Decomposition of radially and azimuthally polarized beams using a circular-polarization and vortex-sensing diffraction grating

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Abstract. Both radially polarized and azimuthally polarized beams can be decomposed into linear combinations of circularly polarized vortex beams having opposite vortex charges. We show experimental evidence for this decomposition using a specially designed vortex sensing diffraction grating that generates multiple vortex patterns having different senses of circularly polarization in the different diffracted orders. When this grating is illuminated with a radially or azimuthally polarized beam, the grating separates the components into different diffracted orders. Experimental results are shown.

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OCIS codes: (050.4865) Optical vortices; (350.2770) Gratings; (230.6120) Spatial light modulators.

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1. Introduction

Radially and/or azimuthally polarized beams have been receiving a great deal of attention, especially because they can produce very small focal spots [1], or generate longitudinal electric field components upon focalization [2]. They have been generated using a variety of techniques, including interferometric systems [3–5], optical processing systems [6,7], specially designed subwavelength structures [8], patterned polarizers [9], or liquid crystal devices [10,11].

These beams can be decomposed as the superposition of two beams. For instance in Ref [1], it was demonstrated that radially polarized beams can be composed as the superposition of two linearly polarized TEM$_{10}$ and TEM$_{01}$ modes. Here we use a different decomposition, which shows that both radially and azimuthally polarized beams can be regarded as the linear combination of two circularly polarized beams with opposite helicity, carrying opposite signed scalar vortices. This decomposition was already pointed in Refs [9,12].

Another area that attracted great interest is the detection and identification of optical beams carrying vortices, and techniques have been reported including optical processing systems that transmit specified vortices [13], or specially designed anisotropic inhomogeneous subwavelength gratings [14]. Embedding a phase singularity onto a diffraction grating was originally proposed in [15], opening a way for laser vortex beams synthesis and their applications [16]. Recently, we exploited this idea to create a vortex sensing grating capable of detecting the value as well as the sign of the topological charge [17].

In this work we extend this concept to create a polarization vortex grating capable of sensing radially and azimuthally polarized beams and of distinguishing them from regular scalar vortex beams. A specifically designed new polarization sensing grating is designed here, by inserting a regular scalar vortex grating between two properly oriented quarter waveplates. The resulting grating splits the incoming beam into its circular polarization components, and also detects its topological charge. Therefore, we exploit these properties to experimentally demonstrate that radially and azimuthally polarized beams are composed of two circularly polarized vortex beams with opposite helicity and opposite topological charge.

We organize the paper as follows: in Section 2 we analyze the radially and azimuthally polarized beams in terms of their circular polarization vortex components. We also describe a radial polarization converter device that was used to generate these beams. In Section 3 we describe the polarization grating design with an embedded phase singularity, and its experimental realization using a parallel aligned liquid crystal display (LCD). Finally, in Section 4 we analyze the transmission of the radially and azimuthally polarized beams through this vortex sensing polarization grating. We show that it can be employed to distinguish these beams from regular scalar vortex beams. The results confirm the theoretical predictions, and we experimentally show that radially and azimuthally polarized beams are composed of two circularly polarized beams with opposite helicity and opposite topological charge.

2. Decomposition of radially and azimuthally polarized beams

2.1 Vortex analysis of the radially and azimuthally polarized beams

Here we show how radially and azimuthally polarized laser beams can be represented and decomposed using Jones Matrices. Figures 1(a) and 1(b) show the electric fields for radially and azimuthally polarized light.

The radially polarized beam can be written as a Jones vector $E_{\text{RAD}}$ and decomposed as
\[ E_{\text{RAD}} = \begin{pmatrix} \cos \phi \\ \sin \phi \end{pmatrix} = \frac{1}{2} \left( e^{i\phi} + e^{-i\phi} \right) = \frac{1}{2} e^{i\phi} \left( \begin{array}{c} 1 \\ -i \end{array} \right) + \frac{1}{2} e^{-i\phi} \left( \begin{array}{c} 1 \\ +i \end{array} \right). \]

Here \( \phi \) is the azimuthal angle. This result shows that the radially polarized beam is the superposition of a positive vortex encoded onto a right circularly polarized beam added to a negative vortex encoded onto a left circularly polarized beam.

