All-optical measurement of liquid crystal viscosities
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We present an all-optical and versatile approach to measure the nematic viscosities $\gamma_1$ and $\alpha_4 + \alpha_5$. The problem of determining the viscosity coefficients of a nematic has attracted numerous publications including mechanical measurements\textsuperscript{[1,2]}, various transient optical methods\textsuperscript{[3]} and measurements of light scattering by the director field.

Our method complements transient optical techniques by providing simultaneous measurements of static and dynamic material parameters. It consists of a modified cross polarised intensity set-up and requires only a small volume of material in comparison to some mechanical methods\textsuperscript{[1]}. We apply an alternating potential of 500 Hz to a planar cell with anchoring enforced by a rubbed PI layer. The director configuration is characterised by passing 532 nm light polarized at an angle of 45° to the PI rubbing direction through the cell. The output beam is passed through a polariser set orthogonally to the initial polarisation and the intensity is measured. The birefringence of the nematic rotates the polarisation of transmitted light and leads to a voltage dependent measured intensity. At the chosen frequency the director is unable to track the rapid oscillations in the applied voltage: instead it follows the Rms voltage and shows small oscillations at twice the driving frequency. These small oscillations are caused by a combination of the applied field driving the director and the induced fluid flow. The amplitude of the oscillations $\Delta I_\perp$ is sensitive to the rotational viscosity $\gamma_1$, which sets the intrinsic time scale of the director, and the combination of Leslie coefficients $\alpha_4 + \alpha_5$ that determine the coupling of the flow and director. We extract the standard deviation of these oscillations from the CPI and use the Erickson-Leslie hydrodynamic theory to fit $\gamma_1$ and $\alpha_4 + \alpha_5$ as a function of voltage. We find excellent agreement between fitted viscosities and literature values for E7, TL205 and ZLI4792 (e.g. the fitted value of the ZLI4792 rotational viscosity is 94.6 mPa s, while the literature value is 95 mPa s).

References:

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Figure 1: Fit of the average, $I_\perp$, and standard deviation, $\Delta I_\perp$, of cross polarized intensity for ZLI4792. Solid line is theory, points are experimental data.