexing) of 100 or more lines is required. It was discovered recently that much steeper electro-optical characteristics could be achieved with chiral-doped nematic layers having twist angles in the region of 270°.[2,3] Waters *et al.*[2] described a 270° guest-host system characterized by a wide viewing cone but a relatively low contrast ratio. Considerably higher contrast ratios (while still retaining a wide viewing cone) were obtained utilizing the so-called supertwisted birefringence effect (SBE)[3] where 270° twisted layers without added dye are located between two polarizers (Fig. 1). The polarizers in a SBE display are oriented so that both optical normal waves are excited within the twisted layer and noticeable interference between these two waves occurs. In this paper we will compute the optical transmission and reflection properties of 270° twisted layers under conditions typical for applications in matrix displays with high rates of multiplexing. The objective of this work is to confirm the essential experimental parameters which have been reported to give optimum SBE display performance[3,4] and to explore in more detail the remarkable electro-optical properties of this new display effect.

### II. ELECTRIC FIELD-INDUCED DISTORTION OF A 270° TWISTED CHIRAL NEMATIC LAYER

The first step in computing the electro-optical properties of a liquid-crystal layer is to solve the continuum equations for the orientation of the local optic axis (director) at every point in the layer. In order to do this we have extended Leslie's approach[5] for nematic liquid crystals with fixed boundary conditions to include the case of a material possessing a finite intrinsic pitch (i.e., a chiral nematic liquid crystal).[6]

Figure 2 (heavy line) shows the voltage dependence of the midlayer tilt angle (measured from the layer plane) computed for a 270° twisted layer of a liquid crystal having typical values for the bend/splay and twist/splay elastic constant ratios of $k_{33}/k_{11} = 1.5$ and $k_{22}/k_{11} = 0.6$ and a parallel/perpendicular dielectric constant ratio of $\epsilon_{\parallel}/\epsilon_{\perp} = 3.5$. Voltages are expressed on a reduced scale, nor-

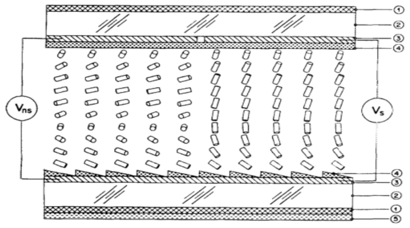


FIG. 1. Schematic view of a reflective, two-polarizer SBE matrix display with a left-handed twist angle of 270° showing the orientation of the local optic axis with applied select and nonselect rms voltages $V_s$ and $V_{ns}$. 1 = polarizer, 2 = glass plate, 3 = transparent electrode, 4 = high-pretilt orientation layer, 5 = reflector.

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