In a similar way, an azimuthally polarized beam can be decomposed as:

\[ E_{\text{AZ}} = \begin{pmatrix} -\sin \phi \\ \cos \phi \end{pmatrix} = \frac{1}{2i} \left( e^{i\phi} - e^{-i\phi} \right) = i \left( \frac{1}{2} e^{i\phi} \left( \begin{array}{c} 1 \\ +i \end{array} \right) - \frac{1}{2} e^{-i\phi} \left( \begin{array}{c} 1 \\ -i \end{array} \right) \right). \]

This result shows that the azimuthally polarized beam is also the superposition of a positive vortex encoded onto a left circularly polarized beam plus a negative vortex encoded onto the right circularly polarized beam. However there are two differences between these two decompositions. For the azimuthally polarized beam there is a global \( \pi/2 \) phase shift multiplying the superposition of the two beams and the two components are subtracted rather than added as in the case of the radially polarized beam.

These or related decompositions have been exploited previously. For instance, Moh et al [9] used circularly polarized light to illuminate a system composed of a polarization axis finder device plus a spiral phase mask to generate azimuthally and radially polarized beams. In ref [12], the above decomposition was employed to describe a system to generate achromatic vortices based on an axially symmetric polarizer. In this work, we go in the opposite direction – to demonstrate the decomposition of these radially and azimuthally polarized beams using a special diffraction grating.

\[ (\text{a,b}) \text{ Decomposition of radially and azimuthally polarized beams as the superposition of two circularly polarized vortex beams with opposite helicity and opposite topological charge.} \]

\[ (\text{c}) \text{ Scheme of the liquid crystal director structure of the radial polarization converter (RPC) device.} \]

However for future reference, we also point out that, if we can add these two beams while providing a \( \pm \pi/2 \) phase shift, we would obtain

\[ E_{\text{RAD}} \pm iE_{\text{AZ}} = \begin{pmatrix} \cos \phi \\ \sin \phi \end{pmatrix} \pm i \begin{pmatrix} -\sin \phi \\ \cos \phi \end{pmatrix} = e^{-i\phi} \left( \begin{array}{c} 1 \\ \pm i \end{array} \right). \]
This surprising result indicates that the sum of the radially and azimuthally polarized beams will produce a circularly polarized vortex beam.

2.2 Generation with a Radial Polarization Converter

The radially or azimuthally polarized beams were generated using a Radial Polarization Converter (RPC) from ARCoOptix [18]. This device has three components: a LC retarder cell, a twisted nematic LC polarization rotator cell, and the RPC or θ-cell (Fig. 1(c)). The radial polarization converter consists of a LC cell having an entrance plate with a linear director axis and an exit plate having a circularly rubbed director axis [10]. The liquid crystal molecules rotate clockwise between the two plates in the upper half of the device and counterclockwise in the lower half. The liquid crystal cell operates in the waveguide mode over a broad range of wavelengths. When the electric field vector of the incident linearly polarized is parallel or perpendicular to the input director axis, the plane of polarization is rotated by the twist angle. Azimuthally polarized light is obtained when the incident light is polarized parallel to the incident cell axis while radially polarized light is achieved for the orthogonal polarization direction. However the rotation for the top half of the cell is clockwise while the rotation for the bottom half is counterclockwise. This causes a π phase step in the center of the beam. This phase step can be removed using the half-plane variable retarder cell whose retardation can be controlled using a programmable voltage. Finally there is a voltage-controlled twisted nematic polarization rotator cell that rotates the incident polarization state by 90° and allows the user to switch between the azimuthal and radial polarization states.

We first examined the performance of this ARCoOptix RPC device to generate radially and azimuthally polarized beams. Figure 2 shows experimental results of the transmitted beam when it is illuminated with vertically polarized collimated light having a diameter of 2 cm from an air-cooled Argon laser operating at a wavelength of 514 nm, which must be well aligned with the center of the RCP device. In Fig. 2(a), no voltage was applied to the TN polarization rotator cell and the incident polarization is rotated by 90 degrees so that it was horizontally polarized. As a result, the azimuthally polarized beam is generated. The image on the left shows the beam without an analyzer polarizer and the vortex is clearly visible in the form of a null intensity at the origin. The central and right images show the transmission when a vertically and horizontally oriented analyzer is placed behind the RPC device. These characteristic patterns show that the light is azimuthally polarized.

Figure 2(b) shows similar results when the incident light was vertically polarized, but we applied a voltage of 4.6 V to the TN polarization rotator. Consequently the polarization incident onto to the θ-cell is maintained in the vertical direction and the radially polarized beam is produced. Again, the left image shows the transmitted beam without analyzer and the vortex is visible. When the analyzer is incorporated, the dark regions are opposite to those in Fig. 2(a), confirming that the beam is now radially polarized.

