New technique measures structured light in a single shot

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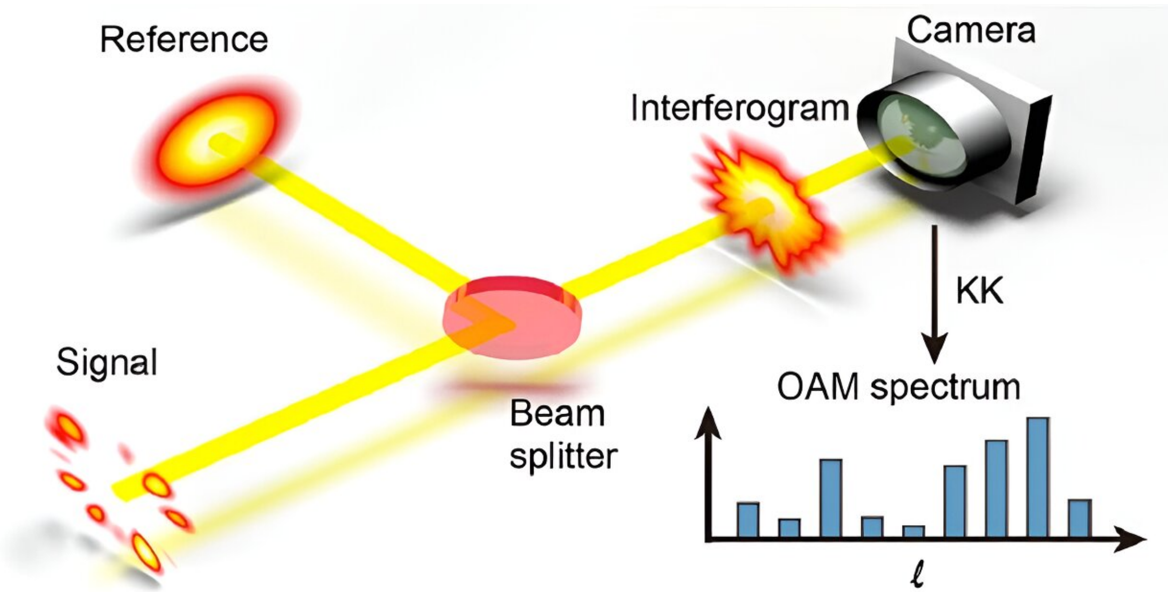
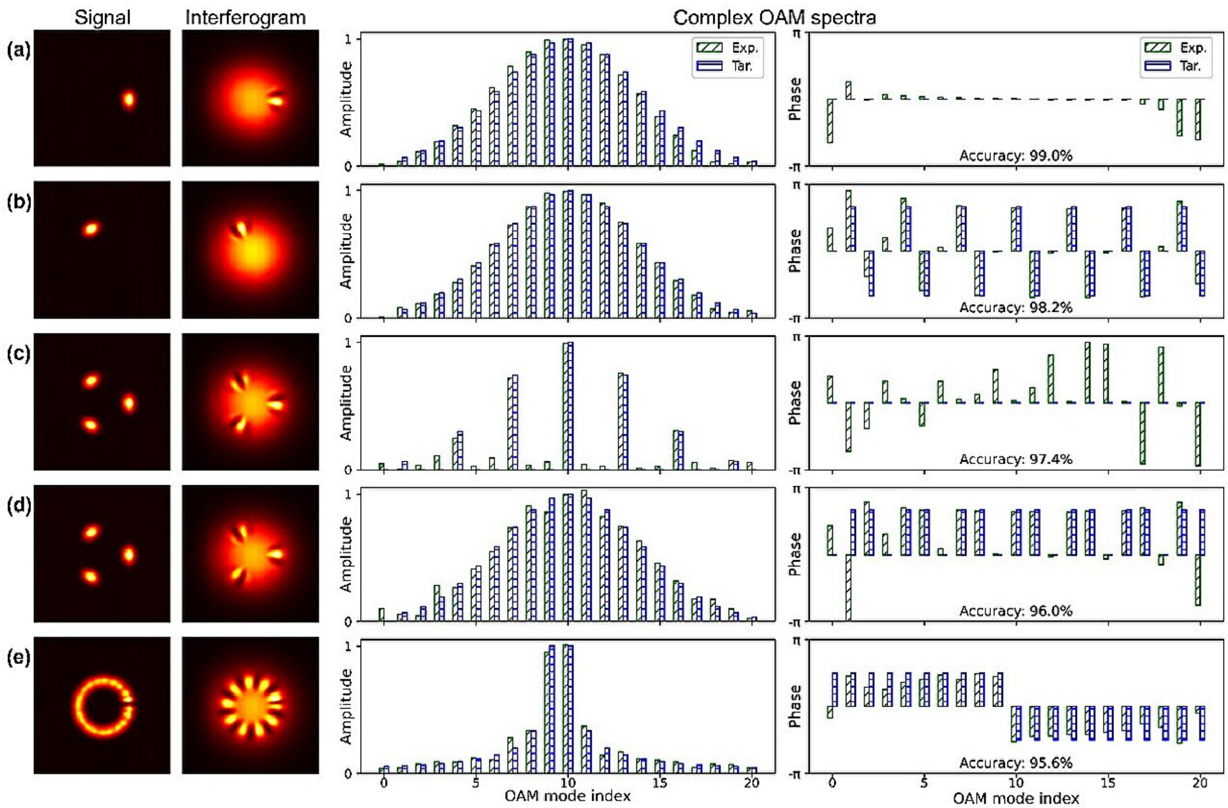


