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## *Entanglement of complex structures of photons*

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ABSTRACT:

In quantum optical experiments, the transverse spatial degree of freedom offers great potential to explore fascinating features of single photons and quantum entanglement. We develop novel methods to generate, investigate, and verify the entanglement of complex spatial structures. First, the orbital angular momentum (OAM) connected to the spatial mode structure is explored. As there is no theoretical upper limit known of how many quanta of OAM a single photon can carry, it appears to be a candidate for testing photonic entanglement of macroscopic values. We are able to demonstrate the entanglement of two photons with 300 quanta of OAM exceeding earlier experiments by two orders of magnitude. In a second experiment, we use an intensified CCD camera to image the effect of entanglement on the transverse structure of a photon depended on the measurement of its entangled partner photon, even in real-time. In a third experiment, we increase the complexity of the state by entangling photons that show a transverse varying polarization. Thereby, we demonstrate a surprising property: Such photons can be both entangled and not entangled in polarization depending on their transverse spatial position.