Finally we observed an unexpected result when we applied a voltage of 2.306 V to the TN polarization rotator cell as shown in Fig. 2(c). Again we see the null intensity at the origin, denoting the presence of a vortex. However the orientation of the analyzer polarizer has no effect on the output. It appears that the twisted nematic cell is applying a phase shift of π/2 radians and produces the linear combination of the radially and azimuthally polarized states as outlined in Eq. (3). We confirmed this unexpected result by supplying the π/2 phase shift with a quarter wave plate.
Fig. 2. Experimental patterns of the beam emerging from the radial polarization converter device. (a) Azimuthally polarized beam, (b) Radially polarized beam, (c) Circularly polarized vortex beam. The left column shows the results without analyzer (polarization states has been drawn as a watermark). The central and right columns show respectively the results with a vertically and horizontally oriented analyzer.

Next we introduce a special polarization diffraction grating with embedded phase singularity that can decompose these azimuthally and radially polarized beams

3. Polarization and vortex splitting diffraction gratings

3.1 Polarization vortex grating design

We begin by summarizing some previously reported results required to build the foundation for understanding our new polarization vortex grating approach. We began with a one-dimensional phase diffraction grating $G(x,y)$ encoded onto a parallel-aligned LCD [19]. Since the grating only affects light polarized along the director axis of the LCD (which is considered here along the $y$ direction), the displayed grating can be described as a spatially dependant Jones matrix $G_L(x,y)$ in the form:

$$G_L(x,y) = \begin{bmatrix} 1 & 0 \\ 0 & G(x,y) \end{bmatrix} = \begin{bmatrix} 1 & 0 \\ 0 & 0 \end{bmatrix} + G(x,y) \begin{bmatrix} 0 & 0 \\ 0 & 1 \end{bmatrix}$$

(4)

Since the displayed phase-only grating function $G(x,y)$ is periodic, it can be decomposed as a Fourier series as:

$$G(x,y) = \sum_{n=-\infty}^{\infty} c_n e^{in2\pi x/D},$$

(5)

where $D$ is the period of the grating, and $c_n$ denote the Fourier coefficients. For simplicity, we consider the case of a binary phase-only grating with a phase shift of $\pi$ radians. Then, the values for these coefficients are determined by the width ($w$) of the region having the phase level of 0 rad compared with the grating period ($D$) as $|c_n|=\sin(n\pi w/D)/(n\pi w/D)$. For an aspect ratio $w/D = 0.5$ the grating provides a null DC component ($c_0=0$), and most of the energy goes to the $\pm 1$ diffraction orders ($|c_{\pm 1}|^2=4/\pi^2=40.5\%$).

Therefore, if we restrict the analysis to the 0 and $\pm 1$ diffraction orders, the Jones matrix in Eq. (4) can be written as:
This result shows that the displayed diffraction grating separates opposite senses of linearly polarized light. The first term forms the zero order of the resulting diffraction pattern, and it polarizes light in the $x$ direction (the Jones matrix corresponds to a linear polarizer along this direction). On the contrary, the two linear phase exponential terms in Eq. (6) each corresponds to the formation of ±1 diffraction orders, and polarize light in the $y$ direction. Thus the polarization grating effectively splits light into two orthogonal polarization states, and the energy in each order is proportional to the power carried by the $x$ and $y$ linearly polarized components of the incoming light.

We modified this system to evaluate the components of light in another orthonormal polarization basis: the $R$ and $L$ circularly polarized states [19]. For this purpose, the linear diffraction grating $G_L(x,y)$ was sandwiched between two quarter-wave plates (QWP) with their principal axes oriented at $\mp 45^\circ$ and $\pm 45^\circ$ respectively. Now the resulting grating $G_c^\pm(x,y)$ is given by the Jones matrix:

$$
G_c^\pm(x,y) = W_{\pm45^\circ} \cdot G_L(x,y) \cdot W_{\mp45^\circ} = 
\begin{bmatrix}
\frac{1}{2}(i \mp 1)
\end{bmatrix} + \frac{1}{\pi}(e^{i2\pi n/D} + e^{-i2\pi n/D})
\begin{bmatrix}
i 
\mp 1
\end{bmatrix}.
$$

(7)