On-axis Kramers-Kronig interferometry retrieves the spectrum of orbital angular momentum in a single-shot. Credit: *Advanced Photonics* (2023). DOI: 10.1117/1.AP.5.3.036006

Structured light waves with spiral phase fronts carry orbital angular momentum (OAM), attributed to the rotational motion of photons. Recently, scientists have been using light waves with OAM, and these special "helical" light beams have become very important in various advanced technologies like communication, imaging, and quantum information processing. In these technologies, it's crucial to know the exact structure of these special light beams. However, this has proven to be quite tricky.

Interferometry—superimposing a light field with a known reference field to extract information from the interference—can retrieve OAM spectrum information using a camera. As the camera only records the intensity of the interference, the measurement technique encounters additional crosstalk known as "signal-signal beat interference" (SSBI), which complicates the retrieval process. It's like hearing multiple overlapping sounds, making it difficult to distinguish the original notes.

In a recent breakthrough reported in *Advanced Photonics*, researchers from Sun Yat-sen University and École Polytechnique Fédérale de Lausanne (EPFL) used a powerful mathematical tool called the Kramers-Kronig (KK) relation, which helps with understanding and solving the problem. This tool enabled them to untangle the complex helical light pattern from the camera's intensity-only measurements for single-shot retrieval in simple on-axis interferometry. Exploring the duality between the time-frequency and azimuth-OAM domains, they apply the KK approach to investigate various OAM fields, including Talbot self-imaged petals and fractional OAM modes.



Measurements of complex OAM spectra. Left: the measured intensity images of the signal and the interferogram; Right: the normalized amplitude and relative phase of the target and experimentally retrieved OAM spectrum. (a-d) Gaussian-shaped OAM spectra centered at 10-th order with versatile OAM mode spacings and relative phase relations. (a) In-phase OAM spectrum with a mode spacing of 1. (b) Linear-phase OAM spectrum with a phase slope of 2π/3 and a mode spacing of 1. (c) In-phase OAM spectrum with a mode spacing of 3. (d) OAM spectrum with periodic Talbot phase [0, 2π/3, 2π/3] and a mode spacing of 1. (e) Fractional OAM mode with a topological charge of 9.5. The retrieval accuracy is also indicated for each case. Credit: *Advanced Photonics* (2023). DOI: 10.1117/1.AP.5.3.036006

The new measurement technique has great potential for advancing technologies that rely on these special light patterns. According to corresponding author Jianqi Hu, now a postdoc at Laboratoire Kastler Brossel, Ėcole Normale Supérieure, France, "The proposed method can also be generalized for OAM beams with complex radial structures, making it a powerful technique for real-time measurement of structured light fields, simply by a snapshot with a camera."

Compared to conventional on-axis interferometry, the KK method demonstrated by the researchers not only accelerates the measurement but also makes it much simpler and cost-effective. Thanks to this new technique, scientists have gained a powerful means to unlock the secrets of structured light waves with OAM. This breakthrough has the potential to revolutionize various technologies, paving the way for exciting advancements in the field of structured light in the near future.

More information: Zhongzheng Lin et al, Single-shot Kramers–Kronig complex orbital angular momentum spectrum retrieval, *Advanced Photonics* (2023). DOI: 10.1117/1.AP.5.3.036006

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