C-Points in a Stressed-Engineered Optic

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Abstract: We present a simple model used to analyze the oblique propagation of polarized light through a thick birefringent element known as a stress-engineered optic (SEO). The model reveals the formation and the evolution of all three types of generic C-points (stars, lemons, and monstars) and we experimentally verify the theoretical predictions.

1. Introduction

SEOs are optical elements that are created from any transparent glass with nonzero stress optical coefficient [1-3]. A uniform circularly-polarized and collimated laser beam that passes through a tilted SEO acquires multiple first-order (generic) C-points [4]. By using a simplified model to understand the oblique propagation of a beam through a thick SEO, we can analytically track the locations of these C-points, as well as characterize them as a function of the SEO tilt angle θ [5].

2. Modified two-slab model and experimental results

We present a simple model (called the modified two-slab model) to understand the emergent C-points from a tilted SEO. Using this model, we find that the locations of the seven near-center C-points, in the shifted Cartesian coordinate system $(\xi, y) = (x + \mathcal{L}\tan\theta'/2, y)$, are given by

$$(\xi_{1,\pm}, 0) = (\pm\pi/c, 0), \quad (\xi_{2,\pm}, 0) = (\pm 2\pi/c, 0), \quad (0, y_{\pm}) = \left(0, \pm 2\sqrt{\pi^2/c^2 - \mathcal{L}^2\tan^2\theta'/16}\right), \qquad (1)$$

and the origin $(0,0)$. From these equations, it is simple to see that only the $(0, y_{\pm})$ points move as a function of the θ', the refracted tilt angle. Therefore, we call these points *dynamic* singularities and the rest are called *passive* singularities. It's also clear that at $\theta' = \theta'_m \equiv \tan^{-1}[4\pi/(c\mathcal{L})]$, the merge angle, the dynamic singularities will merge with the passive on at the origin. Our experimental setup to image the output irradiance from the SEO is shown in Fig. 1 and experimental results are shown in Fig. 2.

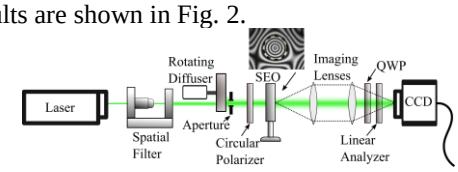

Fig. 1. Region of interest on the SEO center region is marked in dashed lines. The combination of a rotating quarter wave plate (QWP) and the linear analyzer before the camera acts as a Stokes polarimeter.

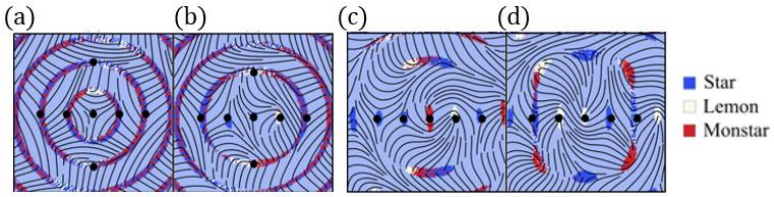

Fig. 2. The types of first-order C-points are marked by colors as indicated by the plot legends and the black dots are the locations of the C-points described by Eq. (1). These are shown for the values of $\theta = 0°, 4°, 12°$, and 20°, for (a-d), respectively. Here, the merge incident angle, for the experimental parameters of $c = 9.35\pi$ and SEO length $L = 5$, is given by $\theta_m \approx 11°$. Part (e) shows the handedness of the polarization ellipses of the output beam. Note that, once again, only the RHC component of the output beam is shown here.

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