EIN PRESSWIRE

Simultaneous Dynamic Detection of Phase and Polarization Topological Charges via Optical Conformal Transformation

Simultaneous Dynamic Detection of Phase and Polarization Topological Charges via Optical Conformal Transformation

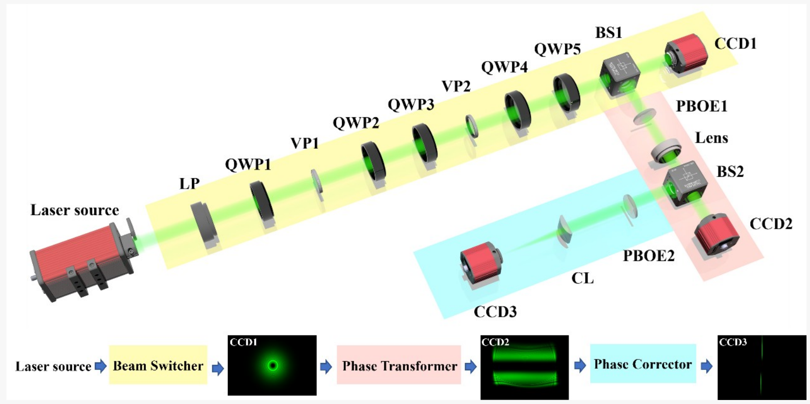

Figure 1. Schematic diagram of the experimental setup for generating switchable PBs and detecting phase and polarization TCs

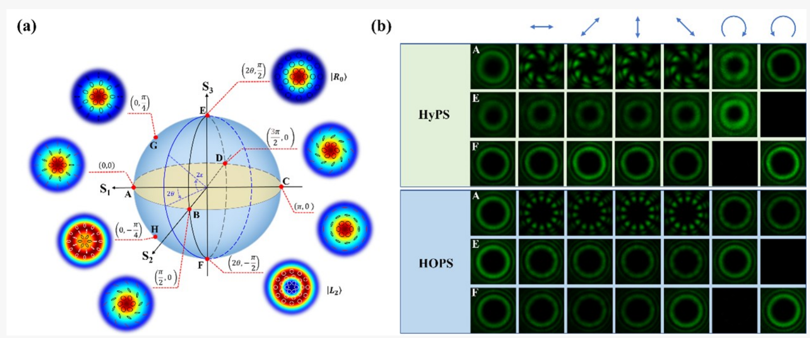

Figure 2. (a) Geometric framework of HyPS. (b) Intensity distributions corresponding to states A, E, and F generated on HyPS and HOPS

CHENGDU, SICHUAN, CHINA, August 19, 2026 /EINPresswire.com/ -- Section 1: Background
In recent years, numerous breakthroughs have been made in the generation and manipulation of structured light fields. For instance, Poincaré beams (PBs), which possess both inhomogeneous polarization distributions and helical wavefronts, allow for independent manipulation of their polarization and phase. These beams exhibit broad application prospects in fields such as laser processing, high-resolution imaging, and optical communications.

The explosive growth of technologies for generating complex light fields has created an urgent need for the simultaneous detection and dynamic decoding of phase and polarization topological charges (TCs). However, traditional detection methods—such as interferometry, which only detects phase TCs and requires a stable reference beam, and Stokes parameter analysis, which only detects polarization TCs and necessitates frequent adjustment of optical components—are unsuitable for characterizing the dynamic evolution of optical field states. They fail to meet the demand for simultaneous detection of polarization and phase in applications such as high-speed communication and quantum information processing.

Section 2: Key Contributions of Your Paper

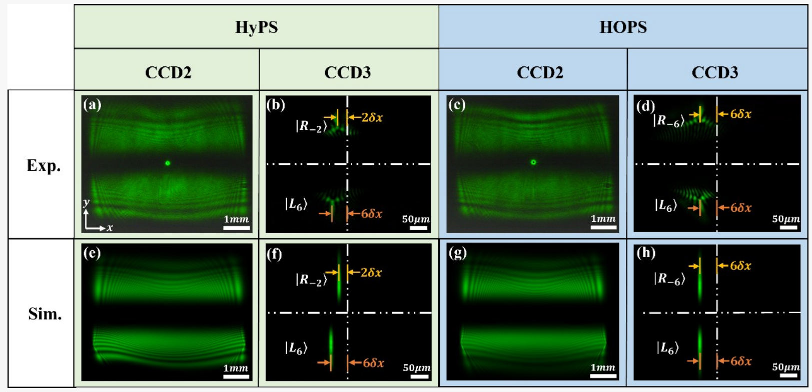

Figure 3. Intensity distributions of state A on the sphere after conformal transformation on HyPS and HOPS