Here $W_{\pm45^\circ}(\theta)$ stands for the Jones matrix of the QWP oriented at an angle $\theta$, i.e.:

$$
W_{\pm45^\circ}(\theta) = \begin{bmatrix}
\cos \theta & \sin \theta \\
-\sin \theta & \cos \theta
\end{bmatrix}.
$$

(8)

where $R(\theta)$ is the rotation matrix:

$$
R(\theta) = \begin{bmatrix}
\cos \theta & \sin \theta \\
-\sin \theta & \cos \theta
\end{bmatrix}.
$$

(9)

For this case, Eq. (7) shows a similar form as Eq. (6) but now the two Jones matrices correspond to $L$ and $R$ circular polarizers respectively. Therefore, the action of the system described with Eq. (7) is to transmit the left (right) circularly polarized component of the incoming light diffracted into the zero order, while the right (left) circularly polarized component is diffracted into the ±1 orders.

In the third grating design, we introduced a vortex sensing grating [16]. We began with a vortex producing phase pattern $V_i(\phi) = \exp(i\ell \phi)$, where $\ell$ is the vortex topological charge, and we formed the product of this pattern with a linear phase grating. We then binarized the phase pattern with phase values of 0 and $\pi$ rad and with a given threshold. The resulting grating $G_c(x,y)$ can be written as a Fourier series as

$$
G_c(x,y) = \sum_{n=-\infty}^{\infty} c_n e^{in\phi} e^{in2\pi n/D}.
$$

(10)

Again the values of the Fourier coefficients $c_n$ depend on the selected threshold value. If this grating is illuminated with a plane wave, each diffraction order $n$ is characterized by a vortex having a charge of $\ell n$. In this work we use this type of grating with embedded vortices $\ell = \pm 1$ and a threshold such that the width of the +1 region is equal to the width of the −1 region. This causes the zero order to vanish and the grating can be represented only by the two strongest orders as:

$$
G_c(x,y) = \sum_{n=-\infty}^{\infty} c_n e^{in\phi} e^{in2\pi n/D}.
$$

(10)
Figure 3 shows sample gratings with an embedded vortex of $\ell = +1$ or $\ell = -1$ respectively. Here the white and black areas represent phase levels of 0 and $\pi$ radians.

\[
G_r(x, y) = \frac{2}{\pi} \left( e^{-i\ell \theta} e^{-i2\pi \ell D} + e^{i\ell \theta} e^{i2\pi \ell D} \right).
\] (11)

This grating will form three diffracted orders when illuminated with a plane wave. The zero order will be left (right) circularly polarized, with an intensity proportional to the left (right) circular polarization component of the incoming beam and will form a regular sharply focused diffraction order. On the contrary, the two first orders will be right (left) circularly polarized, with their intensity proportional to the right (left) circular polarization component of the incoming beam, and they will form diffracted orders with the characteristic doughnut shape of a vortex beam. Since the vortex beams on the $\pm 1$ diffraction orders have opposite topological charges, their intensities appear identical. However, as we show later, the change in the sign of the topological charge in the beam going to each order plays a role when we illuminate the grating with an incident radially or azimuthally polarized beam. We emphasize here that this grating design is totally different from the original vortex grating discussed in Ref. (15) where each diffracted order has the same polarization state.

### 3.2 Experimental details and realization in a liquid crystal display

The vortex sensing binary diffraction gratings described above are selected to have a period of 32 pixels, and were encoded onto a parallel-aligned LCD manufactured by Seiko Epson with 640 × 480 pixels with pixel spacing of 42 microns [20]. The phase shift for each pixel exceeds $2\pi$ radians as a function of gray level at the Argon laser wavelength of 514 nm. By using properly chosen gray levels of 0 and 116, we could encode the binary phase diffraction gratings as shown in Fig. 3.

Next we test these binary gratings when displayed in the parallel aligned LCD sandwiched in between the two QWPs, as described in the previous subsection. We first consider illuminating the polarization diffraction grating $G^\pm_{C,r}(x, y)$ with collimated light that is linearly polarized.
polarized in the vertical direction. This way, we assure that the incoming beam has equal intensity in the two circular polarization components. The output is given by:

\[
G_{1}^{C} \left( x, y \right) = -\frac{1}{2} \left( 1 + i \right) + \frac{1}{\pi} \left( e^{i\theta} e^{i2\pi x/D} + e^{-i\theta} e^{-i2\pi x/D} \right) \left( 1 + i \right).
\]  

(13)

This result shows that the zero diffraction order is left circularly polarized while the two first orders are right circularly polarized and characterized by vortices with opposite signed topological charge.

