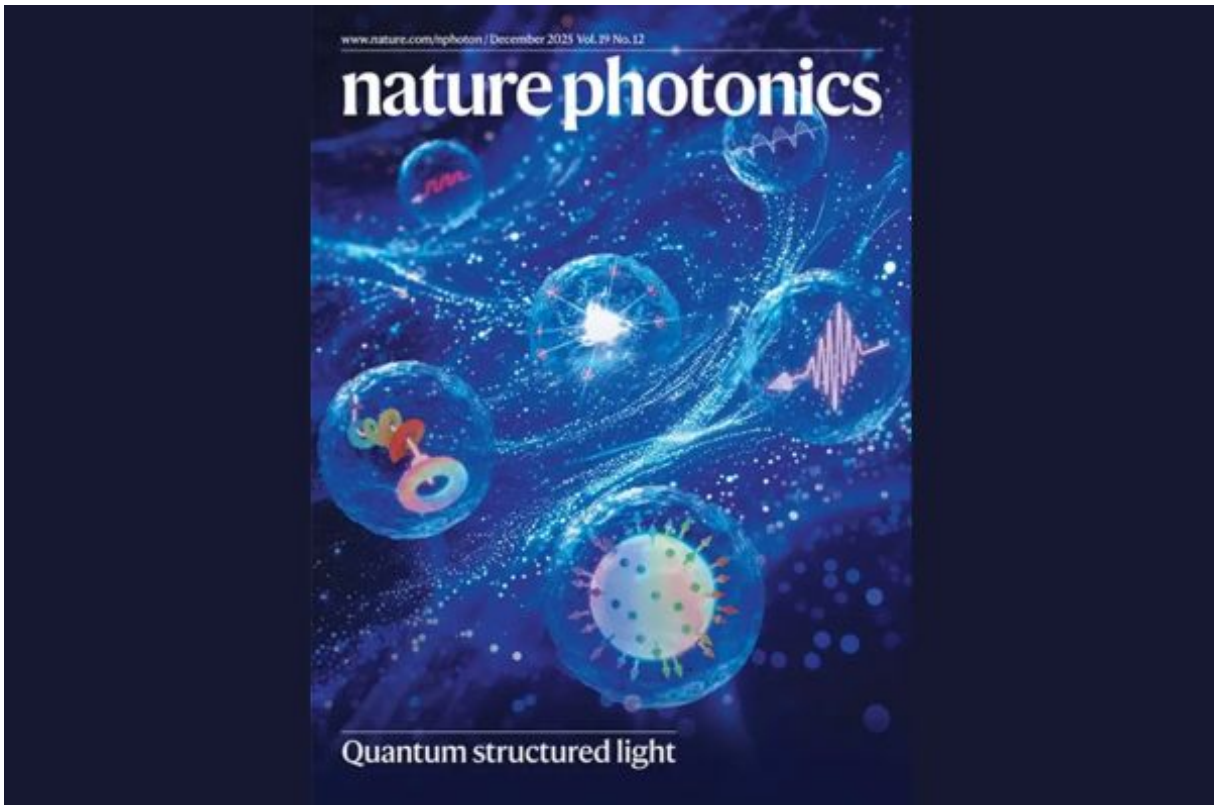


New advances in quantum structured light pave the way for safer communications and ultra-fast computing

Researchers from the Universitat Autonoma de Barcelona (UAB) and the University of the Witwatersrand, South Africa, working within the Catalonia Quantum Academy framework, present in Nature Photonics a comprehensive collection of the latest advances in quantum structured light, an emerging field that allows increasing the amount of information that light can transport. This technology has potential applications in more secure communications, faster quantum computing, and high-sensitivity detection systems.

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An international team of scientists affiliated with the Catalonia Quantum Academy (CQA) has published in Nature Photonics a review on an emerging field that is transforming the way w

communicate, measure and process information: quantum structured light. This technolog combines quantum information with spatial and temporal structures of light to creat photons with unprecedented information capacity

The authors highlight how the manipulation of multiple degrees of freedom of light, such a polarization, spatial modes, and frequency, allows generating high-dimensional quantu states, where the already familiar qubits (two-dimensional, with photons in superposition o two quantum states) become qudits (with more than two dimensions)

These properties create new opportunities across multiple fields. In the field of quantu communications, security is increased, since there is a higher information capacity pe photon, and the possibility of having many simultaneous communication channels is opened with enhanced tolerance for errors and resistance to noise. In terms of quantum computing structured light enables simpler and faster circuits, with the possibility of creating states fo complex simulations. It also opens the door to significant advances in imaging an metrology, with improved resolution techniques - such as the recent development of th holographic quantum microscope, which allows obtaining images of delicate biologica samples - and ultrasensitive sensors based on quantum correlations. In addition, structure light allows simulations of complex quantum systems to predict, for example, the interactio between molecules and networks, with potential for the development of new materials

According to Professor Andrew Forbes, corresponding author from the University of th Witwatersrand, at Johannesburg, the field has changed dramatically in two decades. i¿½ he tailoring of quantum states, where quantum light is engineered for a particular purpose, as gathered pace of late, finally starting to show its full potential. Twenty years ago the tool it for this was virtually empty. Today we have on-chip sources of quantum structured light t at are compact and efficient, able to create and control quantum states.

¿½ i¿½Although we have made amazing progress, there are still challenging issues,i ?½ says Forbes. i¿½The distance reach with structured light, both classical and quant m, remains very low, but this is also an opportunity, stimulating the search for more abstract degrees of freedom to

xploit.i¿½ The article, featuring as the cover article in this month's issue of Nature Photonics, is the result of a longstanding collaboration between the research group specializing in structured light, led by Professor Andrew Forbes, from the Faculty of Physics of the University of the Witwatersrand, Johannesburg, South Africa, and researcher Adam Valles, from the Optics Group of the UAB Department of Physics and visiting scientist at the Optoelectronics group at ICFO. Their latest project, finally published as a review article, has also been possible thanks to the support of the Catalonia Quantum Academy, a collaborative platform coordinated by ICFO and promoted by the Government of Catalonia, which works to strengthen the training and development of talent in quantum sciences and technologies in Catalonia.

Reference:

Forbes, A., Nothlawala, F. & Valles, A. **Progress in quantum structured light**. Nat. Photon. 19, 1291-1300 (2025). https://doi.org/10.1038/s41566-025-01795-x

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