To address the aforementioned challenges, the research team led by Professor Anting Wang at the University of Science and Technology of China, China, has proposed and experimentally verified a system capable of dynamically detecting the phase and polarization TCs of arbitrary PBs based on the spin-dependent response of Pancharatnam-Berry optical elements (PBOEs). The core of this system lies in a pair of conjugate-designed PBOEs that perform the log-polar coordinate conformal optical transformation. As shown in Figure 1, the Beam Switcher generates switchable PBs as the incident light, and its orthogonal eigenstates {□|□ R□,□ □|□ L□□} are then spatially expanded into two vertically aligned rectangular beams by PBOE1, which are collimated and output under the phase correction of PBOE2. Finally, a cylindrical lens is employed to directly convert the topological information of the orthogonal eigenstates {□|□ R□,□ □|□ L□□} into one-dimensional transverse spatial shifts in the focal plane.

In the Beam Switcher, the spin-to-orbital angular momentum conversion of two Q-plates is utilized to modulate the phase and polarization of the beam. As shown in Figure 2, this realizes flexible switching of PBs between different output states on the hybrid-order Poincaré sphere (HyPS) and the high-order Poincaré sphere (HOPS).

This system is capable of separating the orthogonal eigenstates {□|□ R□,□ □|□ L□□} of arbitrary PBs and simultaneously decoding different combinations of phase and polarization TCs in a single measurement. Due to the orthogonal eigenstates of PBs and the inherent characteristics of the PBOEs, the output intensities of the orthogonal components after focusing will naturally separate in the image plane, as shown in Figure 3. This spatial separation mechanism effectively avoids mode crosstalk, thereby ensuring extremely high detection accuracy.

The core value of this work lies in achieving the simultaneous detection of phase and polarization TCs in a single measurement, overcoming the limitations of traditional methods in dynamic decoupling. It not only achieves the simultaneous detection of multidimensional optical field parameters through an elegant physical mechanism but also provides a highly promising technical solution for practical optical communication receivers.

This work was made available online on March 30, 2026, and published in Volume 2 of [Opto-Electronics Plus] on March 30, 2026, under the title “Simultaneous Dynamic Detection of Phase and Polarization Topological Charges of Poincaré Beams.” This research was supported by the

National Natural Science Foundation of China (62375251) and National Key Research and Development Program of China (2020YFB2205802).

Section 3: Overview of the Authors' Research Group
The research team led by Prof. Wang is primarily engaged in research fields such as laser technology, vortex optical fields, and advanced displays. In recent years, the team has undertaken projects funded by the National Key Research and Development Program of China and the National Natural Science Foundation of China. They have published over 130 papers in peer-reviewed journals such as Opto-Electronic Advances, Nature Communications, Laser & Photonics Reviews, ACS Photonics, Physical Review Applied, and Photonics Research. The team has applied for 47 invention patents with 26 authorized and 28 authorized utility model patents, among which technology transfer has been completed for 8 patents. Prof. Wang authored the monograph “Optoelectronic Technology”. He won the Second Prize of the Education and Teaching Achievement Award of Chinese Academy of Sciences in 2016 and the Second Prize of the Teaching Achievement Award of Anhui Province in 2022.

Reference
Title of original paper: Simultaneous dynamic detection of phase and polarization topological charges of Poincaré beams
Journal: Opto-Electronics Plus
DOI: https://doi.org/10.67704/oep.2026.260005

Funding information
The team appreciates the financial support from the National Natural Science Foundation of China (62375251) and National Key Research and Development Program of China (2020YFB2205802).

Xiaoqing Liu
Opto-Electronics Plus
email us here