Figure 4 shows experimental results when the grating was uniformly illuminated and where the diffraction pattern was formed in the focal plane of a 1-meter lens and measured with a DataRay WinCamD camera having 1360 × 1024 pixels with dimensions of 6.7 microns. We selected \( \ell = +1 \) (Fig. 3(a)), but identical intensity patterns are obtained for \( \ell = -1 \). The figure shows a zero order consisting of a sharp focused spot and first order spots showing the doughnut beams characteristic of a vortex beam. These images show results using an analyzer polarizer oriented in the horizontal direction (4(a)), at 45 degrees (4(b)), and in the vertical direction (4(c)), and they show that all three beams are circularly polarized in agreement with the predictions of Eq. (13).

Next, we show that the zero and first orders are circularly polarized in opposite senses. In Fig. 4(d) both circular polarizations are transmitted with equal intensity, and the three orders are visible. However, when circular polarizers are employed, only the zero or only the ± 1 orders are visible, depending on the sense of the circular polarization that is transmitted. Figures 4(e) and 4(f) show corresponding results, showing that the DC order has one sense of circular polarization while the first orders have the opposite sense.

In all these results there is no apparent difference for the ± 1 diffraction orders because vortices with positive and negative charges create the same intensity pattern. This is not the case, as we show next, when we illuminate the grating with radial or azimuthal polarization.

Now we have the two components necessary to experimentally probe the nature of the radially polarized and azimuthally polarized beams as a sum of left and right circularly polarized vortex beams having opposite helicities and opposite topological charge. We have a RPC device capable for generating these structured polarized beams and we have a polarization diffraction grating capable of separating these various components.
4. Transmission of radially and azimuthally polarized beams through the polarization vortex grating

Now we illuminate the LCD system with light from the ARCOptic RPC device in the three cases analyzed earlier in Fig. 2. First we illuminate the system with a radially polarized beam and we select the polarization vortex grating $G^+_{C,\ell=1}$. The product of the input beam from Eq. (1) and the grating from Eq. (12) is given by

$$G^+_{C,\ell}(x,y) \cdot E_{\text{RAD}} = i e^{i\phi} \left( \begin{array}{c} 1 \\ -i \end{array} \right) + \frac{2i}{\pi} \left( e^{-i2\pi \ell/D} + e^{i2\pi \ell/D} \right) \left( \begin{array}{c} 1 \\ +i \end{array} \right). \quad (14)$$

This interesting result says that now the zero order is characterized by a left circularly polarized vortex beam with +1 topological charge. On the contrary, the ±1 diffraction orders have a right circular polarization, but now the −1 order is characterized by a delta function (no vortex), while the +1 order is characterized by a vortex having a −2 topological charge.

When the same polarization vortex grating is illuminated with the azimuthally polarized beam, the product of the input beam from Eq. (2) and the grating from Eq. (12) results in:

$$G^+_{C,\ell=1}(x,y) \cdot E_{\text{AZ}} = -i e^{i\phi} \left( \begin{array}{c} 1 \\ -i \end{array} \right) - \frac{2i}{\pi} \left( e^{-i2\pi \ell/D} e^{i2\pi \ell/D} - e^{i2\pi \ell/D} \right) \left( \begin{array}{c} 1 \\ +i \end{array} \right). \quad (15)$$

This result is (except for the relative phases) equivalent to that for radially polarized light. Therefore we cannot distinguish between the radially and azimuthally beams using this approach simply by measuring the intensity of the diffracted orders.

Experimental results presented in Fig. 5 confirm these predictions. In all cases, the axis of the incoming beam must be aligned with the center of the polarization vortex grating, although we observed misalignment tolerances up to 1 mm. Figures 5(a)-5(c) show the case when the radially polarized beam generated with the ARCOptic RPC device illuminates the polarization grating, while Figs. 5(d)-5(e) correspond to illumination with the azimuthally polarized beam. Figures 5(a) and 5(d) show the result when no grating is encoded onto the LCD. Only the zero order is present and shows the characteristic doughnut shape of the vortex beam. Figure 5b shows the result when using the polarization vortex grating with $\ell=+1$ (Fig. 3(a)). Now, the right circular polarization component of the incoming beam is diffracted onto the ±1 diffraction orders, while the left circular polarization component is transmitted to the zero diffraction order. As expected from Eq. (14), the −1 diffraction order on the right shows a delta function. When the conjugate vortex grating ($\ell=-1$, Fig. 3(b)) is employed, the delta function moves to the opposite order as shown in Fig. 5c. Experimental results in Figs. 5(e) and 5(f) show the same behavior for the azimuthally polarized beam, thus confirming the same conclusions.

