亮点报道：沿任意轨迹偏振可控的结构光束

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现有的研究主要集中在沿光轴方向调控光束的偏振。这大大限制了纵向结构光束的偏振在空间维度上的自由度。脱离光轴的束缚，探索沿着空间中任意传输轨迹进行偏振操纵，进而生成一种任意轨迹传输偏振纵向变化的结构光束，从而为创建定制化空间结构光束开辟新的可能性。

首都师范大学张岩教授团队使用三层金属结构超构表面生成了沿任意空间轨迹偏振变化的结构光束。为了实现这种定制化空间结构光束，该工作首先在输入平面上设计了相位调制函数，而传播的轨迹曲线是从输入平面上这些移动圆环发出的锥形光束汇聚而成。通过控制移动圆环对应的正交偏振光束分量的振幅和相位差，可以实现预定传输轨迹上各点的偏振控制。按照预设的螺旋传输轨迹，他们设计了在庞加莱球上沿着赤道 15°线偏振到 75°线偏振的连续变化的结构光束，以及沿着北半球 15°线偏到圆偏振再到 75°线偏的连续变化的结构光束。

具有纵向偏振变化的任意轨迹结构光束为连续调节非轴向传输的空间结构光束的特性提供了一种实用方法，并为创建定制化空间结构光束开辟了新的可能性。该技术在光学加密、粒子操纵和生物医学成像方面具有潜在用途。

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Highlights: Structured light beams with controllable polarization along arbitrary trajectories

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Current research mainly focuses on controlling the polarization of beams along the optical axis. However, this greatly limits the spatial freedom of polarization for longitudinally structured light beams.

Recently, Prof. Yan Zhang's team at Capital Normal University used tri-layer metallic metasurfaces to generate structured light beams with polarization variations along arbitrary spatial trajectories. In order to achieve these customized spatial structured lights, the work first designed a phase modulation function on the input plane, consisting of a series of expanding circular rings with moving centers. Secondly, by controlling the amplitude and phase difference of the orthogonally polarized beam components corresponding to the moving circular rings, polarization control at each point on the predetermined transmission trajectory can be achieved. Following the preset helical transmission trajectory, they designed continuous variations of structured light polarized from 15° to 75° along the equator line on the Poincaré sphere, as well as continuous variations of structured light polarized from 15° to circular polarization and then to 75° along the equator of the northern hemisphere, respectively.

The proposal for arbitrary trajectory structured light beams with longitudinally varying polarization offers a practical method for continuously regulating the characteristics of spatial structured light beams with non-axial transmission and opens up new possibilities for creating customized spatial structured light beams. This technique has potential uses in optical encryption, particle manipulation, and biomedical imaging.

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