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Neural network assisted high-spatial-resolution polarimetry with non-interleaved chiral metasurfaces

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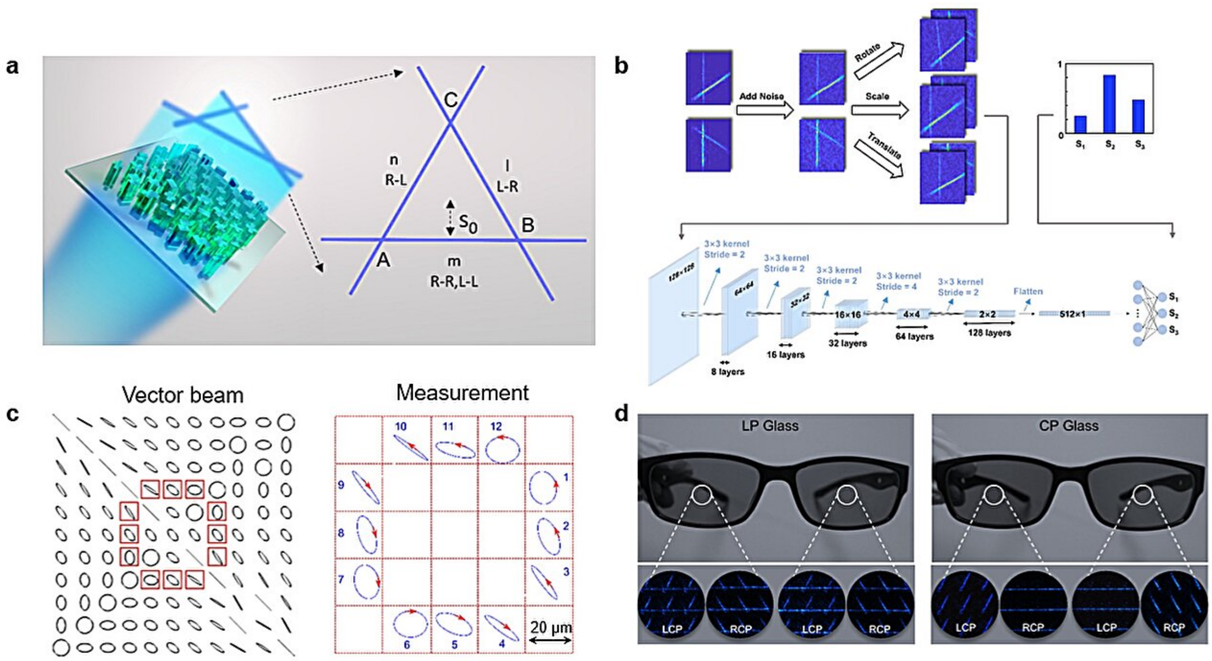

Working principle of the chiral metasurface based polarimetry. Credit: *Light: Science & Applications* (2023). DOI: 10.1038/s41377-023-01337-6

Polarimetry plays a key role in wide applications from remote sensing and astronomy to biology and microscopy. Traditional polarimetry systems are equipped with a set of polarizers, waveplates, beam-splitters or filters, making the systems bulky and complex.

Metasurface, a new emerging flat optical device with flexible light manipulation capability provides potential possibilities for compact polarimetry. Based on metasurface, a well-known startup company called Metalenz, has also launched a Polar ID for consumer products, which captures the unique polarization characteristics of the face to achieve a high-security face unlock function.

So far, the metasurface-based polarimetry can be divided into two categories, one is the metalens type, it achieves the Stokes parameters through the focus intensities under different polarization biases, which inevitably suffer from the limited transverse spatial resolution.

The other is the grating type, Matrix Fourier optics enable the splitting of the light with different polarizations into different diffraction orders, and the propagation and the combination of a lens would occupy a substantial volume of space. However, the demand for higher compactness and spatial resolution is growing with the development of modern optics.

In a new paper published in *Light: Science & Applications*, a team of scientists, led by Professor Tao Li from Nanjing University, China, has developed an non-interleaved, interferometric method to analyze the polarizations based on a single layer tri-channel chiral metasurface.

With the incorporation of a deep convolutional neural network, the polarimetry can work in a fast, robust and accurate way. It fits the bill for both spatially uniform and nonuniform polarization measurements with high spatial resolution requirements. The reported method features the merits of compactness and high spatial resolution, and would inspire more intriguing design for detecting and sensing.

Different from the other schemes that obtain the Stokes parameters through the focus intensities under different polarization biases with different metasurfaces, this work resolves the polarizations by directly measuring the intensity and phase difference with a single chiral metasurface. It can support the polarization resolution of vector beams composed of linear, circular, and various elliptic polarizations. The researchers summarize the operational principle of their polarimetry:

"We design a chiral metasurface to modulate the co-polarization and two cross-polarizations independently. With the displayed three focal lines and the intersection points, the amplitude contrast and phase difference of RCP and LCP components can be obtained to retrieve the polarization information. The tri-channel modulation capability enables the polarimetry with high spatial resolution merits."

"A deep convolutional neural network was constructed to make the polarimetry robust with the environment and the results come out in a very quick time," they added.

"The presented technique can be used to analyze the spatially nonuniform polarization states like vector beam. Objects with similar morphology features while different polarization characteristics can also be easily distinguished through the metasurface. The proposed scheme can undoubtedly extend to other spectral bands and comply with the enhanced performance requirements of modern optics," they forecast.

More information: Chen Chen et al, Neural network assisted high-spatial-resolution polarimetry with non-interleaved chiral metasurfaces, *Light: Science & Applications* (2023). DOI: 10.1038/s41377-023-01337-6

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