If the polarization vortex grating $G^-_{C,\ell=1}$ is used instead, the diffraction patterns are equivalent to those presented in Fig. 5, except for a horizontal mirror flip, and by the fact that the circular polarizations that are diffracted onto the zero and ±1 are reversed.

A different behavior is observed when we illuminate the polarization grating with the beam emerging from the ARCOptic device when a voltage of 2.306 V is applied to the TN polarization rotator cell. In this situation, as we noted in the results in Fig. 3(c), the transmitted light is a circularly polarized vortex beam resulting from the combination of the radially and azimuthally polarized beams (Eq. (3)). This assumption is confirmed when we illuminate the vortex polarization grating with this beam and analyze the diffraction pattern.
Fig. 5. Experimental pattern generated when the polarization diffraction grating is illuminated with (a-c) radially polarized light and (d-f) azimuthally polarized light. In (a,d) the grating is switched off. In (b,e) the vortex grating with $\ell = +1$ is displayed. In (c,f) the vortex grating with $\ell = -1$ is displayed.

Figure 6 shows the results. Figures 6a and 6d show the diffraction pattern in the absence of the grating, and show the characteristic doughnut vortex beam. Now, when the grating is switched on, a different response is obtained for the polarization gratings $G_{C,G}^+$ and $G_{C,G}^-$. For $G_{C,G}^-$, the right circular polarization component in the incident beam is transmitted to the zero diffraction order. Therefore, since the incoming beam is R-circularly polarized (Eq. (3)), the grating has no influence and no $\pm 1$ diffraction orders are observed, independently of the value of $\ell$ encoded on the grating. The results in Fig. 6(b) and 6(c) show this situation, where the gratings $G_{C,G}^-$ with embedded vortices $\ell = +1$ and $\ell = -1$ have been used.

However, when the two QWPs in the system are reoriented to generate the polarization grating $G_{C,G}^+$, the results in Figs. 6(e) and 6(f) are obtained. Now the right circular polarization component is being diffracted onto the $\pm 1$ diffraction orders, while the left circular polarization is transmitted to the zero order. Since the incoming beam has no left circular polarization component, the zero diffraction order is absent. And since the incoming right circularly polarized beam carries an optical vortex, the $+1$ and $-1$ diffraction orders show a different peak depending on the topological charge embedded on the grating. In Fig. 6(e) $\ell = +1$ is selected, and the delta function appears on the $-1$ diffraction. When $\ell = -1$ is selected, then the delta function is moved to the $+1$ diffraction order, as shown in Fig. 6(f).

These results show how the proposed technique can be used to differentiate between polarization singularities (radially and azimuthally polarized beams) and scalar singularities (regular spiral beams).
Fig. 6. Experimental diffraction pattern generated when the polarization diffraction grating is illuminated with the circularly polarized vortex beam. (a-c) correspond to $G_{C,-\ell}$ and (d-f) to $G_{C,\ell}$. In (a,d) the grating is switched off. The displayed grating has $\ell = +1$ in (b,e), and $\ell = -1$ in (c,f).

5. Conclusions

In conclusion, we have investigated the circularly polarized vortex beam nature of radially and azimuthally polarized beams. We show a system based on a new polarization vortex grating capable of separating the circular polarization components and detecting the presence of topological charges on the incoming beam. We have generated radially and azimuthally polarized beams with a radial polarization converter (RPC) device, and tested these beams by means of programmable vortex polarization gratings encoded onto a LCD. Experimental results are excellent, confirming in all cases the theoretical predictions. Thus, radially and azimuthally polarized beams have been experimentally decomposed into their circularly polarized vortex constituent components. The proposed technique can thus be a very useful tool to identify and detect the characteristics and nature (polarization and topological charge) of singular beams generated with different techniques.

Acknowledgments

We thank Tomio Sonehara of Seiko Epson Corporation for the use of the LCD. IM acknowledges support from Ministerio de Ciencia e Innovación from Spain (ref. FIS2009-13955-C02-02).